DISTRIBUTION OF TEACHER PENSION BENEFITS IN MASSACHUSETTS: AN IDIOSYNCRATIC SYSTEM OF CROSS-SUBSIDIES

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ABSTRACT: The value of pension benefits varies widely, by a teacher's age of entry and exit, e.g. between early leavers and those who retire at the "sweet spot" (by age or years of service). This variation is masked by the uniform rate of annual contributions, as a percent of pay, to fund benefits for all – the "normal cost rate." To unmask that variation we calculate annual cost rates at the *individual* level. In Massachusetts, we find that the cost of a new teacher's benefits ranges from about 5 percent of pay to 20 percent, and exhibits patterns that are even more idiosyncratic than other traditional final-average-salary pension formulas. The variation in individual cost rates generates an extensive, but hidden array of cross-subsidies, as winners receive benefits worth more than the uniform contribution rate, and losers receive less. One-quarter of annual contributions are redistributed in this fashion. Due to unfunded liabilities accrued under previously enhanced benefits, new entrants receive reduced benefits, of which relatively little is employer-funded. Thus, the size of the redistribution is equivalent to the entire employer contribution plus about one-sixth of the employees' contributions. Our main policy conclusion is that cash balance plans can rationalize or eliminate the current system of cross-subsidies and provide the transparency lacking in traditional plans.

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I. Introduction and Summary

The funding plans for traditional teacher pension systems are built upon a highly uneven set of benefits, varying widely in value by age of entry and exit.[1] These inequities are masked by a *uniform* fringe benefit rate for pensions. For example, the annual contribution to the pension fund (employer and employee contributions taken together) may be 15 percent of each teacher's salary. These "normal cost" contributions are designed to fund the future retirement benefits as they are earned,[2] for the system *as a whole*. However, the annual cost of benefits for *individual* teachers may deviate widely from this overall average. For example, early leavers may earn benefits worth 5 percent of salary per year while the benefits of those who retire at the "sweet spot" are worth 25 percent. In effect, there is a large cross-subsidy – 10 percent of pay – from the contributions by or for early leavers to help pay the benefits of career teachers. This is a big part of the funding plan. There are also other patterns of cross-subsidies, e.g. from younger to older entrants. In this brief, we present these patterns of *individual* normal cost rates and associated cross-subsidies under the Massachusetts Teachers' Retirement System (MTRS). Our goal is greater transparency and deeper understanding of the system of winners and losers embedded in the funding plans of traditional teacher pension systems. By bringing the

[1] This line of research dates to Costrell and Podgursky (2008, 2009, 2010a, 2010b).

[2] In addition, the employer makes payments for the unfunded liability – benefits earned in the past, but not funded. This is a very large problem, but is not the subject of this brief, except insofar as it lies behind the reduced benefits for new hires, examined here. The intergenerational cross-subsidies generated by unfunded liabilities (Backes, et. al. (2016)) are a consequence of the failure to meet actuarial assumptions, particularly the return on investments (Costrell (2016a,b)). In this brief, we take the assumptions as given to analyze the cross-subsidies within generations that are *built into the system's funding plan for new hires*, as distinct from the cross-subsidies between generations when the assumptions fail. For analyses that incorporate cross-subsidies across generations that arise from the failure to meet assumed investment returns, see Costrell and McGee (2017b).

individual cost rates out into the open, individual teachers may learn how they are affected by the redistribution of contributions that pension systems build into their funding plan.

The cross-subsidies embedded in the MTRS plan are widespread, substantial, and somewhat arbitrary. Individual annual cost rates vary from about 5 percent of pay (for those who enter and leave early) to about 20 percent (for those who enter late and leave in their mid-60s). Three-fourths of entrants are losers: their benefits are worth less than the joint contributions of the employee and the "employer" (the Commonwealth).[3] The cross-subsidies they provide to the winners are not small. They typically include the entire employer contribution (which is small for new hires in Massachusetts), and a good portion of the investment returns on their own contributions also goes to fund others' benefits. As a result, the winners receive benefits of somewhat greater value than the contributions made by or for them.

II. INDIVIDUAL NORMAL COST RATES AND CROSS-SUBSIDIZATION

Pension plans calculate the normal cost rate at the aggregate level, to fund a cohort's benefits as they accrue. Individual cost rates, based on age of entry and exit are implicitly embedded within the calculation (Costrell and McGee (2017a), Appendix), but they are not publicly reported. Specifically, consider an individual of type *(e,s),* where e is the age of entry and s (for separation) is the age of exit. For each type *(e,s)*, one can identify an individual normal cost rate, n_{es} that generates a stream of contributions sufficient to fund the individual's future benefits. It can readily be shown that n_{es} is the ratio of the present value (PV) of benefits, B_{es}, to the PV of earnings, W_{es} (both evaluated at entry):

(1) $n_{es} = B_{es}/W_{es}$.

