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A Simple and Flexible Model to Calculate Annual Merit Raises for Health Sciences Faculty

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ABSTRACT

Purpose: The objective of this study was to develop and implement a simple and flexible mathematical model to generate merit-based salary increases as a percentage of the faculty base salaries, with the flexibility to choose the range of merit raises.

Methods: Annual faculty performance scores, faculty base salaries, and available salary increase pool were used in a relatively simple linear model to determine the individual faculty merit raises as a percentage of their base salary. The core model allows the selection of a slope value that determines how steeply the merit raise changes with a change in the performance score. The application of the method to different scenarios, including random and non-random distribution of salaries and performance scores, was also tested. More advanced versions of the core model, where the slope value is calculated based on various criteria, are presented in an appendix. The models were incorporated into spreadsheets, which automatically calculate percent merit raises for different input scenarios.

Results: The developed method successfully estimates percent merit raises for individual faculty to precisely match the available merit pool fund. Additionally, merit raises simulated for scenarios with different slopes indicate that the range of distribution of percent merit raise is directly proportional to the slope, i.e., doubling the slope doubles the difference in the percent merit raises for the faculty with the lowest and highest performance scores. The application of the method to different scenarios indicates that the method is robust and independent of the available merit raise pool or distribution patterns of the salaries and performance scores among faculty.

Conclusion: Faculty merit raises may be easily calculated using a relatively simple model, which may be applied to a variety of cases where flexibility in the degree of distribution of raises is desired.

Keywords: Merit raise, Merit pay; Performance evaluation; Annual evaluation; Faculty compensation; Spreadsheet

1. Introduction

The performance of faculty in most universities is routinely assessed during annual evaluations and promotion and tenure reviews. In particular, most schools in health-related disciplines have developed processes and metrics to assess faculty performance [1-6]. The annual reviews serve as a mechanism to provide faculty with feedback to improve their performance and productivity and to align faculty activities with the Department, School, and University's mission. The annual faculty performance reviews are also the basis for the annual salary increases or merit raises when funds are available for this purpose [4, 5].

Distribution of merit raises based on the performance (merit) scores may be carried out either with or without consideration of faculty base salaries. In the absence of faculty salary considerations, the merit raise calculation is relatively simple. In those cases, the available merit pool is divided by the total performance scores, and each faculty would receive a portion of the merit pool based on their performance score [7, 8]. In this model, faculty with similar performance scores would receive similar absolute (dollar amount) merit raises, regardless of their base salary differences. However, using this method, the percent merit raise would be lower for the faculty with a higher salary. It is argued that this model would result in salary compression and would not incentivize higher-paid faculty [9, 10]. Therefore, a number of Departments have shifted to an alternative method, which allocates merit raises based on both the faculty's performance scores and their salaries [9]. In the latter model, the performance scores are converted to percent merit raises instead of absolute raises, which means faculty with similar performance scores receive similar percent merit raises. However, a similar percent merit raise for the faculty with a higher salary means higher absolute (dollar amount) merit raise.

In contrast to the distribution of absolute merit raises without salary considerations, the distribution of percent merit raises is more complicated and requires mathematical models or equations. Indeed, we were not able to locate any publications dealing with the allocation of performance-based percent merit raises for the health-related faculty. A few reports in the literature [9-13] describe specific methods for allocating percent merit raises based on the faculty performance evaluations in disciplines such as economics and business. However, most of these methods are complex or hard to understand for the average Department Chair or other administrators responsible for the allocation of merit raises, who may not be proficient in mathematical models. More importantly, with the exception of one report [13], these methods result in a fixed width of the distribution range of the percent merit raises. This means that the difference in the percent merit raises between the faculty with the highest and the lowest performance scores cannot be changed. For example, if a merit raise pool of 4% results in merit raises between 3.5% (for the faculty with the lowest performance score) and 4.5% (for the faculty with the highest performance score) for a group of faculty, one could not increase the width of this distribution to between 1% to 6%.

Here, we present a relatively simple model that allows selection of the distribution width of the percent merit raises by incorporating a Slope value that is directly related to the width of the distribution of merit raises. The value of Slope may be chosen empirically or calculated based on the specific desired width of the distribution range. In addition to being less complex, the main advantage of the presented model over most of those reported previously is the incorporation of the Slope concept, which adds substantial flexibility to the model. The resultant flexibility is significant because administrators in charge of the merit raise allocation are able to decide on the degree by which they would like to discriminate between the faculty with the lowest and highest performance scores. The method has been applied to the allocation of annual merit raises for faculty in the Department of Biomedical and Pharmaceutical Sciences at our institution and may be easily transferred to other Departments and institutions.

2. Methods

2.1. Core model

A weighted performance score (*PS*) was generated for each faculty based on their annual evaluation in each category of their responsibilities. For the Department of Biomedical and Pharmaceutical Sciences, the categories were teaching, research, and service. A five-point scale, consisting of 1 (Unsatisfactory), 2 (Needs Improvement), 3 (Proficient), 4 (Excellent), and 5 (Exceptional) was used to rank individual faculty in each category. The selection of the scale was based on the recommendation of a faculty committee, which reviewed the best practices in the merit review process. Subsequently, *PS* was calculated using the following equation:

$$PS = W_{Teach} \times PS_{Teach} + W_{Res} \times PS_{Res} + W_{Ser} \times PS_{Ser} \quad (1)$$

where W_{Teach}, W_{Res}, and W_{Ser}, are the relative weights of faculty loads (out of a total weight of 1.0) and PS_{Teach}, PS_{Res}, and PS_{Ser} are the performance scores in the areas of teaching, research and service, respectively. For example, a faculty with teaching, research, and service loads of 0.3 (30%), 0.55 (55%), and 0.15 (15%), respectively, and *PS* values of 3 (teaching), 4 (research), and 2 (service) will have an overall *PS* value of 3.4:

