# Impact of Mortality Table Projection Scales on Defined Benefit Pension Plan Valuations

## 1. Purpose and Approach

The study was conducted by David Kays of ACUFF Associates for the SOA Retirement Systems Research Committee and the SOA Mortality Projection Workgroup. The purpose of the study was to provide quantitative information illustrating the impact of reflecting mortality improvement using a "Generational Approach" in the actuarial valuations of defined benefit pension plans versus reflecting mortality improvement by more traditional methods.

**"Generational" Approach:** Under the generational approach, the mortality improvement scale is incorporated exactly into the valuation process by adjusting the each mortality rate applied to a given participant for mortality improvement to the future year in which the mortality rate is applied[1].

The traditional methods compared to the Generational Approach were:

**"Update" Approach:** Mortality improvement recognized as it occurs by periodic updates (every 10 years) to a "then current" mortality table

**"Update + Projection" Approach:** Periodic updates as above, but to a mortality table that incorporates future mortality improvement for a fixed number of years beyond the date of the update (For example, if the fixed number of years is 15, the 1/1/2000 through 1/1/2009 valuations would use a mortality table incorporating mortality improvement through 1/1/2015, while the 1/1/2010 through 1/1/2019 valuations would be based on a table incorporating mortality improvement through 1/1/2025).

Contribution rates, funded status, and pension expense were compared over a 30-year period (January 1, 2000 – January 1, 2030) for a simple retirement plan with a 1.5% final average pay formula - that was 90% funded and covered a fairly mature population (average employee age 44, average service of 17 years, average retiree age 71, and .9 retirees for each employee).

## 2. Actuarial Valuation Assumptions and Methods

All valuations were based on an 8% interest rate for funding and expense and 5% salary increase rates. Retirements were assumed to occur at age 63 and a moderate turnover table was used.

In order to test sensitivity to the rate of mortality improvement, valuations were conducted using two different mortality improvement scales. The first improvement scale was a commonly accepted mortality improvement scale: Scale AA. This scale was recommended for use with the UP-94[2] and RP-2000 Mortality Tables. The scale varies by age and sex, and for most ages over 60 and under 90, anticipates improvement rates of between 1.5% and .5% per year. The second scale tested was a 2% per year improvement scale - used as an upward bound on mortality improvement rates to study the impact of higher rates of mortality improvement.

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[1] Mortality improvement scales generally provide age-based rates of decrease ($scale_x$) in mortality rates ($q_x$). If the scale is applied using a Generational Approach, mortality rates for each participant are determined separately. For example, if the mortality table being used is representative of mortality experience in 1994, the mortality rate in 2010 for a retiree age 65 in 2000 is $q_{75} \times (1\text{-}scale_{75})^{16}$, while the mortality rate in 2011 is $q_{76} \times (1\text{-}scale_{76})^{17}$. On the other hand, if more traditional techniques are used, the table itself is simply projected forward a fixed number of years. For instance, the table might be projected to 2005. In that case, the mortality rates at age 75 would be the same in all future years for all participants and would be $q_{75} \times (1\text{-}scale_{75})^{11}$.

[2] See the 1995 Transactions of the Society of Actuaries for further information regarding the UP-94 Table and Scale AA.

Experience assumptions (including investment returns) were assumed to match valuation assumptions for all assumptions other than mortality rates. In all cases the experience mortality rates (i.e. the mortality rates actually experienced by the group) were assumed to mirror those predicted using the valuation mortality improvement scale applied on a generational basis, so that the only gains and losses experienced were those due to the approach used to reflect mortality improvement in the valuation.

The Projected Unit Credit (PUC) actuarial cost method and market value of assets were used in all calculations. An Initial Unfunded Actuarial Accrued Liability was set up as the difference between the Actuarial Accrued Liability (AAL) using the UP-94 Mortality Table projected to January 1, 2000 by Scale AA and an initial market value of 90% of this Actuarial Accrued Liability. Contribution rates were based on 30-year level-dollar funding of this Initial Unfunded Actuarial Accrued Liability, 10-year level-dollar funding of increases in the AAL for changes in mortality assumptions, and 5-year level-dollar funding of mortality gains and losses.

