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Net Present Value Analysis to Select Public R&D Programs and Valuate Expected Private Sector Participation

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ABSTRACT

One of the main functions of government is to invest taxpayer dollars in projects, programs, and properties that will result in social benefit. Public programs focused on the development of technology are examples of such opportunities. Selecting these programs requires the same investment analysis approaches that private companies and individuals use. Good use of investment analysis approaches to these programs will minimize our tax costs and maximize public benefit from tax dollars invested. This article describes the use of the net present value (NPV) analysis approach to select public R&D programs and valuate expected private sector participation in the programs.

Index Entries: Investment analysis; net present value; R&D; public/private partnerships.

INTRODUCTION

One of the main functions of government is to invest tax dollars in programs, projects, and properties that will result in greater social benefit than would have resulted from leaving those tax dollars in the private sector or using them to pay off the public debt. One traditional area for investment by government is Research and Development (R&D). According to Battelle, US R&D expenditures reached $164.5 billion in 1994, and federal support represented $69.8 billion (42.4%) of the total *(1)*. If invested wisely, these tax dollars can lead to greater social benefit than would be obtained by leaving them in the private sector or using the money to pay off the federal debt. However, if

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not invested wisely, this could result in less-than-optimal social benefit or, even worse, in less social benefit than could be obtained from the other two options. The purpose of this article is to describe an approach to analyzing and selecting investment opportunities for federal money in public R&D programs and valuating expected private sector participation in the programs.

BASICS OF INVESTMENT ANALYSIS

For all investment situations, there are five basic variables:

1. Costs;
2. Profits or benefits;
3. Time;
4. The discount rate; and
5. Risk.

In the analysis of investment alternatives for a given situation, the alternatives under consideration may have differences with respect to costs and profits or benefits, project lives, and uncertainties. If the effects of these factors are not quantified systematically, correctly assessing which alternatives have the best potential is very difficult.

Many methods are available to decision makers to evaluate investment options systematically. These methods, described in detail in a variety of books and articles *(2)*, include present, annual, and future value; rate of return; and break-even analysis. The application of each method depends on whether the analysis is for a single opportunity, two mutually exclusive opportunities, or several nonmutually exclusive opportunities. For the single-opportunity situation, the decision maker is simply trying to decide if the single investment option meets a minimum expected financial return. For the mutually exclusive situation, the decision maker has two investment options and is trying to decide whether the options meet the minimum expected financial return and, if both do, which is the best choice. For the nonmutually exclusive situation, the decision maker has several investment options and is trying to decide which of these meets the minimum expected financial return and, of those that do, which combination of these will provide the maximum return on total investment dollars available.

One must be careful in applying rate of return analysis to mutually exclusive and nonmutually exclusive situations. If one simply calculates the rate of return for each alternative and then chooses the alternative or alternatives with the largest rates of return, this can, and often does, lead to the wrong choice. The correct application of rate-of-return analysis to either situation is known as incremental rate of return, and can be very tedious and time-consuming. One must take extra steps to account for differences in project lives. Net present value (NPV) is the tool of choice for evaluating mutually exclusive or nonmutually exclusive investment options, because it is much less time-consuming, is straightforward, does not require additional steps or considerations for projects with different lives, allows direct comparison between projects of widely differing objectives and scopes, and allows a rational approach to valuating private sector participation in public programs.

NPV APPROACH TO NONMUTUALLY EXCLUSIVE INVESTMENTS

A nonmutually exclusive investment situation is one where more than one investment option can be selected, depending on available capital or budget restrictions. The objective is to select those projects that maximize the cumulative profitability or benefit from the available investment dollars. To maximize the cumulative profitability or benefit, the decision maker selects the combination of projects that maximize the cumulative NPV.

To apply NPV to nonmutually exclusive alternatives, the NPV for each alternative is calculated by determining the present value of the profit/benefit stream calculated at the minimum rate of return (hurdle rate) and subtracting the present value of investment dollars and other costs, also calculated at the minimum rate of return.

$$\begin{aligned} \text{NPV} &= \text{present value revenues @ } i^* \\ &\quad - \text{present value costs @ } i^* \end{aligned}$$

where i^* = minimum rate of return.

If the project NPV is zero, there is enough revenue or benefit to cover the costs at a rate of return that is equal to the minimum rate of return required by the investor. Projects with an NPV less than zero are dropped from further consideration, because their rate of return is less than the minimum required return. If the NPV is greater than zero, the NPV represents how many present value dollars will be returned to the investor above and beyond those that will be returned at the minimum rate of return. Once the NPV for each project is calculated, the decision maker looks at all possible combinations of projects to determine which combination (whose total investment does not exceed the amount of money available) has the largest cumulative NPV. This is the best possible investment portfolio. Often, selecting the best portfolio does not involve selecting projects with the largest individual project NPV and, as will be seen in the following example, does not necessarily involve selecting projects with the highest rates of return.