[3] In Massachusetts, unlike most teacher pension systems, the "employer" contribution is from the state, rather than the local school district.

This is the rate that, applied to the individual's annual earnings over her career, would prefund her benefits. It represents the value of her benefits earned annually, as a percent of earnings – an *individual* fringe benefit rate for pensions. If we compare individuals with different entry and exit ages, *(e,s)*, we find their cost rates, n_{es}, vary widely. In the simple example above, n_{es} was 5 percent for early leavers and 25 percent for career teachers. The actual results for the full array of entry and exit ages will be shown below for MTRS.

Traditional pension plans levy a joint (employee plus employer) contribution rate, n^*, that is *uniform* (independent of the individual's normal cost), calculated to fund the benefits of the whole entering cohort.[4] This rate is a weighted average of individual costs.[5] The deviations $(n_{es} - n^*)$ are positive and negative, as the cost of funding an individual's benefit exceeds or falls short of the uniform contribution rate, n^*, comprising a system of cross-subsidies. By the nature of averages, the weighted sum of cross-subsidies $(n_{es} - n^*)$ is zero: the negative cross-subsidies provided by the losers fund the positive cross-subsidies enjoyed by winners. To continue with the simple example above, n^* = 15 percent, and $(n_{es} - n^*)$ = –/+ 10 percent for early leavers and career teachers, respectively: contributions equal to 10 percent of pay are redistributed. The full array of cross-subsidies embedded within MTRS' funding plan will be shown below.

III. INDIVIDUAL NORMAL COST RATES FOR MTRS

We now apply these concepts specifically to the Massachusetts Teachers' Retirement System plan. We estimate the individual normal cost rates, $n_{es} = B_{es}/W_{es}$, for all entry and exit

[4] It can be shown that n^* applies not simply to a single entering cohort, but to any cohort, past or present, or the full set of such cohorts working their way over time through the workforce, under a given benefit formula and set of actuarial assumptions (Costrell and McGee (2017a)).

[5] The weights for n_{es} are the share of type *(e,s)* in the cohort's PV of earnings. These are not the exact weights used in actuarial practice, but are consistent with the approach (see Costrell and McGee (2017a), Appendix).

ages, $e = 21, \ldots, 60$, and $s = 21, \ldots, 70$. We base the calculations on the MTRS actuarial assumptions and benefit formula for new hires.[6]

Benefits can be in the form of a pension or refund of employee contributions.[7] If a teacher takes the refund she forgoes any future pension and receives, instead, the cumulative value of the employee (but not employer) contributions, with accumulated interest at the rates set by MTRS. Teachers who leave before vesting at 10 years, without the expectation of returning and earning a pension, would certainly take the refund because it is the only benefit to which they are entitled. Teachers who leave after vesting, but too young to draw a pension, may either take the refund or leave the money in the fund to draw a pension in the future, upon reaching eligibility at age 60. Finally, teachers who leave service and are eligible for an immediate pension, may still choose the refund, although it is generally not financially prudent to do so. We assume that teachers choose the refund or pension to maximize the PV of their benefits.

If a teacher takes the pension, B_{es} is the PV of the stream of pension payments, weighted by her survival probabilities, discounted to entry. The payments begin with a starting pension equal to an age-specific multiplier × years of service $(s – e)$ × final average salary (FAS, last 5 years), plus a large premium after 30 years of service. Subsequent payments are augmented annually with a 3.0 percent simple COLA on the first $13,000. Specifically, we consider the formula that covers all new hires (since 2012), with reduced benefits from the prior program. It is important to understand a bit of the background to the reduced benefits.

[6] The actuarial assumptions cover wage growth, investment returns, exit rates, and mortality rates. These assumptions are drawn from the 2016 and 2017 annual valuation reports (PERAC 2016, 2017), based on the most recent 5-year experience study (PERAC 2014). The benefit formula is delineated in the member handbook (MTRS, 2017). This includes the retirement eligibility conditions, age-specific multipliers, cost of living adjustments (COLA), employee contribution rate, and interest rate on refunds (more on that below).

[7] We leave aside disability and survivor benefits, which comprise about 3 percent of benefits.

The roots of the reduction trace, in good part, to a large benefit enhancement enacted in 2000, known as "Retirement-Plus."[8] That enhancement followed the 1990s bull market, which (as elsewhere) improved MTRS' funding status, from a ratio of 39.2 percent in 1990 to a peak of 83.3 percent in 2000. This emboldened the advocacy groups and the Legislature to enhance the teachers' benefit formula (which had previously been identical to the formula for state employees) by adding a large premium to the starting pension upon reaching 30 years of service. The employee contribution rate for program participants was also raised, but not enough to fund the new benefits. Shortly afterwards, the state actuary estimated the additional net liability from the new program at $1.5 billion. Since 2000, the system's unfunded liability has grown from $2.8 billion to $23.6 billion as of 2017, and the funded ratio dropped 83.3 percent, to 52.1 percent, as market returns failed to meet assumptions. The state's amortization payments on the unfunded liability now comprise 80 percent of its annual contributions to the pension fund, running at 16.3 percent of payroll,[9] and those contributions are scheduled to increase (in dollar terms) about 9 percent a year until 2036.