$$PS = 0.3 \times 3 + 0.55 \times 4 + 0.15 \times 2 = 3.4$$

Percent merit raises for individual faculty ($MR_{calculated,\%}$) were then calculated from the individual faculty *PS* (PS_i), average *PS* (PS_X), and available percent merit raise pool ($MR_{Pool,\%}$) using the following equation:

$$MR_{Calculated,\%} = MR_{pool,\%} + (PS_i - PS_X) \times Slope \quad (2)$$

In equation (2), Slope is a flexible steepness factor, representing the extent of change in the percent merit raise when the PS_i is varied by one point. The Slope value may be adjusted based on the desired distribution of merit raises. For example, if the available merit raise pool is 6%, and the average *PS* for all faculty is 3.8, using a Slope of 1 would result in $MR_{Calculated,\%}$ values of 5.6 and 6.6 for the faculty with *PS* values of 3.4 and 4.4, respectively:

$$MR_{Calculated,\%} = 6 + (3.4 - 3.8) \times 1 = 5.6$$

$$MR_{Calculated,\%} = 6 + (4.4 - 3.8) \times 1 = 6.6$$

As expected by the definition of Slope above, a Slope of 1 resulted in a 1% difference in the merit raise (5.6 versus 6.6) when the *PS* values were different by one point (3.4 versus 4.4). On the other hand, if a

Slope of 2 is chosen, the difference in the $MR_{Calculated,\%}$ values for the above two faculty would be equivalent to 2% (5.2 versus 7.2):

$$MR_{Calculated,\%} = 6 + (3.4 - 3.8) \times 2 = 5.2$$

$$MR_{Calculated,\%} = 6 + (4.4 - 3.8) \times 2 = 7.2$$

Similarly, a Slope of 3 would result in a 3% difference in the merit raise for these two faculty with a one-point difference in their *PS* values.

The $MR_{Calculated,\%}$ values are then converted to their respective dollar amounts ($MR_{Calculated,\$}$) by multiplying them by the respective faculty base salaries, and the total calculated raise ($\sum MR_{Calculated,\$}$) is obtained by summation of the individual faculty raises. In most cases, $\sum MR_{Calculated,\$}$ is the same as or close to the available pool of funds for the merit raise ($MR_{Pool,\$}$). Therefore, the $MR_{Calculated,\%}$ values are the final values assigned to each faculty. However, in some cases, $\sum MR_{Calculated,\$}$ may be significantly different from the available pool of merit raise dollars ($MR_{Pool,\$}$). This is because the distribution of faculty salaries and performance scores may be skewed. For example, faculty with higher salaries may have disproportionately higher performance scores. In those cases, the $\sum MR_{Calculated,\$}$ becomes higher than the available $MR_{Pool,\$}$. If the differences between the $\sum MR_{Calculated,\$}$ and $MR_{Pool,\$}$ cannot be administratively accommodated, the calculated merit raises may be easily adjusted ($MR_{Ajusteded,\$}$) using the following equation to match the sum of adjusted raises ($\sum MR_{Ajusteded,\$}$) to $MR_{Pool,\$}$:

$$MR_{Adjusted,\%} = MR_{Calcualted,\%} \times \frac{MR_{Pool,\$}}{\sum MR_{Calculated,\$}} \quad (3)$$

In equation (3), $\frac{MR_{Pool,\$}}{\sum MR_{Calculated,\$}}$ is considered an adjustment factor, which is very close to 1 when higher and lower *PS* values are evenly distributed among the faculty with the higher and lower base salaries (Scenario 1). However, in the absence of such an even and balanced distribution, the adjustment factor may be significantly lower (Scenario 2) or higher (Scenario 3) than 1. Examples of these three scenarios are presented in the subsequent sections of this manuscript.

2.2. Selection of the value of Slope

As stated above, the model allows the selection of the value of Slope by the user. Generally, an increase in the slope results in a steeper change in the allocated merit raise and a wider range of distribution of raises among faculty. However, equation (2) suggests that when the value of Slope is too high, the merit raises become negative for faculty with the low-performance scores. Therefore, the maximum value of Slope ($Slope_{MAX}$) that does not produce any negative merit raises may be calculated from equation (2) by setting the $MR_{Calculated,\%}$ value for the faculty with the lowest performance score (PS_{Lowest}) to zero and rearranging the equation to solve for Slope:

$$Slope_{MAX} = \frac{MR_{pool,\%}}{PS_X - PS_{Lowest}} \quad (4)$$

For example, for a scenario with a merit raise pool of 6%, an average PS of 3.8, and the lowest PS value of 2.3, the maximum Slope value without any negative raises ($Slope_{MAX}$) would be equal to 4:

$$Slope_{MAX} = \frac{6}{3.8 - 2.3} = 4$$

With the use of $Slope_{MAX}$, the lowest-performing faculty would receive a raise of zero. At the other extreme, the lower boundary of Slope is zero, which, according to equation (2), results in all faculty receiving the same $MR_{Pool,\%}$. Therefore, the lower and upper boundaries of Slope are zero (no differentiation among faculty) and $Slope_{MAX}$ (highest differentiation among faculty), respectively.

In addition to the arbitrary selection of the value of Slope between zero and $Slope_{MAX}$, the value of Slope may be calculated based on the desired width of the merit raise distribution (narrow or wide) or fixing the merit raise for the faculty with the lowest performance score. These more complex scenarios are described in detail in Appendix A.