## 3. Results

In the subsections that follow, the Generational Approach is compared first to the Update Approach and then to the Update + Projection Approach. Results using Mortality Improvement Scale AA are presented in detail, augmented by results for the 2% Scale only when these help clarify the findings.

### A. Generational Approach vs. Update Approach

#### (i) Impact on Liabilities and Normal Cost

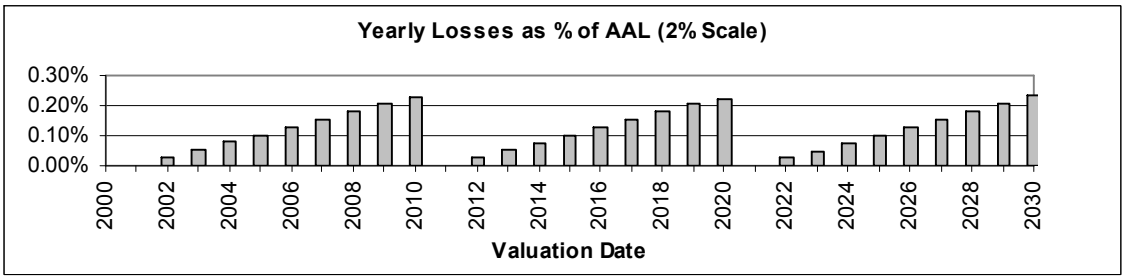
Under the Generational Approach in the first valuation (1/1/2000) the liabilities are recalculated to incorporate generation projection of future mortality improvement. This increases liabilities by the percentages shown in Table A below. After this initial adjustment, gains and losses are zero and there is no need to change the mortality table assumption in the future.

**Table A: Percentage Increases in 1/1/2000 initial Liabilities and Normal Cost due to Implementation of Generational Approach Using:**

| Present Value of Benefits: | Scale AA | 2% Scale |
|---|---|---|
| Retirees | 1.5% | 4.3% |
| Vested Terminations | 3.9% | 8.9% |
| Actives | 4.4% | 10.0% |
| Total | 3.0% | 7.3% |
| Actuarial Accrued Liability (PUC Method) | 2.5% | 6.3% |
| Accrued Benefit Obligation | 2.2% | 5.6% |
| Normal Cost (PUC Method) | 4.6% | 10.2% |

Under the Update Approach, except in update years, mortality losses are experienced and increase in magnitude between updates. These mortality losses impact valuation results starting when 2001 losses are recognized in the 1/1/2002 valuation. The yearly mortality losses are always under .25% of the Actuarial Accrued Liability (AAL) for both mortality improvement scales over the 30-year period - as illustrated Figure 1 for the 2% scale, which presents the worst-case scenario.

Figure 1:

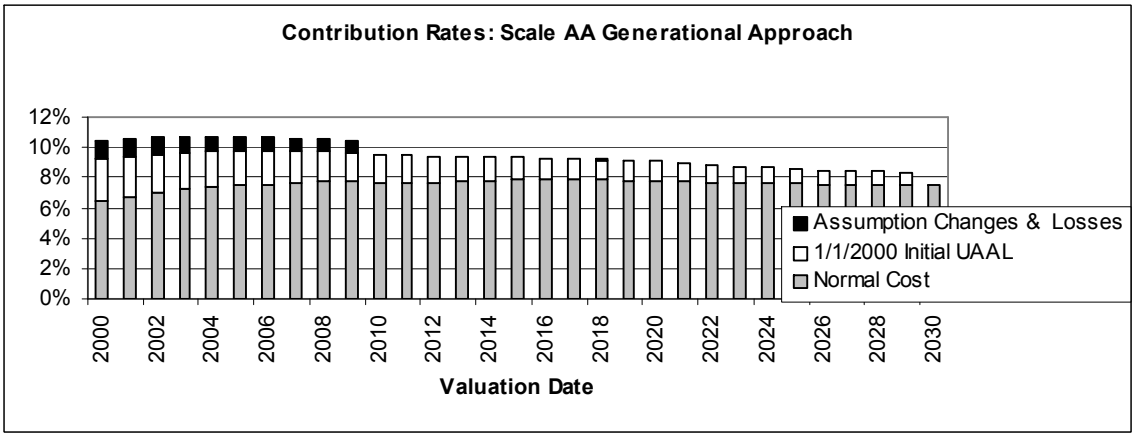



When updates commence starting with the 1/1/2010 valuation, the Unfunded Actuarial Accrued Liability (UAAL) and Normal Cost increase. The impact of these assumption updates is more material than the yearly mortality losses. Using Scale AA they run 2.1% and 1.9% of the AAL's at the 2010 and 2020 updates, and using the 2% scale they run 4.6% and 4.2% of the AAL's at the 2010 and 2020 updates.

**(ii) Contribution Rates (Scale AA)**

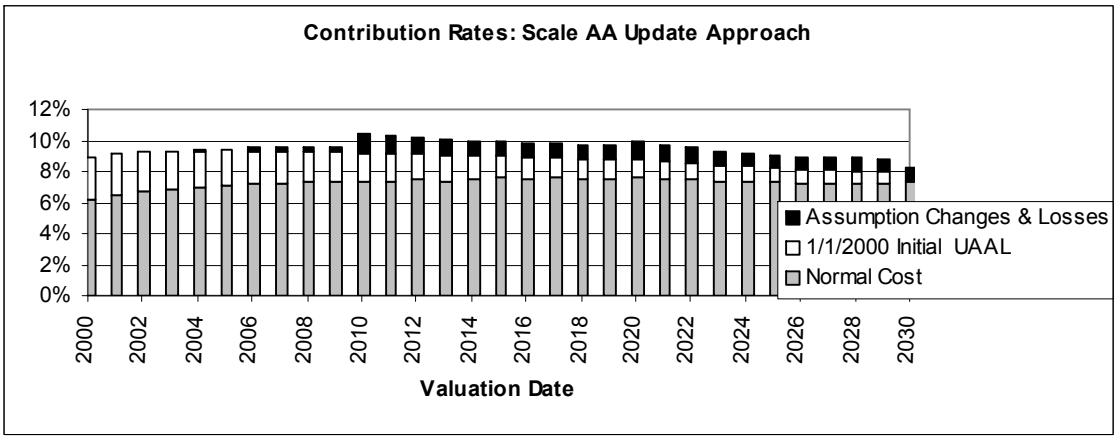
Contribution rates as a percentage of payroll are shown below using the Generational Approach. Note that after the first 10 years, since there are no gains or losses and the added AAL for the change of assumptions has been amortized, the Generational Approach only impacts Normal Cost.

Figure 2:



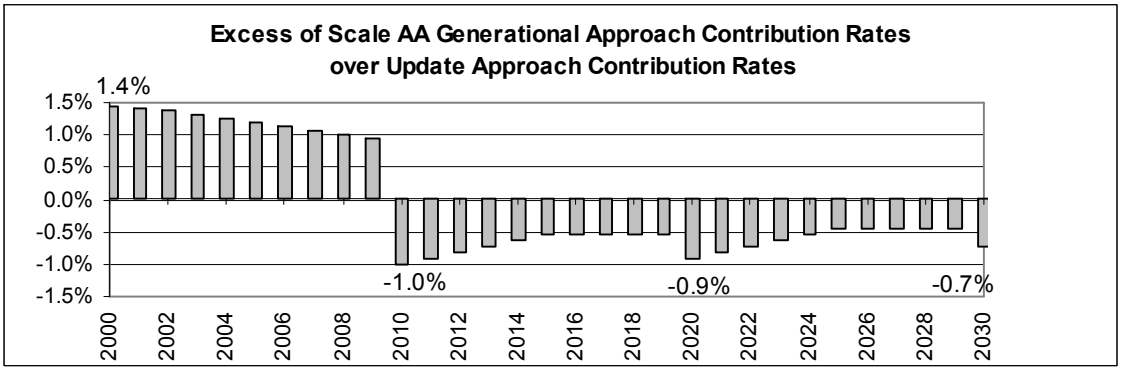

Contribution rates using the Update Approach with updates every 10 years, starting January 1, 2010, are shown in Figure 3. Prior to the January 1, 2010 valuation, no mortality-related assumption changes (only mortality losses) are being amortized. In these calculations, the "current table" for the 1/1/2000 – 1/1/2009 valuations is the UP-94 Table projected to 1/1/2000, the "current table" for the 1/1/2010 – 1/1/2019 valuations is the UP-94 Table projected to 1/1/2010, etc.