In the face of this daunting funding situation, benefits for new hires were reduced, effective in 2012. Specifically, the minimum retirement age was raised from 55 to 60 and the retirement age that maximizes the multiplier was raised from 65 to 67. For retirement with less than 30 years of service, the multipliers now vary from 1.45 percent at age 60 (down from 2.0 percent previously) to 2.5 percent at age 67. However, the "Retirement-Plus" enhancement enacted in 2000 was retained (with some modification). Upon reaching 30 years of service, "Retirement-Plus" enhances the multiplier (e.g. from 1.45 percent at age 60 to 1.625 percent) and

[8] For a more complete account of this episode, based on Costrell's experience in the administration of Governor Paul Cellucci, who vetoed the measure, but was overridden, see Costrell and Podgursky, 2007, pp. 9-10. (By way of disclosure, Costrell, along with other staff, advised in favor of the veto.)
[9] Authors' calculations from the 2017 valuation report (PERAC, 2017).

adds a *premium* of 14 percentage points of FAS to the starting annuity, rising to 24 percentage points at 35 years of service. For example, a 25-year-old entrant leaving at age 54, with 29 years of service can collect a pension equal to 29 × 1.45 = 42.05 percent of FAS, collectible at age 60, while a 30th year would raise the pension to 30 × 1.625 + 14.00 = 62.75 percent; after working 35 years, she could retire at age 60 with an undeferred pension at 80 percent of FAS, the cap on starting pensions. This formula, together with MTRS mortality assumptions, allows us to calculate the PV of benefits, relative to that of wages, $n_{es} = B_{es}/W_{es}$, the annual contribution rate required to fund the benefits of an individual entering at age *e* and exiting at age *s*.

Variation in Normal Cost Rates By Age of Exit

Let us consider further an entrant of age 25, using the metric of the normal cost rate. This rate is depicted in Figure 1, varying by age of exit. Prior to vesting, and for some years beyond, the benefit is the refund of employee contributions. The normal cost rate, therefore, starts at the employee contribution of 11 percent: the curve begins at the dashed horizontal line representing that rate. The cost rate then declines, falling below the employee contribution rate. That is because the interest credit of 3 percent is below the fund's assumed return, 7.5 percent. The contribution rate needed to cover the refund falls as this difference accumulates. Upon reaching 10 years of service, the interest provided on refunds drops to the amount that has accrued at the rate paid on individual bank savings accounts – which averaged 0.1 percent in 2016.[10] Thus, the normal cost rate for refunds drops further below the employee contribution rate and continues to decline with further years of service.

[10] This rate was reported in MTRS' 2016 CAFR, p. 12. The actuarial valuations assume interest credited at 3.5 percent. We have performed our calculations with that assumption, too, which raises the minimum normal cost rate from about 5 percent to 6 percent, but overall has little impact on our summary statistics. For example, the overall normal cost rate, n^*, rises by 0.2 percentage points.

At a certain point, the pension becomes more attractive than the refund. A 25-year-old entrant reaches that point at age 49; at this age the pension would still be deferred until eligibility at 60, but exceeds in PV the value of the employee refunds. Beyond that point, the normal cost rate rises as the deferral becomes shorter, and jumps at age 55 with the "Retirement-Plus" reward for 30 years of service. (At that point, the employee contributions drop to 8 percent, resulting in a slight decline in the overall employee contribution rate, depicted by the dotted gray line.)

Beyond the 30-year mark, the normal cost rate continues to rise as the "Retirement-Plus" reward grows. By age 60 (35 years of service), the pension maxes out at 80 percent of FAS and the normal cost rate reaches 14 percent.[11] Beyond age 60, there is no further rise of the pension (as percent of FAS), so each year of forgone pension payments, due to delayed retirement, reduces the normal cost rate. Overall, the normal cost rate for a 25-year-old entrant varies from about 5 to 14 percent of pay per year. This is a manifestation of the well-known back-loading of benefits that favors long-termers under traditional FAS formulas (Costrell and Podgursky (2008, 2009, 2010a, 2010b)), along with the policy of low interest on refunds.