2.3. Application of the method

The Application of the method was demonstrated by randomly generating salaries for twenty faculty using a normal distribution function with a mean of \$150,000 and an SD of 30,000 (CV of 20%). Similarly, performance scores were randomly generated using a mean of 3.5 and an SD of 0.35 (CV of

10%). Although for the sake of simulations, the assignment of salaries and performance scores were random and normally distributed, there is no need for either of these assumptions for the method to be applied to the real-world settings. This means the methods presented here are equally applicable to any form of distribution. To demonstrate this concepts, in addition to the random distribution (Scenario 1), two other scenarios were simulated where the higher performance scores were manually assigned to the faculty with the higher (Scenario 2) or lower (Scenario 3) salaries, resulting in skewed distribution of salaries and performance scores for the 20 faculty.

For automatic calculation, equations (2), (3), and (4) were incorporated into an Excel® spreadsheet, which is included as a Supplementary File. Merit raise calculations were performed using the spreadsheet, assuming two merit raises of 3% or 6%. The effect of steepness factor (Slope) on the results was demonstrated by performing calculations using Slopes of 0.5, 1, 2, 3, and 4.

3. Results

Table 1 shows hypothetical faculty base salaries and *PS* values for 20 faculty with a random distribution of salaries and *PS* values among the faculty (Scenario 1). The randomly generated faculty salaries ranged from $81,250 to $210,901, with an average of $145,908 and a total salary of $2,918,158. The *PS* values ranged from 2.85 to 4.01, with an average of 3.50 and a CV of 9.6%. Also shown in Table 1 are the calculated and adjusted (final) merit raises, based on equation (2) and equation (3), respectively, for a 3 percent merit raise pool with the Slope values of 0.5 and 4 as examples.

For the Slope of 0.5, which means a 0.5% increase for every one-point increase in *PS*, the calculated merit raises ranged from 2.68% to 3.26% (Table 1). Similar calculations are also shown in Table 1 for the Slope value of 4. As expected, the range of calculated percent merit raises for the Slope of 4 (0.41% – 5.05%) was much larger than that for the slope of 0.5 (2.68% – 3.26%). Additionally, the CV of merit raises for the Slope of 4 (45%) was eight times that for the Slope of 0.5 (5.61%) (Table 1), indicating a linear relationship between the Slope value and degree of variability (CV) in the merit raise.

The 3 percent merit raise pool for a total salary of $2,918,158 (Table 1) means a total of $87,545 (0.03 x $2,918,158) is available for distribution among the faculty. As demonstrated in Table 1, the calculated merit raises required $87,647 and $88,364 for the Slope values of 0.5 and 4, respectively, which are slightly higher than the available fund ($87,545). If these small differences between the available and calculated funds can be accommodated administratively, the calculated merit raises are the final merit raises. Otherwise, the calculated merit raises may be easily adjusted using equation (3), which uses an adjustment factor that is calculated by dividing the available merit raise pool ($MR_{Pool,\$}$) of $87,545 by the calculated merit raise pool ($\sum MR_{Calculated,\$}$) of $87,647 or $88,364 for the Slope values of 0.5 and 4, respectively. For the data reported in Table 1, the adjustment factors are 0.999 ($87,545/$87,647) and 0.991 ($87,545/$88,364) for the Slope values of 0.5 and 4, respectively, which are very close to 1 because of random distribution of salaries and PS values in Scenario 1 (Table 1). Therefore, the adjusted merit raises are indeed very close to the calculated merit raises for both Slope values presented in Table 1.

Figure 1 depicts the percent merit raises for individual faculty as a function of chosen Slope values between 0.5 to 4 for merit raises of 3% (top panel) and 6% (bottom panel). For both panels, an increase in the Slope value resulted in a wider distribution of merit raises. The figure also demonstrates that although for the same Slope the absolute width of the distributions around the means is the same for the two different merit raises, the distribution relative to the mean raise is narrower for the higher raise (6%).

Based on equation (4) and the performance scores presented in Table 1, the maximum possible value of Slope ($Slope_{MAX}$) that does not result in any negative merit raises is 4.63 for the merit raise of 3%:

$$Slope_{MAX} = \frac{3}{3.4975 - 2.85} = 4.63$$

Therefore, the user may select a Slope value between zero, when all faculty receive the same 3% raise, and 4.63, when the faculty with the lowest performance (Faculty 1) receives a merit raise of 0%.

Similarly, the $Slope_{MAX}$ for the merit raise of 6% is 9.26. The spreadsheets in the Supplementary File automatically calculate $Slope_{MAX}$ for any given scenario and will only allow input of Slope values between zero and $Slope_{MAX}$.

The merit raise data when the higher performance scores are manually assigned to the faculty with the higher salaries (Scenario 2) are presented in Table 2 for a 3 percent merit raise pool and a Slope of 4. As demonstrated in the Table, the resultant adjustment factor of 0.907 ($87,545/$96,542) was much less than 1, compared with the same factor for Scenario 1 with the same Slope of 4 (0.991) (Table 1). Therefore, the adjusted merit raise dollars were lower than the calculated merit raises by almost 9% (Table 2). Similar data when the higher performance scores are manually assigned to the faculty with the lower salaries (Scenario 3) are presented in Table 3. In this case, the adjustment factor ($87,545/$78,604) was higher than 1 (1.11). Therefore, the adjusted merit raise dollars were higher than the calculated raises by almost 11% (Table 3). Collectively, the data in Tables 1-3 clearly indicate that using the adjustment factor, the model can precisely match the allocated merit raises to the available merit raise dollars, regardless of the distribution patterns of the salaries and performance scores.

4. Discussion

Merit raises are generally distributed using absolute dollar amounts, as a percentage of base salary, or a combination of both [9]. The absolute dollar amount method distributes the available merit raise pool based on the performance scores of faculty without any regard for the faculty base salaries. This is a simple, one-step method, in which all the faculty with the same performance scores would receive the same absolute dollar raise, regardless of their base salaries [12]. However, when the raises generated by this method are translated into the percentage of base salaries, the faculty with the lower performance scores may indeed receive higher %raises [10]. This method may potentially cause salary compression over an extended period of time [9, 10]. Consequently, most Departments allocate merit raises as a percentage of the faculty base salaries, which is a much more mathematically involved process.