For example, consider the following three investment alternatives. Each has a different life. Assume that the investor's minimum rate of return is 10% and the investor has $50,000 to invest.

Alternative	*Investment*	*Profit/benefit at the end of each year*	*Project life*
1	$50,000	$26,000	3 yr
2	$30,000	$10,000	5 yr
3	$20,000	$6000	7 yr

The NPVs and rates of return for each alternative follow:

Alternative	*NPV*	*Rate of return*
1	+$14,658	26%
2	+$7908	20%
3	+$9211	23%

Because all these projects have positive NPVs, they will all provide a rate of return >10% to the investor. Thus, all are to be considered for possible inclusion in the optimum portfolio. The two possible portfolios that do not exceed the $50,000 available to invest are: (1) Alternative 1 and (2) the combination of Alternatives 2 and 3. The combination of Alternatives 2 and 3 has a cumulative NPV of $17,119, whereas Alternative 1 has an NPV of $14,658. Thus, the best portfolio is the combination of Alternatives 2 and 3. In fact, this combination of investments will return $2,460 to the investor above and beyond what Alternative 1 by itself will do. Also, ranking the alternatives by regular rate of return does not give the correct answer, because Alternative 1 has a short project life, and when it is finished, the investor would have to reinvest at the minimum rate of return of only 10%, giving an overall lower rate of return to the investor compared to investing in Alternatives 2 and 3, which have longer lives at a return much better than the minimum rate of return, providing an overall greater rate of return for the combination of Alternatives 2 and 3.

If one is faced with the daunting task of selecting an investment portfolio when there are dozens of investment options, an alternate method may be used to simplify the process. Growth rate of return or ratio analysis may be used to rank nonmutually exclusive alternatives rather than cumulative NPV analysis *(2)*. Large companies and government programs are often faced with the task of evaluating literally hundreds of potential projects. Many combinations of projects must be analyzed to determine the optimum group of projects that will maximize the cumulative NPV for a given budget. The use of growth rate of return or ratio analysis only requires the calculation of the respective values for each project and then ranking the projects in the order of decreasing values. The illustration of these concepts will not be demonstrated here, but the reader should be aware of these methods to evaluate a complex investment portfolio.

SPECIAL CONSIDERATIONS FOR NONMUTUALLY EXCLUSIVE GOVERNMENT INVESTMENTS

Converting Intangible Benefits and Costs into Dollar Values

A basic tenet of this article is that to make rational investments of public dollars, one must have some approximate, quantitative idea of the value of critical costs and benefits. Moreover, as a practical matter, it is essential that the measure of value be the same for both costs and benefits, so that direct comparisons between costs and benefits can be made. The most universal measure of value is the dollar. In the private sector, this is the measure of cost and benefit. In the public sector, particularly with respect to R&D programs, it is the established measure of cost. However, on the benefit side, there is no established measure of value. The authors contend that the dollar should be the measure of benefit, so that direct comparisons can be made with costs and so that the established and the well-recognized investments analysis methodology described above can be employed in the public sector.

In many cases, converting benefits to dollars is fairly straightforward. For example, a key benefit that the US Department of Energy (DOE) is interested in is reducing imported petroleum. The dollar value of the yearly benefit can easily be calculated from the present and projected price of petroleum *(3)*. As another example, it is possible to estimate the net annual increase or decrease in jobs that results from introducing new technology. In addition, it is fairly straightforward to place a dollar value on these jobs *(4)*. Other possible costs and benefits are environmental and social, which are more difficult to quantify. Nevertheless, the US Environmental Protection Agency has studied these issues carefully, and has given dollar estimates of health costs associated with various types and levels of pollution. Clearly, more effort needs to be made to develop methodologies to convert public benefit to dollar value, so that time-tested investment decision-making methodologies can be employed.

Minimal Rate of Return for Public Projects

Establishing a minimal rate of return for public projects requires some special considerations, which have been reviewed extensively by Heaps and Pratt *(5)* for Canadian public projects. They concluded that the correct social discount rate for Canada was 3–7%. In another study performed by Wilson Hill Associates *(3)*, a discount rate of 7% was used for projects evaluated for the Office of Transportation Programs in DOE.

SELECTING PUBLIC R&D PROGRAMS AND VALUATING EXPECTED PARTICIPATION BY THE IMPLEMENTING INDUSTRY

Commonly, a government R&D program is initiated without the private sector, but the private sector is expected to "come on board" at some point to carry, the ball forward into the commercial arena. For these situations, the government and the private sector make investments in R&D and technology commercialization in order to obtain what each desires—social benefit in the case of government, and profit in the case of the private companies.

Analysis of the value of these programs demands answers to three questions:

1. What portion of the R&D cost can the private sector incur and still obtain its minimum return from implementing the technology?
2. When this private sector cost allowance is subtracted from the total estimated cost to carry out R&D to obtain an estimate of the R&D cost that must be borne by government, is the estimated government R&D cost justified given the expected social benefit from implementing the technology?
3. If the answer to questions 2 is positive, does the program represent one of government's best opportunities for its limited investment dollars?