Variation in Normal Cost Rates By Age of Entry, Age of Exit, and Years of Service

The normal cost rate also varies with age of entry. In general, the normal cost rate can rise or fall with later entry under traditional FAS plans,[12] and, indeed, for MTRS we find a very

[11] Unlike two previous studies (Lueken 2017, Aldeman and Johnson 2015), we find that some 25-year-old entrants in Massachusetts reach a point where the value of benefits exceeds that of their own contributions. This seems largely due to the higher growth rate of earnings assumed by MTRS (and adopted here) than in these studies. That said, we still find that employer-funded benefits are negative for over three-quarters of such entrants.

[12] Later entrants with the same exit age have shorter service, so their pension is lower, reducing B_{es}, but the stream of earnings is shorter, reducing W_{es}. Thus, the ratio, $n_{es} = B_{es}/W_{es}$, can rise or fall, over different ranges of *s*, discount rates, and benefit formulas. Another way of seeing the ambiguity is to note that for any given exit age, the normal cost rate varies with (i) the starting pension as a percent of FAS; and (ii) FAS relative to cumulative earnings. For older entrants, with shorter service, the starting pension is a lower percent of FAS, which reduces normal cost. But their FAS is higher relative to cumulative earnings (since it is a shorter stream), which raises normal cost.

mixed pattern. Figure 2 depicts the normal cost curves of selected entry ages.[13] Thus, in addition to the variation *within* entry-age cohorts, Figure 2 also depicts the (vertical) variation *across* entry ages, for the same exit age. For those exiting before age 53 or after age 65, the normal cost rate increases with age of entry, but in between those exit ages, the normal cost curves cross each other at multiple points. For example, the annual cost to fund retirement at age 67 varies from 9.2 percent per year over the career of a 25-year-old entrant to 18.6 percent for a teacher who enters late, at age 45. Consequently, the overall variation in normal cost rates depicted, within and across entry ages, is rather wide, ranging from 5.1 to 18.6 percent of pay per year; the full range, for entry ages not shown, is 4.5 to 23.8 percent.[14]

Advocates of traditional FAS pension systems often defend the apparent inequities as a rational human resource policy to reward longevity.[15] As we have seen, in Figures 1 and 2, MTRS does generally reward longevity for any given entry age, over a certain range, by awarding benefits at a higher annual rate, as the exit age rises from about age 50, up through a peak that varies from age 60 to 67. One may debate whether the extent of the reward (the steepness of the curves) is effective or goes beyond what is efficient for human resource goals.[16] But the variation across entry ages can lead to very different rewards for the same length of service, and can significantly reward *shorter* tenures. This can be seen directly in Figure 3, which depicts the relationship between normal cost rates and years of service, for various entry ages. For example, if we compare the peak normal cost rates by entry age, we see that a 25-year-

[13] To get a sense of how many entrants are represented by each such curve, we need the age distribution of entrants (also used below for various summary statistics). We estimated this by reverse engineering from the valuation report's age-service distribution and exit rates. To summarize this distribution, entry ages at the 10th, 25th, 50th, 75th, and 90th percentiles are, respectively, about 22, 24, 27, 35, and 45.
[14] The higher rates are for unusual entry ages, later than 50.
[15] See, for example, Rhee and Fornia (2016, 2017) and Weingarten (2017).
[16] For a good summary of the research, see Koedel and Podgursky (2016), as well as the recent papers by Ni and Podgursky (2016), McGee and Winters (2016), and Roth (2017).

old entrant reaches a peak of 14 percent (as stated earlier) after 35 years of service, while older entrants reach higher peaks after shorter years of service. The curves also depict the sharp rise upon reaching 30 years of service, jumping to higher normal cost rates for later entrants who reach that milestone at later ages. But even a 45-year-old entrant, who (by MTRS assumptions) never reaches that milestone, enjoys higher normal cost rates yet after 20 years or so of service. These highly idiosyncratic patterns are difficult to reconcile with the usual defense of traditional pension systems, based on rewarding longevity. One may wonder if there is any human resource rationale for such seemingly arbitrary rewards.

IV. Cross-Subsidy Rates and the Degree of Redistribution

The wide variation among individual cost rates contrasts with the uniform contribution rate, n^*. That is the weighted average of the individual cost rates, n_{es}, where the weights are the shares of the cohort's lifetime earnings for entrants of type *(e,s)*. These weights generate the normal cost rate that will fund the benefits of each cohort, past and present, taken as a whole, under the current benefit formula and actuarial assumptions. We calculate n^* to be 11.9 percent of pay, depicted in Figure 2 as the solid horizontal line. The deviations of individual cost rates from n^* represent the cross-subsidy rates, $(n_{es} - n^*)$. Those above the line receive cross-subsidies from those below the line. For example, the extreme points depicted for n_{es}, of 5.1 and 18.6 percent, represent cross-subsidies of –6.8 and +6.7 percent of pay. These cross-subsidies are built into the funding plan. For those individuals below the solid line, the plan is counting on using some or all of the employer contributions – plus, for most (those below the dashed line[17]), part of the assumed earnings on employee contributions – to help finance the benefits of others.

