The Role of Interest and Inflation Rates In Life-Cycle Cost Analysis

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The effect of projected interest and inflation rates on life-cycle cost calculations is discussed and a method is proposed for making such calculations which replaces these rates by a single parameter. Besides simplifying the analysis, the method clarifies the roles of these rates. An analysis of historical interest and inflation rates from 1950 to 1976 shows that the proposed method can be expected to yield very good projections of life-cycle cost even if the rates themselves fluctuate considerably.

I. Introduction

In life-cycle cost (LCC) studies it is common practice to estimate future costs in constant dollars and to use an assumed inflation rate to transform these estimates to actual dollars. The choice of an inflation rate for such projections can strongly affect the computed LCC. Table 1 shows the effect of the inflation rate on the 10-year LCC of a project whose yearly cost is $1 in constant dollars (reflecting prices and wages at the start of the project).

Frequently LCC studies take into account the "time value of money" by discounting future expenditures using an assumed discount rate (interest rate). The effect of discounting on LCC (assuming no inflation) is illustrated by Table 2.

These tables show how strongly LCC computations reflect the choice of rates. Even when both inflation and discounting are considered, if a wide range of possible choices for the rates is permitted, then the comparison of a project with high initial cost and, say, another project with low initial cost but comparatively high recurring costs can vary drastically.

This report proposes a simplified method of LCC calculation using a single parameter V that combines the effects of inflation and discounting, taking advantage of the fact that, to a large extent, they cancel each other out. Historical data on interest rates and inflation rates from 1950 to 1976 are analyzed to determine how stable the parameter V is and to indicate a reasonable value for this parameter and the accuracy one can expect from its use in LCC projections.

II. Combining Discount and Inflation Rates

Whenever the "time value of money" is considered, the life-cycle cost is the sum of all costs in the life-cycle *discounted* at an interest rate i to some time point t_0. One might choose t_0 to be the beginning of the operational phase or, perhaps, the time of first expenditure not yet committed. Furthermore, it is common practice to pick a time point t_1 at

which wages and prices are known and then to estimate all costs in "t_1 - dollars." *Actual dollar* expenditures are estimated by transforming from t_1 - dollars, using an assumed inflation rate j. (For simplicity, we ignore the straightforward refinement where different j's are applied to different types of costs such as labor costs or material costs.)

There is good reason to choose t_0 and t_1 to coincide. The LCC then depends only on

$$V = \frac{1+j}{1+i}$$

This is because an expenditure at time t of an amount C in t_1 - dollars implies a cost in actual dollars of

$$C(1+j)^{t-t_1},$$

and the discounted value of this at time t_0 is

$$C(1+j)^{t-t_1}(1+i)^{-(t-t_0)},$$

which, if $t_0 = t_1$, is equal to CV^{t-t_0}. Thus, one can compute the LCC by specifying only the assumed V rather than both i and j. Specifically, if $C_1, \ldots, C_n$ are the estimated yearly costs in current dollars, then the LCC (evaluated at the present) is given by

$$LCC = \sum_{k=1}^{n} C_k V^k$$

There are obvious advantages to dealing with only one "arbitrary" parameter. For example, one can bracket the LCC by computing it using "high" and "low" choices of V. A more important benefit from considering V is to reduce substantially the seeming unpredictability of future interest and inflation rates. Historically, interest rates tend to exceed inflation rates by about 2-3%. Figure 1 shows this tendency over the years 1950 to 1976, using for illustration the long-term Treasury bond yield (Refs. 1 and 2) and the index of consumer prices by the Bureau of Labor Statistics (Ref. 3). Furthermore, V is essentially a function of the difference of rates, $i - j$, as Fig. 2 reveals. (In fact, the approximation $V = 1 - (i - j)/(1 + i) \approx 1 - (i - j)$ is good enough for most purposes). It is natural, then, to ask how stable is V historically or, more important, how much do LCC's vary when computed using *actual* interest and inflation rates over different historical periods?