Allocating merit raises as a percentage of base salaries may be carried out through two different approaches. In a trial and error method, higher percent raises are manually assigned to high performers while trying to match the total dollar raise to the available funds. In some cases, faculty may be divided into discrete categories based on their performance scores, and different raises be assigned manually to each category. This is a cumbersome, inefficient method, which is hard to explain and justify to faculty and other stakeholders. In a second approach, a mathematical model is used to precisely allocate the merit raises based on the faculty performance and their base salaries, which is the basis of the model presented here.

In addition to being mathematically complex, most of the few methods reported in the literature [9-12] do not allow flexibility to choose the width of the raise distribution among faculty. A flexible model with a changeable constant has been introduced before [13]. However, how that constant affects the slope of the percent merit raise versus *PS* plot is not easily clear from the model. Therefore, it is hard to relate the value of the constant to the magnitude of Slope. A relatively simpler model was reported recently [14]. However, the method requires the calculation of z-scores and does not allow adjustment of merit raises if the calculated and available merit raises do not match. More importantly, the method is based on a fixed 1 percent merit raise difference for every one-point difference in the performance score for a performance scale of 5, which is equivalent to the Slope of 1 in our model. The performance scores of faculty on a scale of 5 are normally clustered around values of 3 to 4.5. Therefore, the difference in the *PS* for the highest and lowest performer faculty is usually narrow. In the example provided in Table 1, the difference between the lowest (2.85) and highest (4.01) *PS* (*PS* range) is only 1.16 points. Therefore, using a fixed Slope of 1, as used in the reported method [14], is expected to result in a difference of 1.16% in the percent merit raises for the faculty with the highest and lowest *PS*, regardless of the magnitude of the available merit raise pool [14]. As demonstrated in Fig. 1, a Slope of 1 results in a percent merit raise range of 2.35% – 3.51% for a 3% average merit pool (Fig. 1, top panel) and a range of 5.35% – 6.51% for a 6% average merit pool (Fig. 1, bottom panel). Although the range of 2.35% – 3.51% may be desired for the smaller percent merit raise pool of 3%, the range of 5.35% – 6.51% would be relatively narrow for a 6 percent merit raise pool when Slope is fixed at 1. Our model does not have this limitation because higher or lower Slope values could be chosen to make the range of assigned percent merit raises wider or narrower, respectively.

It should be noted that the degree of distribution of the merit raises in our model are dependent on both the Slope value used in equation (2) and the width of the distribution of performance scores. However, as stated above, the performance scores for faculty typically follow a narrow distribution range. The use of Slope in our model allows allocation of merit raises with high discriminations among faculty even in the presence of a narrow distribution of performance scores.

Although the method presented here is applied to a performance scale of 5, it can be easily applied to any performance scale. However, to achieve the same degree of distribution in the percent merit raises, the magnitude of the selected Slope would be different for different scales. For example, if the chosen performance scale is 10, instead of 5, a two-fold (5/10) lower Slope for the scale of 10, compared with the Slope for the scale of 5, would produce the same percent merit raise distribution in both cases. This means a slope of 0.5 for a scale of 10 would be equivalent to a slope of 1 for a scale of 5 because, in both cases, the products of Slope and scale are the same (0.5 x 10 or 1 x 5). To generalize this concept, one could use the ratio of 5 over the new scale to convert the Slope value for the scale of 5 to an equivalent Slope for the new scale. Based on this generalization, for the performance scales of 3, 20, 50, and 100, conversion factors of 1.67 (5/3), 0.25 (5/20), 0.1 (5/50), and 0.05 (5/100), respectively, should be multiplied by the desired Slope for the scale of 5 to create the same degree of distribution of the percent merit raises for all the scales. Nevertheless, in all the cases, Slope represents the magnitude of change in the percent merit raise for a 1-point change in *PS*, regardless of the scale.

Furthermore, the method presented here is based on a continuous scale of *PS*, resulting in continuous values of percent merit raises. If it is desired to have faculty receive raises in fixed intervals, the performance scores may be divided into fixed interval bins. For example, with an increment of 0.25, all the *PS* values between 3.00 to 3.25 are assigned a value of 3.125 before entering into the spreadsheet.

In this case, the percent merit raise calculated by the spreadsheet for all the members of each bin would be the same.

The primary purpose of this communication was to develop and implement a mathematical model for allocating merit raises to faculty based on their predetermined performance scores. Therefore, the faculty performance evaluation process, which has been the subject of extensive research [1-6], is not discussed here in detail. Nevertheless, equation (1), which is used for the evaluation of basic sciences faculty in three areas of teaching, research, and service, may be modified for evaluation of clinicians by incorporating an additional term defining the weight and performance score for clinical practice. Indeed, the model presented here, along with such a modified version of equation (1), has also been used for allocating annual merit raises for Pharmacy Practice faculty at our institution.