Those who provide the cross-subsidies comprise 74 percent of entrants[18] and account for 50 percent of their lifetime earnings;[19] those who receive the cross-subsidies are the remainder. How large are the cross-subsidies? Taken together, the losers provide cross-subsidies that total –2.8 percent of their lifetime earnings. That is the average cross-subsidy rate for those below the solid line in Figure 2 (weighted by shares of lifetime earnings). The winners receive cross-subsidies that average +2.9 percent of pay. Aside from rounding, one can readily verify the zero-sum result: 0.50 × 2.9% – 0.50 × 2.8% = 0.0%. Thus, in all, taking absolute values of the cross-subsidies, *2.85 percent of total income is redistributed* (0.50 × 2.9% + 0.50 × 2.8%). This represents about one-fourth of the total normal cost and exceeds the employer contribution, which is relatively low. Since the plan for new entrants reduced benefits, as discussed above, the employer contribution rate is only about 1.0 percent of pay.[20] Thus, the losers, who provide cross-subsidies averaging –2.8 percent of pay, lose their entire employer contribution and more, receiving benefits that effectively cost the employer about –1.9 percent. Conversely, the employer funded benefits of the winners are worth +3.9 percent of pay.

[17] For ease of presentation, the 11 percent employee contribution is depicted for all exit ages, rather than the slightly lower rates for those who exit after 30 years. However, the results given below that depend on those lower rates are fully calculated.

[18] Rhee and Fornia (2016, 2017) argue that prior entrants who are no longer in the workforce should be excluded when counting winners and losers. But as explained in Costrell and McGee (2017a), this results in "survivorship bias" toward winners. As a result, the losses left behind by prior leavers are excluded, such that the cross-subsidies do not sum to zero. In other words, the funding math simply does not add up.

[19] Those with lower normal cost rates (negative cross-subsidies) tend to be early leavers with shorter earnings streams, so they have smaller shares of the cohort's PV of earnings.

[20] By contrast, the current employer contribution rate is 3.5 percent, reflecting the predominance in the current workforce of those who entered under previous plans, with higher benefits (13.6 percent average normal cost) and lower contributions (10.1 percent). (authors' estimate from 2017 valuation report)

V. CONCLUSION

The distinguishing characteristic of traditional FAS pension plans, such as MTRS, is that the benefit is delinked from contributions, unlike cash balance or other account-based plans (discussed below). Some individuals receive benefits that cost more than the contributions made by or for them, and some receive less. This creates a system of hidden cross-subsidies, varying by age of entry and exit. In this brief, we have measured the value of individual benefits as the annual contributions required to fund them, as a percent of pay. The wide variation in these individual cost rates – ranging from about 5 to 20 percent – contrasts with the uniformity in the contribution rate actually levied, clearly revealing the system of cross-subsidies. In effect, the great majority of entrants help fund the benefits of others through some or all of their employer contribution and, for most, the value of some of their own contributions, too. We estimate that this redistribution represents all of the employer contribution, plus about one-sixth of the employee contribution. Without these cross-subsidies, the employer and/or employee would have to contribute much more to fund the benefits of career teachers.

Our analysis covers the full range of entry and exit ages, illuminating additional patterns of cross-subsidies to those previously identified between short-termers and career teachers. Benefits not only vary by age of exit, but also by age of entry. Older entrants are often strongly subsidized by younger entrants leaving with the same – or even fewer – years of service. In addition, there are marked idiosyncrasies generated by the sharp cliffs embedded in the MTRS benefit enhancement of 2001, which remain today, even as the rest of the formula has been pared back in the face of growing unfunded liabilities. These patterns are difficult to reconcile with the claim that traditional FAS systems rationally and consistently serve human resource goals.

What are the policy implications of this analysis? At the very least, any good policy should be transparent. Where traditional FAS plans are employed, the system of hidden cross-subsidies should be laid bare. The uniform contribution rate, designed for funding purposes, masks the wide variation in individual cost rates. These rates can be readily calculated, by age of entry and exit, as a byproduct of the annual actuarial valuations, and should be made publicly available, so that members can better understand how their plan may affect them.

There is reason to go further, by reducing the actual variation in cost rates. One of the reasons employers offer retirement plans is to help workers save enough across their careers to reach a secure retirement. The low savings rates effectively offered to workers who leave early (in order to help fund those with high normal costs) have the potential to endanger this goal, placing them at a big retirement savings deficit. The most efficient way of reducing the variation in cost rates is through an account-based system, such as a cash balance (CB) plan.