A study was made using the inflation and interest rate data for 1950 - 1976 to determine what actual LCCs would have been for projects spanning all 5, 10, 15, or 20-year subintervals

of that period, assuming costs of one dollar per year expressed in current dollars at the start of the project. The LCC for, say, a 10-year project starting in year m is then obtained from the formulas

$$i_k = \text{interest rate in year } k$$

$$j_k = \text{inflation rate in year } k$$

$$V_k = \frac{1+j_k}{1+i_k}$$

$$LCC = V_m + (V_m V_{m+1}) + \cdots + (V_m V_{m+1} \cdots V_{m+9})$$

The results of these computations are displayed in Fig. 3. The conclusion indicated by these results is clearly that LCCs based on actual rates are quite stable historically. Over this 27-year period the variations of LCCs are a relatively small percentage of the LCCs themselves. If this stability continues (and recall that the actual yearly rate fluctuations in Fig. 1 are considerable), it should be possible to choose a value of V that will project future experience with a reasonable degree of accuracy and confidence. Standardizing the V to be used in LCC calculations for the DSN has the advantages of simplicity and uniformity.

What is a good choice of V for the DSN? The value of V that yields a 10-year LCC matching the average of the 10-year LCCs in Fig. 3 is 0.983, and choosing $V = 0.98$ (for simplicity) seems reasonable to us.

This choice agrees very well with the data for 5, 10, 15, and 20 years. A good case can be made for setting $V = 1$, thereby letting interest and inflation cancel completely and simplifying LCC calculations. How much difference does it make in the LCC when one makes small changes in V? Routine computation shows that for V between 0.9 and 1, each decrease of 0.01 in V yields about the same percentage decrease in LCC, the amount of this decrease depending on the length of the life cycle. Table 3 illustrates the outcomes for $n = 5, 10, 15$, and 20 years with $V = 0.97$ and 0.98. Note that for a 10-year project the LCC with $V = 1$ is 10 and drops to about 9.5, 9.0, 8.5 as V goes through 0.99, 0.98, 0.97.

Whatever value of V is settled upon, this approach to inflation and discounting seems to us a valid and simple alternative to the conventional numbers game of trying to predict future interest and inflation rates.

III. Conclusion

As pointed out in the introduction, the choice of inflation and discount rates can have a powerful effect on the results of

LCC calculations. Inflating costs without discounting (or the reverse) can easily lead to making the wrong choice between competing projects. Even when both rates are used, arbitrary choices can lead to a wide range of possible results.

Our analysis shows that inflation and discounting largely cancel each other and it is essentially only the difference between them that affects LCC. This difference is relatively small, discount rates generally being slightly higher than inflation rates. Furthermore, fluctuations in the rates tend to cancel out over project lifetimes. As a consequence, a single parameter V can be chosen to estimate the net effect of future discount and inflation rates with a reasonable degree of confidence. The value $V = 0.98$, reflecting discount rates about 2% higher than inflation rates, is recommended for DSN use, based on a good fit to actual rates over the period 1950−1976.

References

1. "Business Conditions Digest," U.S. Department of Commerce, Bureau of Economic Analysis, p. 108, Feb. 1976.

2. Federal Reserve Bulletin, p. A27, June 1977.

3. "Business Conditions Digest," U.S. Department of Commerce, Bureau of Economic Analysis, p. 97, Mar. 1977.