To demonstrate the application of the method, we first simulated salaries and *PS* values, which were randomly assigned to the faculty (Scenario 1; Table 1 and Fig. 1). However, in real-life scenarios, the distribution of baseline salaries and *PS* values and their relationship may not necessarily follow normal or random patterns. Therefore, to demonstrate the applicability of our model to other situations, we created two extreme non-random scenarios where we manually assigned higher *PS* values to the faculty with higher (Scenario 2) or lower (Scenario 3) base salaries. As shown in Scenario 1 (Table 1), the value of the adjustment factor was very close to 1 in the presence of random distributions of *PS* values and salaries among faculty. However, the adjustment factor was lower than 1 (0.907) when the faculty with the higher salaries were assigned higher *PS* values (Scenario 2), which meant the calculated merit raises needed to be adjusted downward in order to match the available merit fund (Table 2). In contrast, for Scenario 3, where higher *PS* values were manually assigned to the faculty with the lower base salaries, the adjustment factor was higher than 1 (1.11). Therefore, for Scenario 3, the calculated merit raises needed to be adjusted upward to match the available merit fund (Table 3). Although the adjustment factors in our simulated cases were between 0.907 and 1.11, the factor may deviate from the unity even farther, depending on the range of *PS* values, faculty salaries, and the number of faculty in the department. Nevertheless, our model does not assume any particular value or range of adjustment factors to be functioning accurately. Overall, the three presented scenarios indicate that our model is applicable to any scenarios independently of the distribution pattern of the salaries and PS values among faculty.

In the relatively simple method presented here, the value of Slope is selected empirically between the values of zero (equal merit raises for all faculty) and $Slope_{MAX}$ (widest possible merit raise distribution without any negative raises). However, as demonstrated in Appendix A, the value of Slope may also be precisely estimated based on the desired width of the distribution of merit raises (i.e., the desired difference between the maximum and minimum percent merit raises) or the desired percent merit raise for the faculty with the lowest performance score.

5. Conclusion

A relatively simple method for calculation of faculty merit raises as a percentage of their base salaries is presented. The method may be applied to a variety of cases where flexibility in the degree of merit raise spread among the faculty with the lowest and highest performance scores is desired. This flexibility is achieved by incorporating a Slope value in the model that determines how steeply a one-point difference in the performance score affects the allocated merit raises. In addition to an arbitrary selection of Slope, two situations are presented to calculate the Slope value (Appendix A) mathematically. Future studies need to expand on the non-arbitrary selection of the Slope value based on specific criteria related to the desired distribution pattern of the raises, as opposed to a trial and error approach.

Declaration of interest

The author reports no conflicts of interest.

Note on contributors

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Supplementary data

A copy of an Excel® workbook, containing three worksheets for calculations related to the core model, determination of Slope based on the desired width of merit raise distribution, and determination of Slope based on the desired raise for the faculty with the lowest performance score, is provided here.

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Appendix A. Determination of Slope based on fixing the desired width of merit raise distribution or fixing the merit raise for the faculty with the lowest performance score

In the core model presented in the body of this manuscript, the Slope value is selected empirically between zero and $Slope_{MAX}$ (equation 4). However, the model also allows estimation of Slope under certain criteria. For example, Slope may be calculated by fixing the desired width of the percent merit raise range ($Slope_{Fixed\ Width}$), which is the desired difference between the percent merit raises for the faculty with the highest and lowest performances. For determination of $Slope_{Fixed\ Width}$, equation (2) may be used to define the percent merit raise for the faculty with the highest and lowest performance scores ($PS_{Highest}$ and PS_{Lowest}) and merit raises ($MR_{Highest,\%}$ and $MR_{Lowest,\%}$):

$$MR_{Highest,\%} = MR_{pool,\%} + \left(PS_{Highest} - PS_X\right) \times Slope_{Fixed\ Range} \quad (A1)$$

$$MR_{Lowest,\%} = MR_{pool,\%} + \left(PS_{Lowest} - PS_X\right) \times Slope_{Fixed\ Range} \quad (A2)$$

Subsequently, the width of percent merit raise range ($MR_{Width\%}$) is calculated by subtracting equation (A2) from equation (A1):

$$MR_{Width,\%} = MR_{Highest,\%} - MR_{Lowest,\%} \quad (A3)$$

$$MR_{Width,\%} = MR_{pool,\%} + \left(PS_{Highest} - PS_X\right) \times Slope_{Fixed\ Width} - [MR_{pool,\%} + (PS_{Lowest} - PS_X) \times Slope_{Fixed\ Width}] \quad (A4)$$

$$MR_{Width,\%} = PS_{Highest} \times Slope_{Fixed\ Width} - PS_{Lowest} \times Slope_{Fixed\ Width} \quad (A5)$$

Equation (A5) is then rearranged to solve for $Slope_{Fixed\ Width}$ using the desired $MR_{Width,\%}$:

$$Slope_{Fixed\ Width} = \frac{MR_{Width,\%}}{PS_{Highest} - PS_{Lowest}} \quad (A6)$$

Equation (A6) may be used to estimate the value of Slope from the highest ($PS_{Highest}$) and lowest (PS_{Lowest}) performance scores and the desired width of percent merit raise range distribution ($MR_{Width,\%}$). For example, if the desired $MR_{Width,\%}$ is 2%, for the $PS_{Highest}$ and PS_{Lowest} values of 2.85 and 4.01 (Table 1), the calculated slope ($Slope_{Fixed\ Width}$) based on equation (A6) will be equal to 1.72:

$$Slope_{Fixed\ Width} = \frac{2}{4.01 - 2.85} = 1.72$$

The lower boundary of $MR_{Width,\%}$ input occurs when Slope is equal to zero, which means equal merit raises for all faculty and an $MR_{Width,\%}$ value of zero. The upper boundary of $MR_{Width,\%}$ occurs when Slope is equal to $Slope_{MAX}$, which is the widest possible merit raise distribution without any negative merit raises. The upper boundary of $MR_{Width,\%}$ is calculated by setting $Slope_{Fixed\ Width}$ (equation A6) equal to $Slope_{MAX}$ (equation 4) and solving for $MR_{Width,\%}$:

$$Slope_{Fixed\ Width} = Slope_{MAX} \tag{A7}$$

$$\frac{MR_{Width,\%}}{PS_{Highest} - PS_{Lowest}} = \frac{MR_{pool,\%}}{PS_X - PS_{Lowest}} \tag{A8}$$

$$MR_{Width,\%} = \frac{MR_{pool,\%} \times (PS_{Highest} - PS_{Lowest})}{PS_X - PS_{Lowest}} \tag{A9}$$

