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AN HISTORICAL PERSPECTIVE OF NET PRESENT VALUE AND EQUIVALENT ANNUAL COST

Abstract: Net present value and equivalent annual cost are two discounted cash flow criteria for comparing investment proposals. Why have accountants taken to net present value? Why do engineers readily use equivalent annual cost? This paper investigates the historical development of these principles to provide an explanation of why this is so.

Capital financing and budgeting represents a fundamental function of management. In a recent paper, Truitt[1] discussed the problem of comparing investments with unequal lives by contrasting the traditional net present value (NPV) method with the equivalent annual cost (EAC) method. He indicated that the annual cost method appears in the engineering literature but apparently has not appeared in the accounting literature.

The purpose of this paper is to explain why engineers are conversant with the EAC method while, for the most part, this method is unknown to accountants. This objective is accomplished by tracing the historical development of NPV and EAC.

Background

The net present value and equivalent annual cost methods are members of the family of discounted cash flow criteria of investment evaluation which have their modern-day foundation in actuarial science and the financial investment market of the nineteenth century.[2] However, discounted cash flow criteria were not applied to nonfinancial investments until late in the century.[3]

In the net present value method, cash flows are discounted to the present while the equivalent annual cost method converts cash flows into an equivalent series of uniform annual amounts. NPV computations often result in a dollar amount of such considerable

magnitude that they consequently may be misleading. On the other hand, EAC expresses the dollar amount in a context that may be more meaningful to a decision maker whereas organizations typically report their activities on an annual basis. In addition, EAC possesses certain computational advantages, especially when comparing alternatives with unequal lives.

Since NPV and EAC are equivalent concepts,[4] it is not surprising that both methods are utilized for comparing investment proposals. Nevertheless, a very intriguing situation is that both methods are not universally known to all individuals involved in capital budgeting decisions.

Harris and Schonberger[5] indicated that as a result of differences in the methods employed in capital budgeting decisions, a communications gap has occurred between engineers, management accountants, and top management. This communications gap is the consequence of differences in the educational emphasis placed upon the discounted cash flow methods. While the education and training of engineers includes all of the methods used by management accountants (NPV, internal rate of return, payback), EAC is emphasized. On the other hand, a trend setter and leading managerial accounting textbook, currently in its fourth edition, stresses NPV. In fact, EAC is not even mentioned.[6]

In tracing the historical development of these two discounted cash flow techniques in the following sections, selected events in the fields of engineering, economics, and accounting are surveyed.

The Development of NPV

In 1887 an American civil engineer, A. M. Wellington, published the second edition of his standard work on the location of railways—*The Economic Theory of the Location of Railways.* He pointed out that the problem of utmost importance to railway construction was to ascertain if a line should be built or not. The significant size of its capital expenditures and the financial structure of the railway industry created the need for a method of capital budgeting to aid management in decision making. In justifying capital expenditures, Wellington was one of the first writers to employ present value computations to nonfinancial investments.[7]

The engineering literature from the end of the nineteenth century until the end of World War I contained only scattered attempts to discuss present value or capital budgeting techniques. None of these appears to have made a significant contribution.[8] The literature of this period indicated that engineers were more concerned

with improving the concepts and techniques of cost accounting than with refining the procedures of capital budgeting.[9]

The first reference to NPV in American economic literature appeared in 1907 in Irving Fisher's *The Rate of Interest*. This important work was revised and reissued in 1930 as *The Theory of Interest.* Fisher presented four principles to evaluate alternative investment proposals. These were (1) the principle of maximum present value: i.e., selection based on the maximum present value determined by using the market rate of interest; (2) the principle of return over cost: selection of the alternative whose "rate of return over cost" or "rate of return on sacrifice" exceeds the market rate of interest; (3) the principle of comparative advantage: selection of the alternative whose returns outweigh its costs stated in present value using the market rate of interest as the discount rate; and (4) select "where options differ by continuous gradations, the one the difference of which from its nearest rival gives a rate of return over cost equal to the rate of interest."[10]