A CB plan is a defined benefit plan, in which each individual's benefit is directly tied to a retirement account balance (to be annuitized or drawn down). That balance is equal to the cumulative value of employee contributions and employer contribution credits (a bookkeeping entry), plus accumulated interest credits. The employer contribution credit, with interest, *is* the employer-funded benefit, transparent to all. If the credit is uniform, so are the rewards – there are no cross-subsidies; benefits accrue smoothly in tandem with contributions.

If human resource goals are to include rewarding longevity, CB plans can do so more efficiently. As we have seen, FAS systems do not reward longevity consistently. CB systems can reward longevity far more rationally, by designing employer contributions to rise smoothly, gently, and non-idiosyncratically, with years of service. For example, under Kansas' Tier 3 CB plan (Schmitz, 2016; KPERS, 2017) – the nation's first such plan covering teachers – the employer match (to the employee's contribution of 6 percent) rises from 3 percent of pay for years 1-4 of service to 6 percent of pay for years 24 and beyond.[21] Such a gently varying system of employer matches, readily understood by teachers, may enhance the efficiency of the embedded incentives and accommodate teacher heterogeneity. In short, a CB or other account-based system, tying benefits directly to contributions, offers a more effective and equitable vehicle for delivering transparent and deliberate rewards to meet the goals of teachers and employers than the seemingly arbitrary system of cross-subsidies that are embedded in traditional FAS plans, such as MTRS.

[21] Typical of other CB plans, the employers' actual contribution rate is less than the notional contribution credit, because the plan's assumed return exceeds the interest credit. The individual employer normal cost rate, averaged over one's years of service, for providing these credits would range from 3.0% to 4.7%, with interest credits equal to the assumed return of 7.75%. Under the assumed interest credit of 6.25%, the range in individual employer normal cost rates is only 3.0% to 3.7%. Either way, the range is much narrower than under FAS systems, as we have seen.

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Figure 1. Normal Cost Rate, Entry Age 25