Figure 3:



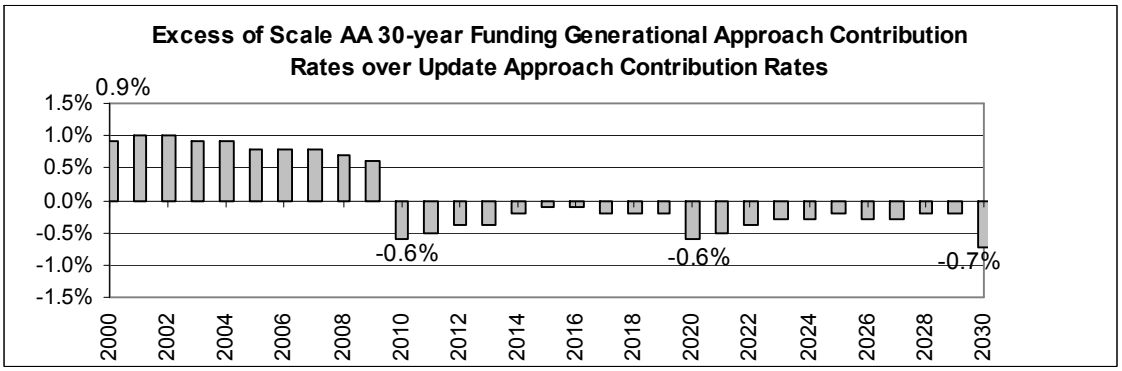

As illustrated below, the contribution rates under the Generational Approach are higher than those under the Update Approach, until the first update occurs (in the January 1, 2010 valuation). Thereafter the Update Approach contribution rates are higher.

Figure 4:



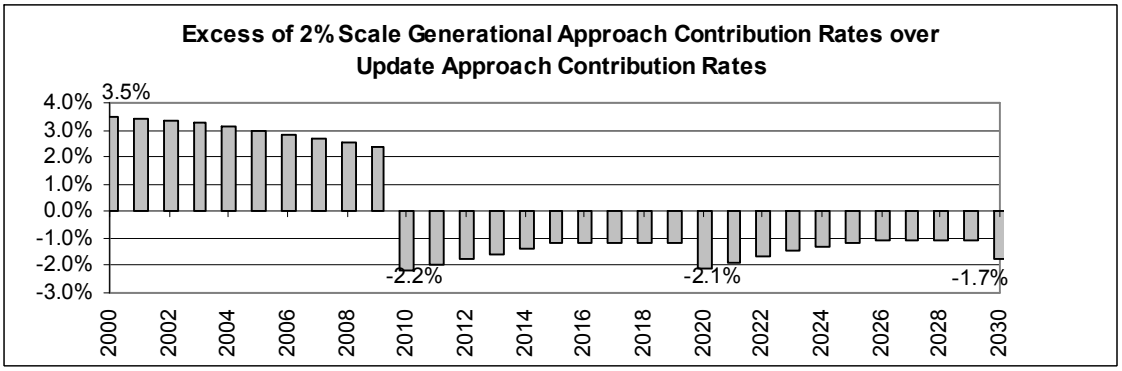

If the added AAL for the change in the 1/1/2000 valuation to the Generational Approach had been amortized over 30 years, the difference in contribution rates would have been less, but the update contribution rate would still have been higher after the first update as shown below.