The NPV approach to investments provides the answer to all three questions. For example, to answer the first question, one calculates the industry NPV. To do this, one estimates over time the capital and operating costs the industry at large will incur to implement a new technology and, using the average minimum interest rate for the industry, calculates the present value of these costs to industry at the initial time of commercialization. One also estimates over time the present value at the time of commercialization of the expected increased revenues or savings the industry should experience from implementing the technology. Subtracting the present value costs from the present value revenues gives the industry NPV at the time when commercialization is expected to begin. If the NPV is negative, the industry cannot afford to contribute to the R&D effort, and cannot afford the capital and/or operating costs of commercialization. As a result, it will not "come on board," and the government should drop consideration of the program. If the industry NPV is zero, industry cannot afford to contribute to the R&D costs, but can afford the capital and operating costs to implement the technology. In this situation, the government will have to incur all the R&D costs in order for industry to adopt the technology. If the industry NPV is positive, the government can expect the industry to participate in the R&D costs at a level equivalent to the NPV. This participation may be provided in the form of cost-sharing or through licensing arrangements.

To answer the second question, one calculates the government NPV. To do this, the expected social benefits are estimated over time, and dollar values are assigned. Then the present value of these benefits is calculated at the time the program was initiated using the social discount factor. Next, the entire R&D costs over time are estimated and discounted to the time the program began using the social discount factor. Next, the expected R&D contribution from industry, calculated above as industry NPV, is discounted to the time of initiating the program using the industry discount factor. This industry R&D contribution, discounted to when the program began, is then subtracted from the entire R&D costs, also discounted to when the program began, to obtain the governments expected R&D costs discounted to the time the program began. These discounted government R&D costs are then subtracted from the discounted benefits to obtain the government NPV for the program at the time the program was initiated. If the government NPV is less than zero, the program should not be considered for investment of tax dollars. If the government NPV is zero or greater, it should be thrown in the pot of possible government investments.

To answer the third question, government should list all investment options with an NPV greater than zero and select that combination of projects that will maximize the governments cumulative net present value.

VALUATING EXPECTED PARTICIPATION BY INDIVIDUAL COMPANIES

If, from the above analysis, the industry NPV is positive, individual companies that are members of the industry can be expected to cost share in the R&D phase of a program or purchase licensing arrangements. However, the level of cost-sharing or license fees will depend on each company's circumstances. The expected level of cost-sharing or the licensing fee for a given company can be calculated using NPV analysis. For example, for a given company, one can estimate over time the capital and operating costs the company will incur to implement a new technology and, using the company's minimum interest rate, calculate the present value of these costs to the company at the time of expected commercialization. One can also estimate over time the present value of the expected increased revenues or savings a company should experience from implementing the new technology. Subtracting the present value costs from the present value revenues gives the NPV to the company when it is expected to begin its commercialization effort. If the company NPV is negative, the particular company cannot afford to implement the technology, even if the technology is provided free. Such a company is not a viable partner to the government program. If the company NPV is zero, the company may be a partner only in the sense that it will implement the government—developed technology if it is free to the company. If the company NPV is positive, the company can afford to cost-share the R&D effort or purchase a licensing arrangement at a level equal to the company NPV. Such companies are potentially the most valuable partners to the program.

RISK ANALYSIS, INFLATION, AND ESCALATION

All the above analyses presumed that no risk was involved. To account for the risk associated with a program or project, one can use a higher discount rate, or modify the various expected benefits, profits, or costs accordingly. In addition, when conducting NPV analysis, one must account for anticipated inflation and escalation of costs, revenues, and benefits.

CONCLUSIONS

With federal R&D dollars dwindling, wise choices must be made with regard to investing in projects so that maximum social benefit results. In addition, the government must work closely in partnership with the private sector to leverage public dollars.

To accomplish this, an accepted methodology must be developed to evaluate the "goodness" of government programs and the expected contributions from the private sector. The authors contend that NPV analysis is the most appropriate methodology. The major advantages of this methodology is that it allows direct comparison between public projects of widely differing purposes and scopes, and it allows direct comparison of the value of public endeavors vs public endeavors. In addition, through NPV analysis, it is possible to separate clearly the costs and benefits of a joint project between government and industry. The description of this last application is a unique aspect of this article.

We recognize that a significant hurdle to using NPV analysis is that methodologies for valuating public benefits in terms of dollars are not always available. However, because the value of NPV analysis is so great, particularly when analyzing joint public/private ventures, it behooves public agencies to work to establish methodologies to put dollar values on pubic benefits.

The authors hope that this article will stimulate discussion toward a model that attempts to compare competing programs for limited resources based on parameters that are both relevant and measurable. Such discussion will certainly lead to refinement of the ideas in this article, to detailed examples of their use, and hopefully, to the development of improved methodologies to valuate public benefits in terms of dollars.

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