Estimated using 2016 MTRS assumptions and benefit formula for new hires

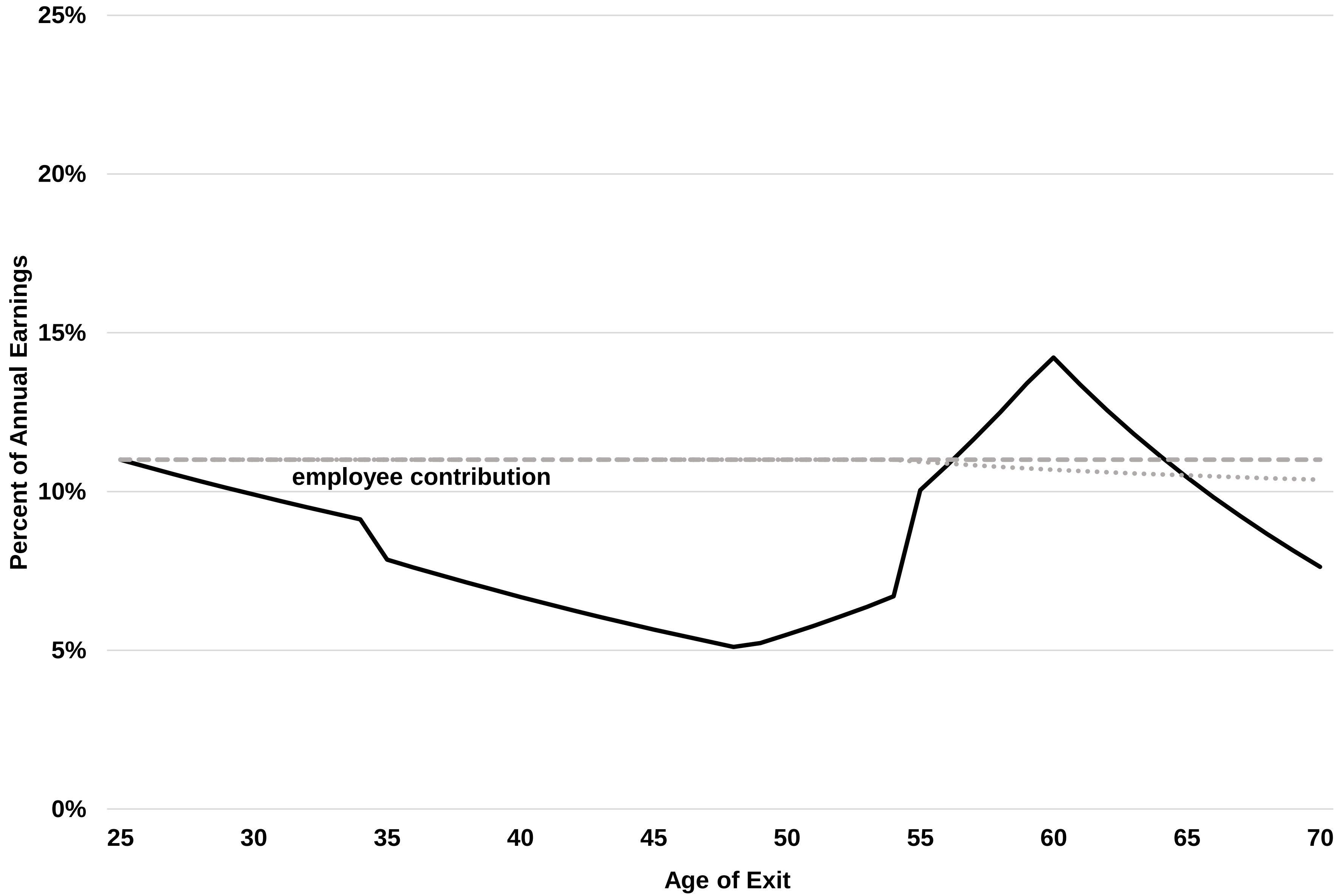
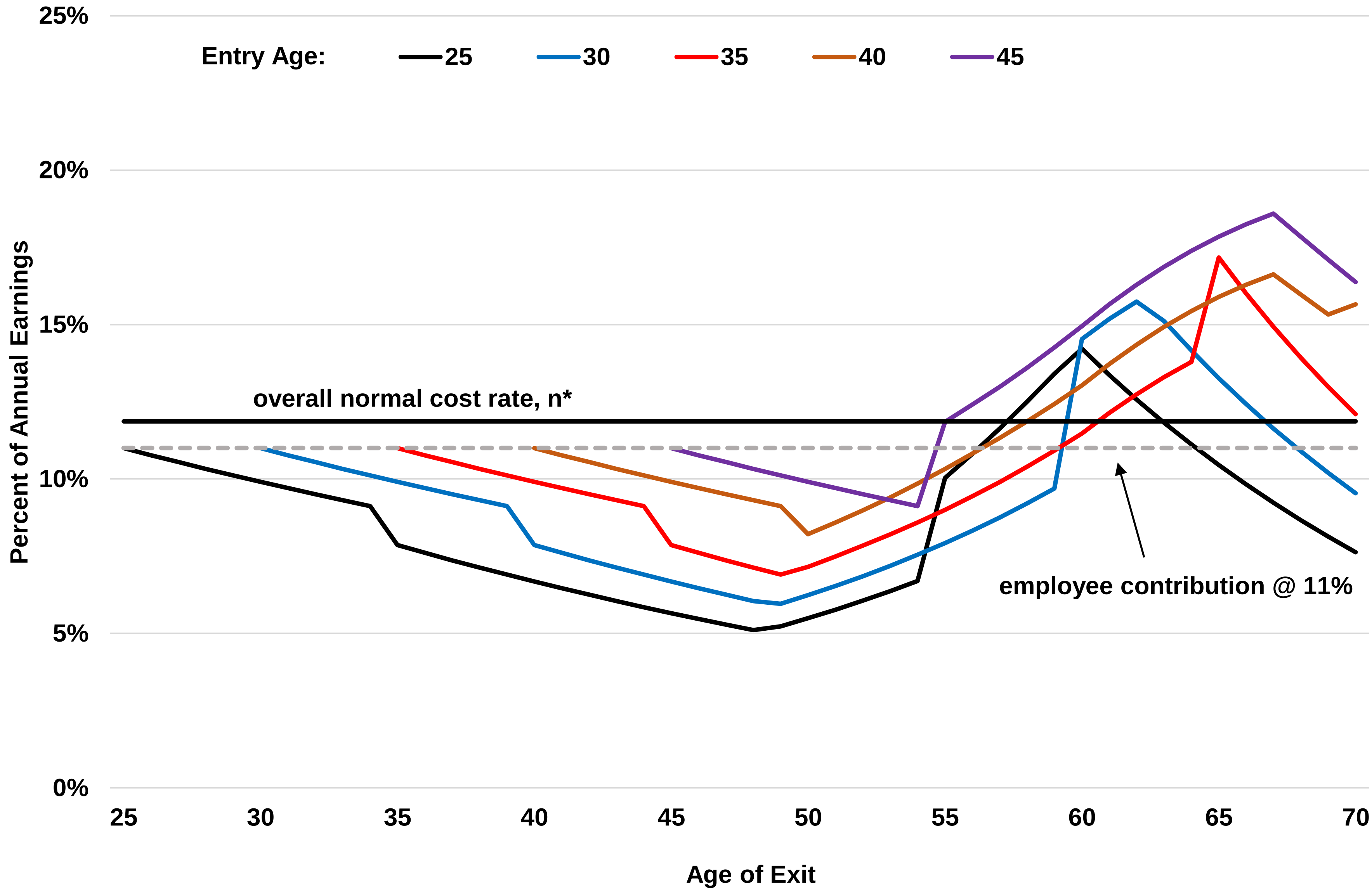