Figure 5:



(iii) **Contribution Rates (2% Scale)**
Using the 2% projection scale, the difference in both contribution rates and contribution rate patterns is more pronounced as shown below based on 10-year funding of the impact of the 1/1/2000 change to the Generational Approach.

Figure 6:




**(iv) Coverage of Liabilities by Assets**

Scale AA: If the Update Approach is used, the coverage by assets of the generational-basis AAL as of 1/1/2029 is 4% lower than if contributions had been based on the Generational Approach. On an Accrued Benefit Obligation (ABO) basis, the coverage is also 4% lower.

2% Scale: If the Update Approach is used, the coverage by assets of the generational-basis AAL as of January 1, 2029 is 9% lower than if contributions had been based on the Generational Approach. On an ABO basis, the coverage is 10% lower than if contributions had been based on the Generational Approach.

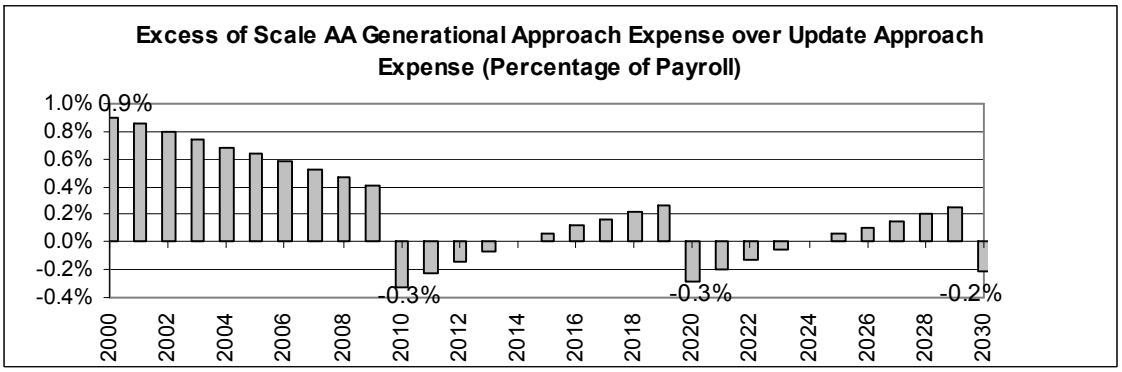
**(v) FAS 87 Expense**
Pension expense was based on 15-year amortization of the initial UAAL in the January 1, 2000 valuation and application of the 10% of AAL[3] corridor for accumulated gains and losses, which are assumed to be zero at the start of the study.

Using Scale AA, mortality-related actuarial losses from assumption changes and experience deviations fall within the FAS 87 "10% of AAL" Corridor throughout the period (not over 2.5% for the Generational Approach and not over 5.0% for the Update Approach), thus requiring no amortization. Using the 2% Scale, under the Generational Approach the percentage does not exceed 6.3% while for the Update Approach, the percentage first reaches 10% in the January 1, 2030 valuation (the third update).

Comparing the resulting expense amounts on a Scale AA basis, the higher normal cost and initially higher interest cost for the Generational Approach produce the pattern of differences illustrated in Figure 7.

[3] In this study, the Projected Unit Credit method AAL equals the FAS 87 Projected Benefit Obligation (PBO).

Figure 7:




In both cases an unfunded accrued pension cost is generated initially because of the difference in the amortization of the initial 1/1/2000 UAAL for FAS 87 expense vs. funding. After 15-year amortization of this UAAL is completed for expense purposes, contributions exceed expense and ultimately a prepaid pension cost emerges - reflecting the impact of the FAS 87 10% corridor for gains and losses.

**B. Generational Approach vs. "Update + Projection" Approach**

Other techniques that can be used to recognize mortality improvement involve the use of a mortality table projected beyond the valuation date (or an age setback) to recognize some mortality improvement between updates. The study investigated the impact of these techniques by producing forecast results for the use of 5-year and 15-year mortality table projections at each update. (For instance, the mortality table used in the 1/1/2000 through 1/1/2009 valuations was the UP-94 table projected to 1/1/2015 using Scale AA). The 15-year projection came closest to replicating the generational results. Contribution rates and differences are shown in Figures 8 and 9. Note that this method consistently produces experience gains on mortality, which decrease between updates and to some extent lower the impact of the periodic assumption changes.