Using equation (A9), the higher boundary of $MR_{Width,\%}$ for the data presented in Table 1 and a 3% $MR_{pool,\%}$ is equal to 5.37:

$$MR_{Width,\%} = \frac{3 \times (4.01 - 2.85)}{3.5 - 2.85} = 5.37$$

Equations (A6) and (A9), along with equations (2) and (3), were incorporated into the second spreadsheet in the Supplementary File to determine merit raises for individual faculty based on a desired fixed merit raise width ($MR_{Width,\%}$) that is entered by the user, allowing the model to calculate the appropriate Slope. The spreadsheet allows only $MR_{Width,\%}$ values between its lower (zero) and upper (equation A9) boundaries.

Similarly, a Slope ($Slope_{Fixed\ Lowest}$) may be estimated if it is desired to have a fixed percent merit raise for the faculty with the lowest performance score. For this case, equation (2) may be used to define $MR_{Lowest,\%}$ from the performance score of the faculty with the lowest score (PS_{Lowest}):

$$MR_{Lowest,\%} = MR_{pool,\%} + (PS_{Lowest} - PS_X) \times Slope_{Fixed\ Lowest} \tag{A10}$$

Subsequently, equation (A10) may be rearranged to determine the $Slope_{Fixed\ Lowest}$:

$$Slope_{Fixed\ Lowest} = \frac{MR_{Lowest,\%} - MR_{pool,\%}}{PS_{Lowest} - PS_X} \tag{A11}$$

For example, if one would like to fix the merit raise for the faculty with the lowest PS value of 2.85 to 2%, the value of $Slope_{Fixed\ Lowest}$ becomes equal to 1.54 for a merit raise pool of 3%:

$$Slope_{Fixed\ Lowest} = \frac{2-3}{2.85-3.5} = 1.54$$

The lower and upper boundaries of $Slope_{Fixed\ Lowest}$ occur when $MR_{Lowest,\%}$ is equal to $MR_{pool,\%}$ (equal merit raise for all faculty) and zero (widest possible merit raise distribution), respectively. For the upper boundary extreme, when the desired $MR_{Lowest,\%}$ is zero, equation (A11) transforms to equation (4) in the body of the text, which means $Slope_{Fixed\ Lowest}$ becomes equal to $Slope_{MAX}$.

Equation (A11), along with equations (2) and (3), was incorporated into the third spreadsheet in the Supplementary File to determine merit raises for individual faculty based on a desired fixed merit raise for the lowest faculty performer ($MR_{Lowest,\%}$), which is entered by the user, allowing the model to calculate the appropriate Slope. The spreadsheet only allows $MR_{Lowest,\%}$ values between its lower (zero) and upper ($MR_{pool,\%}$) boundaries.

Equations (A6) and (A11) were used to determine the Slope values and calculated and adjusted merit raises for the faculty with the performance scores and base salaries reported in Table 1 and a 3 percent merit raise pool. For $MR_{Width,\%}$, values within the boundaries of 0.0 to 5.37% were entered into equation (A6) as input to estimate Slope and merit raises. The upper boundary value of $MR_{Width,\%}$ (5.37) was calculated in the spreadsheet from equation (A9). For $MR_{Lowest,\%}$, values within the boundaries of 0.0 to 3.0% were entered into equation (A11) as input. The results are presented in Table A1. For fixing the width of merit raise distribution, when the desired $MR_{Width,\%}$ increased from 0.00% to 5.37%, the $Slope_{Width,\%}$ increased from 0.00 to 4.63 (Table 1A). Indeed, there was a linear relationship between the $Slope_{Width,\%}$ and the desired $MR_{Width,\%}$ with an intercept of zero. Therefore, for example, if doubling the width is desired, the value of Slope should be doubled.

For fixing the lowest merit raise, an increase in the $MR_{Lowest,\%}$ values from 0.00 to 3.0% resulted in a progressive decrease in the $Slope_{Fixed\ Lowest}$ from 4.63 to 0.00 (Table A1). Based on these data, the highest possible Slope without having any negative percent merit raises, i.e., when the $MR_{Lowest,\%}$ is set to zero, is equal to 4.63 (Table A1) for the faculty performance data presented in Table 1 and a merit raise pool of 3%.

It should be noted that the calculations presented above are based on the calculated merit raises. The adjusted merit raises may be slightly different from the desired values (Table 1A).

Table A1
Slope values estimated by fixing the width of merit raise distribution or fixing the lowest merit raise for a merit pool of 3%[a]

	Slope	Merit Raise Range	
		Calculated	Adjusted
Fixing width of merit raise[b]			
MR_{Width}, %			
0.00	0.00	3.00-3.00	3.00-3.00
0.25	0.216	2.86-3.11	2.86-3.11
0.50	0.431	2.72-3.22	2.72-3.22
1.00	0.862	2.44-3.44	2.44-3.43
2.00	1.72	1.88-3.88	1.88-3.87
3.00	2.59	1.33-4.33	1.32-4.30
4.00	3.45	0.77-4.77	0.76-4.73
5.00	4.31	0.21-5.21	0.21-5.16
5.37	4.63	0.00-5.37	0.00-5.32
Fixing lowest merit raise[c]			
MR_{Lowest}, %			
0.00	4.63	0.00-5.37	0.00-5.32
0.50	3.86	0.50-4.98	0.50-4.93
1.0	3.09	1.00-4.58	0.99-4.55
1.5	2.31	1.50-4.19	1.49-4.16
2.0	1.54	2.00-3.79	1.99-3.78
2.5	0.772	2.50-3.40	2.50-3.39
3.0	0.00	3.00-3.00	3.00-3.00

[a] Shaded rows represent the lower and upper boundaries of the values.
[b] Based on equation (A6).
[c] Based on equation (A11).