Figure 2. Normal Cost Rate, by Entry Age and Age of Exit, n_{es}

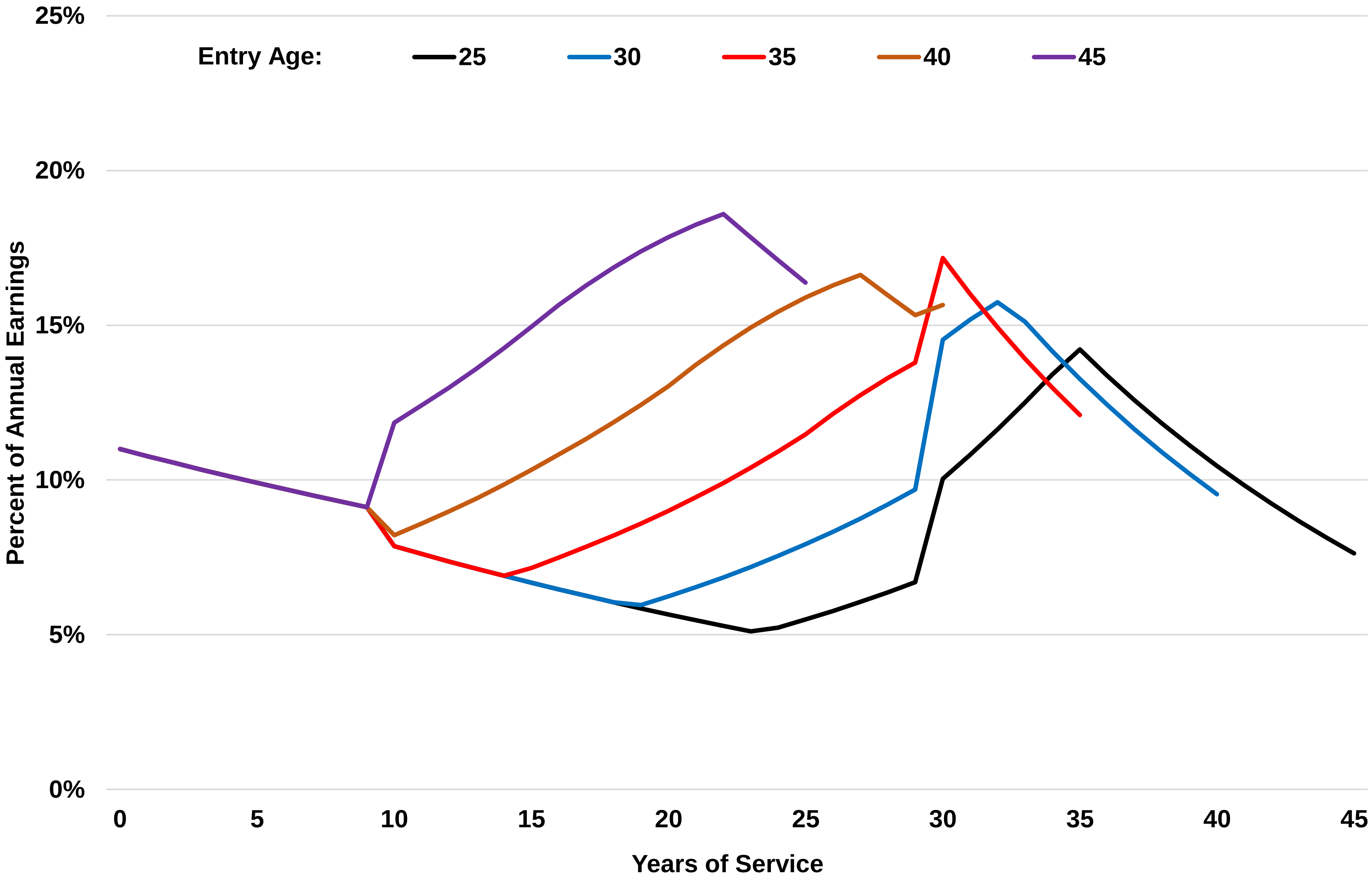
Estimated using 2016 MTRS assumptions and benefit formula for new hires



The curves depict n_{es}, the annual contribution rate required to fund benefits of an individual entering at age e and exiting at age s.
Variation in cost by age of exit is shown along each curve; variation by age of entry is shown across curves.

Figure 3. Normal Cost Rate, by Entry Age and Years of Service

Estimated using 2016 MTRS assumptions and benefit formula for new hires



The curves depict n_{es}, the annual contribution rate required to fund benefits of an individual entering at age e and serving s-e years.
Variation in cost by years of service is shown along each curve; variation by age of entry is shown across curves.