–Before the Public Service Commission of Utah–

Generation Overhaul Expense Model

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GENERATION OVERHAUL EXPENSE MODEL

Assume that the generation overhaul expense (GOE) is equal to a base, unobserved amount plus a random error or shock term. That is,

$$G_i \; = \; H_i \; + \; \varepsilon_i$$

Eq. 1

where

G_i = the actual or observed generation overhaul expense for period "i";

H_i = the base or unobserved (unknown) generation overhaul expense for period "i"; and

ε_i = a random error (shock) term with a mean zero and standard deviation σ_ε;

Assume also that the unobserved values are linearly related period-to-period through a constant rate of inflation:

$$H_i = H_{i-1}(1 \; + \; \pi)$$

Eq. 2

where π is the inflation rate. Given these assumptions, the observed GEO will on average equal the unobserved GEO value:

$$E(G_i) \; = \; H_i$$

Eq. 3

where E(·) is the linear expectation operator.[1]

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[1] The expectation operator defines the expected (or average) value for a random variable. For a discrete random variable, the expectation value is defined as the sum of the probability weighted values of the random variable. For example, for a random variable X, with discrete values x_1, x_2, . . . , x_n, the expected value of X is defined as

FORECASTING METHOD 1

Forecasting Method 1 inflates or escalates the average of four historical values. For example, suppose we observe the four historical values G_1, G_2, G_3, and G_4. Method 1 forecasts the fifth year as the inflated average value:

$$\hat{G}_5 = \frac{1}{4}[G_1 + G_2 + G_3 + G_4](1 + \pi) = \frac{(1 + \pi)}{4} \sum_{i=1}^{4} G_i \qquad \text{Eq. 4}$$

Applying the Expectation operator to $\hat{G}_5$ yields,

$$E(\hat{G}_5) = \frac{(1 + \pi)}{4} \sum_{i=1}^{4} E(G_i) = \frac{(1 + \pi)}{4} \sum_{i=1}^{4} H_i \qquad \text{Eq. 5}$$

Substituting using the relationship defined in Equation 2, Equation 5 can be rewritten as,

$$E(\hat{G}_5) = \frac{(1 + \pi)}{4}\left[H_1 + H_1(1+\pi) + H_1(1+\pi)^2 + H_1(1+\pi)^3 \right]$$

$$= H_1(1 + \pi)^4 \frac{\left[1+(1+\pi)^{-1}+(1+\pi)^{-2}+(1+\pi)^{-3} \right]}{4} \qquad \text{Eq. 6}$$

$$= \theta H_5$$

where θ is a number between zero and one:

$$\theta = \frac{[1 + (1 + \pi)^{-1} + (1 + \pi)^{-2} + (1 + \pi)^{-3}]}{4} \qquad \text{Eq. 7}$$

$E(X) = \sum_{i=1}^{n} p_i x_i$, where p_i is the probability of x_i. For a continues random variable, the expected value is defined as $E(X) = \int_X x f(x) dx$, where the integral is over the range of X, and f(·) is the density function of X.

and H_5 is by definition (Equation 2) equal to $H_1 (1 + \pi)^4$. If inflation is zero, $\pi = 0$, then θ will be equal to one, and on average forecasting Method 1 will equal the fifth year value. However, if the inflation rate is not zero then θ will be less than one and, on average, Method 1 will underestimate the fifth year value. In summary,

$$If\ \pi = 0, then\ \theta = 1, and\ E\left(\hat{G}_5\right) = H_5 \qquad \text{Eq. 8}$$

however,

$$If\ \pi \neq 0, then\ \theta < 1, and\ E\left(\hat{G}_5\right) = \theta H_5 < H_5 \qquad \text{Eq. 9}$$

GENERALIZATION OF METHOD 1

It is possible to generalize Forecasting Method 1 by specifying Equation 4 as,

$$\hat{G}_5 = \frac{\left(1 + \pi\right)^k}{4} \sum_{i=1}^{4} G_i \qquad \text{Eq. 10}$$

where k is a constant greater than or equal to one. If k is equal to one, then Equation 10 reduces to equation 4. If k is greater than one, then Equation 7 can be rewritten as,

$$\theta = (1 + \pi)^{k-1} \frac{[1 + (1 + \pi)^{-1} + (1 + \pi)^{-2} + (1 + \pi)^{-3}]}{4} \qquad \text{Eq. 11}$$

If the inflation rate, is zero or if k is equal to one, then Equation 11 yields the results defined in Equations 8 and 9, respectively. However, if k is greater than one, then,

$$\lim_{k>1, \pi \to \infty} \theta = \lim_{k>1, \pi \to \infty} \frac{(1 + \pi)^{k-1}}{4} \to \infty \qquad \text{Eq. 12}$$

Therefore, whether the simple version or the generalized version of Method 1 is used to estimate the test year value, Method 1 is likely to systematically under or over estimate the test year value. Only in the special case where the inflation rate is zero and k is equal to one, will Method 1 accurately estimate the test year value.

FORECASTING METHOD 2

Forecasting Method 2 averages the inflated or escalated historical values as an estimate of the test year value, where each of the inflated historical values are brought to a common base year (e.g., the test year). For example, suppose we observe the four historical values G_1, G_2, G_3, and G_4. Method 2 forecasts the fifth year as the average of the inflated values:

$$\tilde{G}_5 = \frac{1}{4}\left[G_1(1+\pi)^4 + G_2(1+\pi)^3 + G_3(1+\pi)^2 + G_4(1+\pi)^1 \right]$$

Eq. 13

$$= \frac{1}{4}\sum_{i=1}^{4} G_i (1+\pi)^{5-i}$$

Applying the Expectation operator to $\tilde{G}_5$ yields,

$$E\left(\tilde{G}_5\right) = \frac{1}{4}\sum_{i=1}^{4} E\left(G_i\right)(1+\pi)^{5-i}$$

$$= \frac{1}{4}\sum_{i=1}^{4} H_i\,(1+\pi)^{5-i}$$

Eq. 14

$$= \frac{1}{4}\sum_{i=1}^{4} H_5$$

$$= H_5$$

Therefore, on average, Forecasting Method 2 will equal the fifth year value we are trying to estimate or forecast.

CONCLUSION

Given our specification of the generation overhaul expense (model), Forecasting Method 1, inflating the average of the historical models to forecast the test year value, will on average systematically under or over estimate the test year value. Forecasting Method 2, averaging the inflated historical values, will on average equal the test year value being forecast. Therefore, Method 2 is the superior method to forecast the generation overhaul expense test year value.