Figure 8:

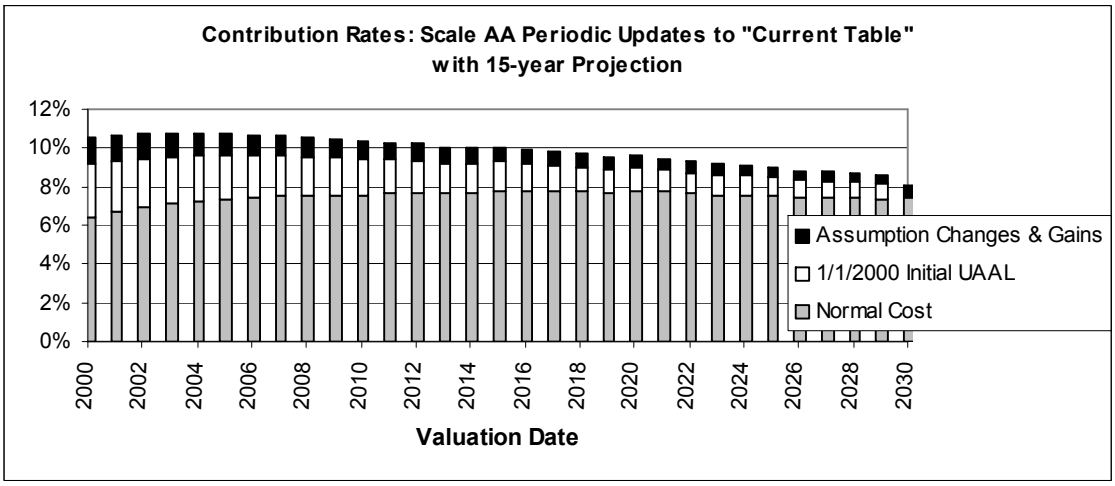
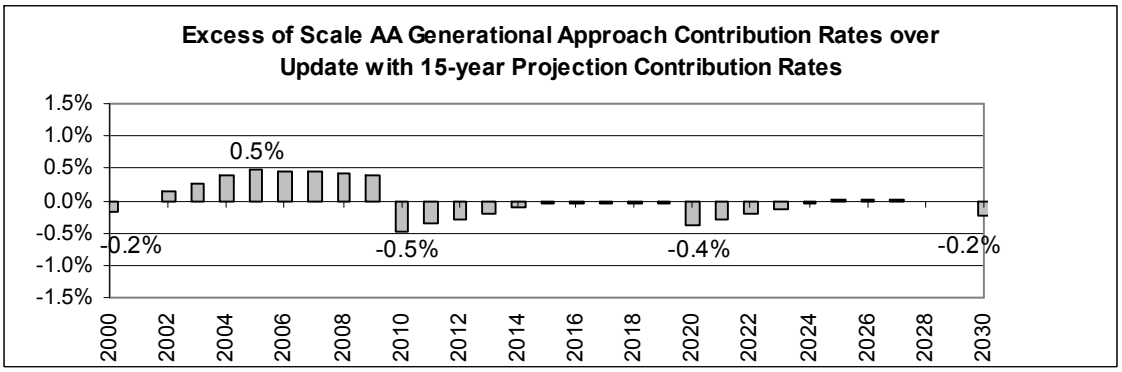


Figure 9:




Asset coverage of the generational-basis AAL and generational-basis ABO as of 1/1/2029 are both less than 1% lower than if contributions had been based on the Generational Approach.

**4. Caveats**

The impact of recognizing future mortality improvement will depend on the participant demography and plan design characteristics of each case. For instance, the impact would be greater when valuing retirement plans that include post-retirement cost of living increases or when valuing post-retirement medical plans.

**5. Further Information**

The complete report is available on the SOA website (www.soa.org). It includes additional update scenarios, detailed backup numbers and assumptions as well as further analysis. For further information, contact Steve Siegel at the Society of Actuaries.