Table 1
Merit raise calculations for twenty faculty with an available merit raise pool of $87,545 (3% of overall annual salaries) using the proposed model with a slope (steepness factor) of 0.5 or 4 and random distribution of salaries and performance scores (Scenario 1)

			Slope = 0.5				Slope = 4			
	Base Salary	Performance	Calculated Merit Raise[a]		Adjusted Merit Raise[b]		Calculated Merit Raise[a]		Adjusted Merit Raise[c]	
Faculty	($)	Score	%	$	%	$	%	$	%	$
1	189,673	2.85	2.68	5,076	2.67	5,070	0.41	778	0.41	770
2	84,932	2.93	2.72	2,307	2.71	2,304	0.73	620	0.72	614
3	177,446	3.14	2.82	5,006	2.82	5,000	1.57	2,786	1.56	2,760
4	125,356	3.21	2.86	3,580	2.85	3,576	1.85	2,319	1.83	2,298
5	169,510	3.23	2.87	4,859	2.86	4,853	1.93	3,272	1.91	3,241
6	168,640	3.28	2.89	4,876	2.89	4,870	2.13	3,592	2.11	3,559
7	113,491	3.32	2.91	3,304	2.91	3,300	2.29	2,599	2.27	2,575
8	138,478	3.34	2.92	4,045	2.92	4,041	2.37	3,282	2.35	3,251
9	105,850	3.35	2.93	3,097	2.92	3,094	2.41	2,551	2.39	2,527
10	210,901	3.49	3.00	6,319	2.99	6,312	2.97	6,264	2.94	6,206
11	114,017	3.57	3.04	3,462	3.03	3,458	3.29	3,751	3.26	3,716
12	81,250	3.61	3.06	2,483	3.05	2,480	3.45	2,803	3.42	2,777
13	163,029	3.63	3.07	4,999	3.06	4,993	3.53	5,755	3.50	5,702
14	131,124	3.71	3.11	4,073	3.10	4,068	3.85	5,048	3.81	5,001
15	174,547	3.77	3.14	5,474	3.13	5,468	4.09	7,139	4.05	7,073
16	121,585	3.80	3.15	3,831	3.15	3,827	4.21	5,119	4.17	5,071
17	165,564	3.83	3.17	5,242	3.16	5,236	4.33	7,169	4.29	7,102
18	157,171	3.91	3.21	5,039	3.20	5,033	4.65	7,308	4.61	7,241
19	145,346	3.97	3.24	4,704	3.23	4,698	4.89	7,107	4.84	7,041
20	180,248	4.01	3.26	5,866	3.25	5,862	5.05	9,103	5.00	9,018
Sum	2,918,158			87,647		87,545		88,364		87,545
Mean	145,908	3.50	3.00		3.00		3.00		2.97	
SD	35447	0.34	0.17		0.17		1.35		1.34	
CV (%)	24.3	9.64	5.62		5.61		45.0		45.0	

[a] Based on equation (2).
[b] Based on equation (3), with an Adjustment Factor of 0.999 for the Slope of 0.5.
[c] Based on equation (3), with an Adjustment Factor of 0.991 for the Slope of 4.

Table 2
Merit raise calculations for twenty faculty with an available merit raise pool of $87,545 (3% of overall annual salaries) using the proposed model with a slope (steepness factor) of 4 and manual assignment of higher performance scores to faculty with higher salaries (Scenario 2)[a]

			Slope = 4			
			Calculated Merit Raise[b]		Adjusted Merit Raise[c]	
Faculty	Base Salary ($)	Performance Score	%	$	%	$
1	81,250	2.85	0.41	333	0.37	302
2	84,932	2.93	0.73	620	0.66	562
3	105,850	3.14	1.57	1,662	1.42	1,507
4	113,491	3.21	1.85	2,100	1.68	1,904
5	114,017	3.23	1.93	2,201	1.75	1,995
6	121,585	3.28	2.13	2,590	1.93	2,348
7	125,356	3.32	2.29	2,871	2.08	2,603
8	131,124	3.34	2.37	3,108	2.15	2,818
9	138,478	3.35	2.41	3,337	2.19	3,026
10	145,346	3.49	2.97	4,317	2.69	3,914
11	157,171	3.57	3.29	5,171	2.98	4,689
12	163,029	3.61	3.45	5,625	3.13	5,100
13	165,564	3.63	3.53	5,844	3.20	5,300
14	168,640	3.71	3.85	6,493	3.49	5,888
15	169,510	3.77	4.09	6,933	3.71	6,287
16	174,547	3.80	4.21	7,348	3.82	6,664
17	177,446	3.83	4.33	7,683	3.93	6,967
18	180,248	3.91	4.65	8,382	4.22	7,600
19	189,673	3.97	4.89	9,275	4.43	8,411
20	210,901	4.01	5.05	10,651	4.58	9,658
Sum	2,918,158			96,542		87,545
Mean	145,908	3.50	3.00		2.72	
SD	35447	0.34	1.35		1.22	
CV (%)	24.3	9.64	45.0		45.0	

[a] The same salaries and PS values in Table 1 were used with a manual assignment.
[b] Based on equation (2).
[c] Based on equation (3), with an Adjustment Factor of 0.907.