In 1930, Eugene L. Grant, a Stanford University engineering professor, published the first edition of his classic textbook *Principles of Engineering Economy.* Grant discussed applications of the present worth, the rate of return, and the equivalent annual cost methods for making capital budgeting decisions. Each of these methods is widely used today, and Grant has been recognized for the initial presentation of these methods in a single textbook.[11]

Although the economists and engineers had made significant contributions to the ideas on discounted cash flow, the accountants had little, if any, impact. Few references to investment decision making had appeared in the accounting literature. One noteworthy series of articles by R. H. Coase was published in 1938 in the *Accountant.*

During the period from the turn of the century until the conclusion of World War II, the accountants' involvement with interest was either in calculating financial interest, or in debating if interest was a cost of manufacturing. Parker attributed this condition to an over concern of accountants with historical recording rather than with decision making. However, accountants in their role as financial experts were consulted in capital-expenditure decisions.[12]

In 1938, J. F. Ebersole examined 757 of 13,119 cases on file at the Harvard School of Business in order to answer the question, "Is the interest rate an important influence in determining whether businesses expand or contract their operations or plants?"[13] Ebersole concluded that "the interest rate is not viewed as an important

problem by business management; the interest rate is seldom considered as a factor in entrepreneurial decisions of business to expand or contract and is a controlling factor in a negligible number of instances."[14]

Two of the earliest references to NPV in the economic literature of the 1950s appeared almost simultaneously. Lorie and Savage, dealing with problems of multiple rates of return connected with the internal rate of return method, showed that investment proposals which have positive present value with the firm's cost of capital as the discount factor will also have an internal rate of return greater than the cost of capital.[15] Alchian, in discussing Keynes' Marginal Efficiency of Capital, described the present worth of an investment option as

$$\int_0^t [R(t)-E(t)]\, e^{-rt}dt$$

where R(t) represents the inflow stream and E(t) represents the outflow stream, both as functions of time, and e^{-rt} is the discount factor for t.[16]

In the decade that followed, numerous writers investigated the relationship between internal rate of return and net present value and the potential conflicts between these criteria.[17]

Apparently, the first significant event appearing in accounting literature was the publication in 1960 of *The Capital Budgeting Decision* by Bierman and Smidt. This textbook presented a comprehensive treatment of capital budgeting with an emphasis on NPV. Another major publication was Charles Horngren's *Cost Accounting: A Managerial Emphasis.* This textbook which was to become a leader in managerial accounting advocated NPV.

The Development of EAC

The initial work in the advancement of equivalent annual cost was the publication of the second edition of J. C. L. Fish's *Engineering Economics.* Fish, an engineering professor at Stanford University, "explained that in deciding among alternative investments comparison should be made of:

(i) the equivalent uniform annual operation cost (excluding depreciation), which is found by reducing the series of actual annual costs to a convenient date, and

distributing the sum of the results uniformly over the whole period;

(ii) annual depreciation cost calculated by the sinking-fund method and taking into account the salvage value;

(iii) interest on capital;

(iv) the equivalent uniform annual income."[18]

Thus, in 1923, the EAC method emerged as a discounted cash flow technique emphasizing annual costs as opposed to the present value of costs descended from Wellington. EAC has since received considerable attention in engineering education.