Table 1. Effect of inflation rate on LCC

Inflation rate, %/yr	LCC	% increase over zero inflation
0	10.0	—
2	11.17	11.7
4	12.49	24.9
6	13.97	39.7
8	15.65	56.5
10	17.53	75.3
15	23.35	133.5

Table 2. Effect of discount rate on LCC

Discount rate, %/yr	LCC	% decrease over zero discounting
0	10.00	—
2	8.98	10.2
4	8.11	18.9
6	7.36	26.4
8	6.71	32.9
10	6.14	38.6
15	5.02	49.8

Table 3. LCC of a project costing $1 per year

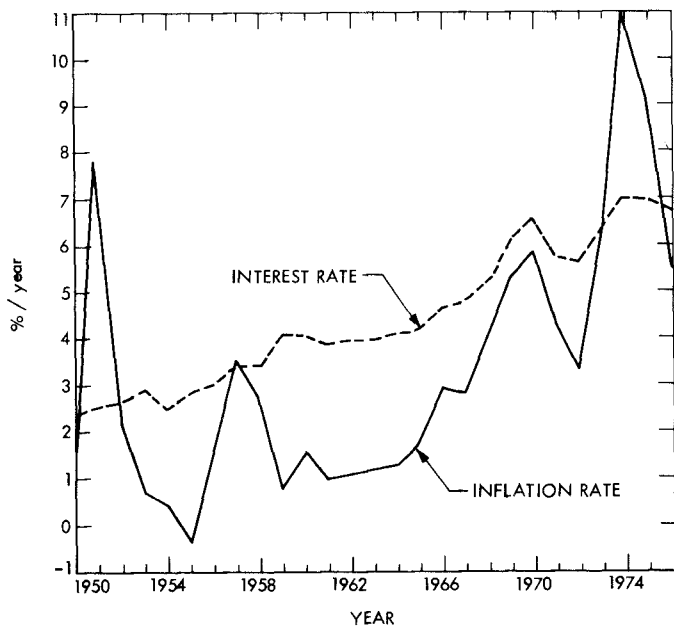| No. years	$V = 0.97$	$V = 0.98$	% increase
5	4.57	4.71	3.1
10	8.49	8.96	5.6
15	11.86	12.81	8.0
20	14.75	16.29	10.4

Fig. 1. Interest and inflation rates (1950–1976)

Fig. 2. *V* as a function of *i* for fixed $\Delta = i - j$
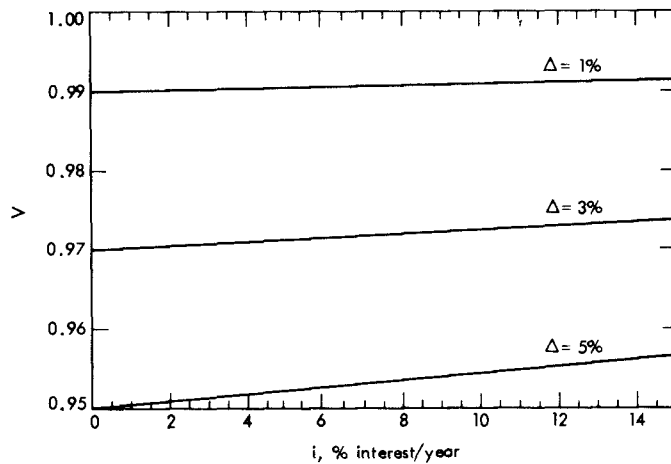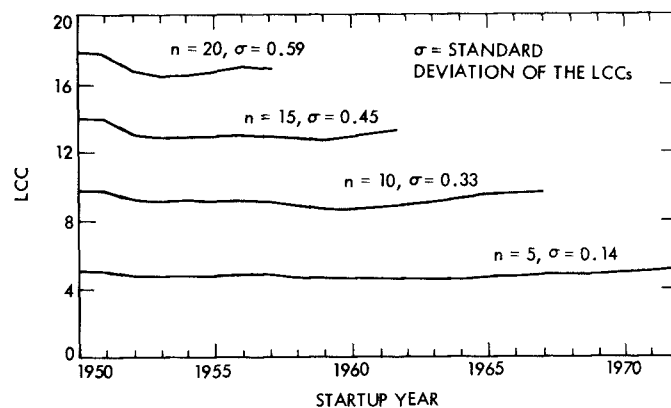

Fig. 3. LCC for *n*-year lifetimes, with startup years from 1950–1972