Table 3

Merit raise calculations for twenty faculty with an available merit raise pool of $87,545 (3% of overall annual salaries) using the proposed model with a slope (steepness factor) of 4 and manual assignment of higher performance scores to faculty with lower salaries (Scenario 3)[a]

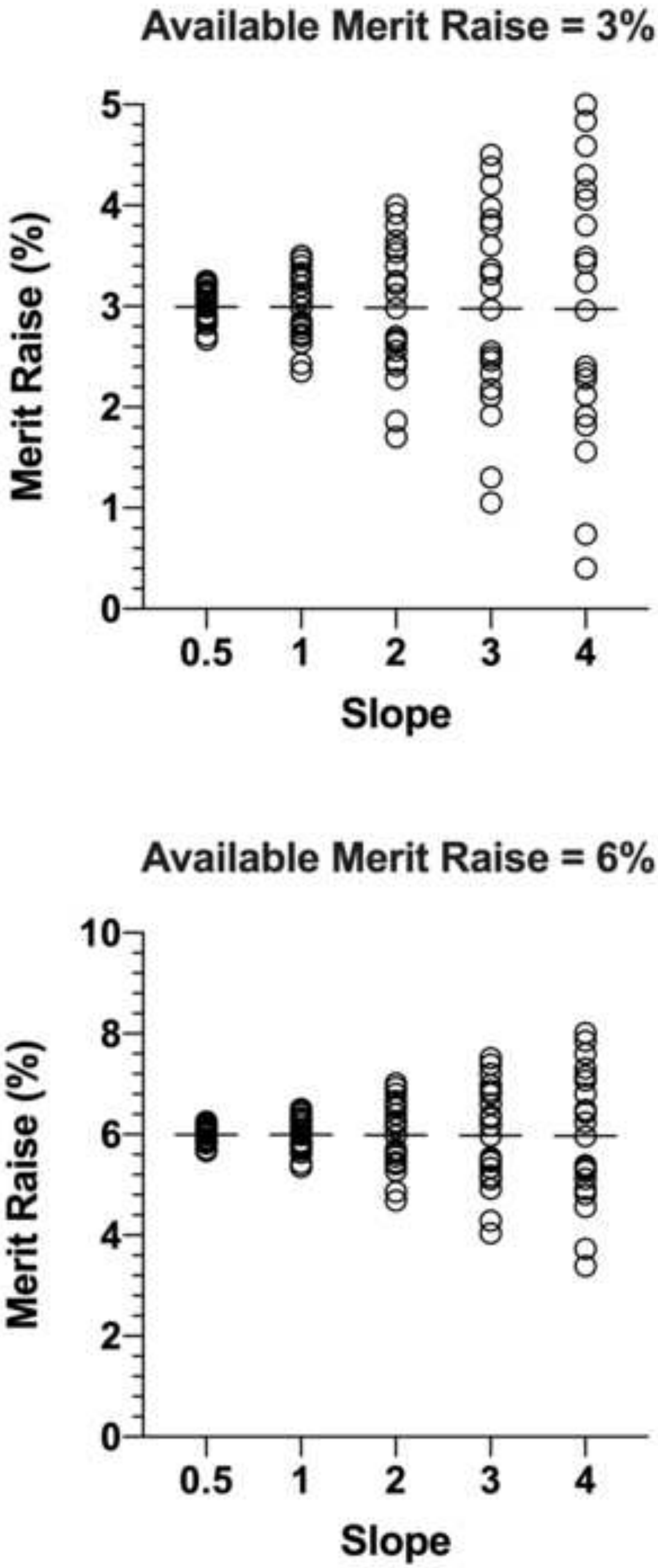
			Slope = 4			
	Base Salary	Performance	Calculated Merit Raise[b]		Adjusted Merit Raise[c]	
Faculty	($)	Score	%	$	%	$
1	210,901	2.85	0.41	865	0.46	963
2	189,673	2.93	0.73	1,385	0.81	1,542
3	180,248	3.14	1.57	2,830	1.75	3,152
4	177,446	3.21	1.85	3,283	2.06	3,656
5	174,547	3.23	1.93	3,369	2.15	3,752
6	169,510	3.28	2.13	3,611	2.37	4,021
7	168,640	3.32	2.29	3,862	2.55	4,301
8	165,564	3.34	2.37	3,924	2.64	4,370
9	163,029	3.35	2.41	3,929	2.68	4,376
10	157,171	3.49	2.97	4,668	3.31	5,199
11	145,346	3.57	3.29	4,782	3.66	5,326
12	138,478	3.61	3.45	4,777	3.84	5,321
13	131,124	3.63	3.53	4,629	3.93	5,155
14	125,356	3.71	3.85	4,826	4.29	5,375
15	121,585	3.77	4.09	4,973	4.56	5,538
16	114,017	3.80	4.21	4,800	4.69	5,346
17	113,491	3.83	4.33	4,914	4.82	5,473
18	105,850	3.91	4.65	4,922	5.18	5,482
19	84,932	3.97	4.89	4,153	5.45	4,626
20	81,250	4.01	5.05	4,103	5.62	4,570
Sum	2,918,158			78,604		87,545
Mean	145,908	3.50	3.00		3.34	
SD	35447	0.34	1.35		1.50	
CV (%)	24.3	9.64	45.0		45.0	

[a] The same salaries and PS values in Table 1 were used with a manual assignment.
[b] Based on equation (2).
[c] Based on equation (3), with an Adjustment Factor of 1.11.

Legend to Figures

Figure 1. Distribution of Merit Raise (%) as a Function of Steepness Factor (Slope). The merit raises (%) for 20 faculty are shown for slopes of 0.5–4 and merit raise pools of 3% (top panel) and 6% (bottom panel). Symbols and horizontal lines represent raises for individual faculty and the average raises, respectively.

Figure 1



Available Merit Raise = 3%
Merit Raise (%)
0
1
2
3
4
5
0.5
1
2
3
4
Slope
Available Merit Raise = 6%
Merit Raise (%)
0
2
4
6
8
10
0.5
1
2
3
4
Slope