An event which appears to have had a prominent impact on the acceptance of EAC was the publication of Grant's *Principles of Engineering Economy,* previously referenced in the discussion of NPV. Although Grant explained the present worth, rate of return, and equivalent annual cost methods, he placed major emphasis upon the use of EAC in making capital budgeting decisions. He reasoned that the latter method is preferable because it can be understood more easily and that it is easier to compute. The explanation of the three methods, as well as the emphasis on EAC, contributed to making Grant's textbook a significant publication within the engineering literature. It is currently in its sixth edition and is considered a leader in its field.[19]

In the succeeding fifty years, EAC failed to make any impact on the theory or literature of economics, and its existence apparently received only passing reference in the accounting literature.[20] A survey of 35 accounting textbooks (published between 1976 and 1981), containing a discussion of techniques for evaluating capital projects, found only two which made mention of the equivalent annual cost method.[21] Consequently, out of the fields examined, only engineering is versed in the EAC method.[22]

Concluding Remarks

This historical perspective of net present value and equivalent annual cost reveals that both methods had their present-day origin in engineering economics. However, neither NPV nor EAC made any significant impression outside the field of engineering until economists adopted NPV in the 1950s. Widespread usage of the NPV method by accountants was delayed until the 1960s.[23]

EAC has been the preferential method of engineers while receiving limited exposure in accounting literature. Furthermore, the lead-

ing managerial accounting textbook advocates NPV—without discussion of the EAC method.

Thus, education appears to be the only plausible explanation why NPV, rather than EAC, was adopted by the accounting profession; and why EAC is used almost exclusively by engineers. This point is particularly surprising since the interpretation and computational efficiency of EAC is generally regarded as being superior to that of NPV.[24]

FOOTNOTES

[1]Truitt, p. 44.

[2]Simon Stevin was one of the first writers to include interest tables in a book. He applied the net present value criterion to the selection of loans in 1582.

[3]Parker, p. 39.

[4]The two methods are mathematically related by the expression NPV $=$ EAC $\cdot$ PV_a where PV_a denotes the present value of an ordinary annuity.

[5]Harris and Schonberger, pp. 1-2.

[6]See Horngren, Chapter 13. During a conversation with Charles Horngren, he indicated that he had often been asked by engineers the question of why EAC had not been included in his textbook. He stated, in capsule form, that a value judgment was made not to include EAC. His major reason was that the additional cost of explaining the subject matter did not justify its inclusion in light of other discount methods, which seem easier to understand.

[7]Parker, p. 39.

[8]See, for example, "Common Errors . . ." *Engineering and Contracting*; Pennell; and Van Deventer.

[9]See Solomons. His discussion of the contributions of engineers like Alexander Hamilton Church to overhead allocation and the idea of profit centers, and the contributions of Percy Longmuir, Harrington Emerson, and W. E. McHenry to the development of standard costing indicates the involvement of engineers in the development of cost accounting during this period in contrast to the literature concerning capital budgeting previously cited.

[10]Parker, p. 44.

[11]Grant.

[12]Parker, p. 57.

[13]Ebersole, p. 35.

[14]Ebersole, p. 39.

[15]Lorie and Savage, p. 236.

[16]Alchian, p. 938.

[17]It should be noted that during the interim between Fisher's *The Theory of Interest* and the articles by Lorie and Savage and Alchian, economic theory pursued the path of the internal rate of return. The major proponent of this method, J. Dean, brought the problems of capital budgeting to the fore in the early 1950s, and laid the foundation for much of the work that we have today. See J. Dean.

[18]Parker, p. 43.

[19]Grant, Ireson, and Leavenworth.

[20]See, for example, Bierman and Smidt; Fremgen; Johnson and Newton; Moore; and Truitt.

[21]Bierman and Smidt; and Fremgen.

[22]Grant Ireson commented during a telephone interview that a possible explanation is that engineers are primarily looking to the future and accountants are not. That is, engineers become involved in projects before investment decisions are made while accountants become involved after investments have been made. Consequently, accountants record things as they happen, focusing on the logical costs to carry on business. Their interest is in historical costing rather than decision making.

[23]A reviewer commented that historically, interest rates were relatively low until recently, particularly low in this country prior to the 1960s. This might account for the slow acceptance of the time value of money, as some users possibly viewed the whole concept as immaterial.

[24]While not part of this research investigation, the reader is referred to Harris and Schonberger; Jones and Smith; and Truitt for information concerning the comparative computational efficiency of NPV and EAC.

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