ON THE PROPER DISCOUNT RATE FOR PUBLIC INVESTMENT PROJECTS IN NATURAL RESOURCES

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Angelos Pagoulatos and Larry A. Walker

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Agricultural Experiment Station :: Department of Agricultural Economics

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I. INTRODUCTION

The proper discount rate for public investment projects in natural resources is a topic for which there simultaneously exists a considerable degree of knowledge, yet a surprising degree of confusion when one attempts to transpose this knowledge into actual policy. Economists understand thoroughly just what this variable should measure – the welfare foregone by not having these benefits. Above all, economists and politicians alike are generally in accord on the view that a very serious misallocation of resources can result from the use of an incorrect estimate of the discount rate in benefit-cost (B/C) calculations. However, there is considerable controversy concerning how such elements as risk and uncertainty, taxes, intangibles, externalities, inflation, and society's future welfare should be incorporated into the present value formulas. As a result economists, politicians, and government agencies provide, in print, estimates of the proper discount rate ranging from 0 to 15 percent.

The objectives of this paper are separated into three parts. Part I explains the rationale behind the main theories with respect to the derivation of the proper social discount rate. Part II clarifies how risk and uncertainty, taxation, intangibles, externalities, and inflation should be incorporated into B/C analyses. Part III shows that, given our institutional arrangements, there exists the possibility of significant constraints to the actual policy implementation of an economically optimal discount rate.

*Assistant Professor of Agricultural Economics, University of Kentucky and Agricultural Economist (NEAD) ERS-USDA, Washington, D.C.

II. ALTERNATIVE APPROACHES TO THE DETERMINATION OF THE DISCOUNT RATE

The need for public investments in our society is obvious. However, analysis of these expenditures is subject to complexities, primarily owing to the multiplicity of government objectives, i.e., 1) the provision of public goods; 2) the redistribution of income; 3) dealing with externalities; 4) the management of publicly owned resources; and 5) the removal of imperfections in the functioning of the private market system, or the alleviation of external effects. Government investments in water resources may contain all these categories of benefits in the objective function. Evaluation and the proper weighting of the Government activities are particularly difficult. Each activity is likely to have multiple objectives and cardinal utility measures, and hence interpersonal utility comparisons are impossible. Therefore, there exists great difficulty in making comparisons and evaluating trade-offs between program objectives (15-18). Such topics must be considered when developing a discounting procedure for public investments.

The derivation of a proper discount rate is based upon the explicit consideration of balancing a society's time preference and the productive possibilities of alternative investment against returns from a particular set of physical capital assets. To determine whether an investment is worthwhile, it is necessary to incorporate a discounting procedure to compare an early net outlay with a later return, i.e., dollar quantities received at different points in time. Given the time preference, production possibilities, and the ability of the consumers to alter the time stream of their consumption by borrowing and lending, a single rate of interest would occur if there were no uncertainty.

Consumers and entrepreneurs would both adjust their activities to that rate of interest.

In an economy where there are no barriers among markets and no risk or uncertainty, the government should also use that single rate as its discount rate for investments under an opportunity cost approach. To depart from this rate would reduce the total productivity of the economy. Using a higher discount rate would cause the government to ignore investments that would have a larger return than that available from opportunities in the private sector, thus diverting resources into lower pay-off areas. The application of a lower discount rate would result in the opposite effect. However, problems arise because reality is more complex than this model. Owing to such market imperfections as barriers to entry, administrative costs of borrowing and lending, imperfections in information, slow adjustment processes, inherent aspects of risk and uncertainty, taxes, and externalities, the normative significance of the actual rates found in the market is lost (16-19). These imperfections give rise to two main viewpoints with respect to developing a proper discount rate for public investments. These are:

a) the opportunity cost of public capital

b) the social rate of time preference.

A. Opportunity Cost Appraisal

The opportunity cost approach views the discount rate applied to government programs as reflecting the cost of the funds withdrawn from the private sector of the economy. This transfer should be undertaken only when a potential project available to the government offers social benefits greater than the loss sustained by removing these resources from the private sector. This approach views economic efficiency as one of the significant criteria and requires measurement of gains and costs in terms of the valuations of the individuals constituting the present society[1] (17-92). Some literature mistakenly views the opportunity cost only in terms of funds withdrawn from investments in real physical capital i.e., assumes all resources used would have been invested. However, the funds used by government programs are withdrawn not only from investment in real physical capital but also from private consumption. Granted that the funds come from both private consumption and investment, there still is disagreement among economists concerning how to derive the proper discount rate. Three variations to the opportunity cost approach will be discussed.

Baumol proposes that the correct social discount rate for the evaluation of a government project is the weighted average of the percent rates of return that the resources would otherwise have provided in their respective areas within the private sector (27-489). The weight assigned to each area is the proportion of the total resources coming from that sector. If the projects derive their resources from different sectors, then their opportunity costs may vary. Consequently, it may be possible to decrease the opportunity cost rate for a project by careful planning of the means by which its resources are obtained. In particular, a project designed to draw heavily on resources which would otherwise be unemployed will incur an opportunity cost that is quite low (11-67).

The simplicity of Baumol's weighting scheme is deceptive. It is not easy to determine from which productive sectors the resources for a given project will be drawn. What one seeks in trying to obtain this information is the catalog of the decrements in the outputs of the various portions of the private sector resulting from the public

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[1]Efficiency is a relative concept dependent upon a specific income distribution. The set of demands resulting from one income distribution will not necessarily be identical with the demands generated by a different income distribution.

investment program. Viewed in these terms, difficulties in using the model are obvious. Nor is it easy to judge the rate of return on various types of debt and equity. It is not easy to derive a single number representing the rate of return on companies' capital. Another questionable facet of Baumol's scheme is the incorporation of risk and externalities into the discount rate rather than into the net benefit stream. This last point will be discussed in Part II.

Krutilla and Eckstein developed a model designed to reflect the social cost of capital raised through federal taxation. This model takes account of the actual structure of capital flows in the United States. They felt that, in considering alternative methods of financing water resources development and in evaluating the economic worth of projects, reasonable estimates of the social cost of federal funds are essential. Krutilla and Eckstein tried to determine the incidence of the marginal tax dollars. This required a quantitative study of the revenues produced by different taxes, the persons and organizations who pay the taxes, the extent to which taxpayers are able to shift their tax liabilities, and an assumption concerning the proportion of various taxes that would be cut in the event of a contraction. Once the sources of money were ascertained, values to attach to these funds in their alternative uses could be estimated.

The imposition of a tax to finance public investments is similar to levying a compulsory loan or forced saving upon a community. This leads to reduced private investment and consumption. The social cost of the capital raised from foregone investment equals the foregone rate of return on private investments (17-85). To estimate the cost of funds which would have been spent for consumption, Krutilla and Eckstein turned to the saving and borrowing behavior of households. The social cost with respect to this portion of the federal funds equals the interest rate which the government would have to offer to the taxed individuals to induce them to grant the loan voluntarily. Then a weighted average of these sources of funds is taken.

Harberger presents a third rationale based upon the opportunity cost of borrowed funds. He believes that there exists a definable pattern in which government borrowing displaces private investment. This is determined by the relative sensitivity of different types of investment and, possibly, savings to changes in the degree of tightness of the capital market. On this ground, he prefers the opportunity cost of borrowed funds approach, as opposed to an unknown and unstable mix of opportunity costs of tax funds, or to a weighted average containing a mix of taxed and borrowed funds, as the relevant discount rate (16-63).

Harberger contends that the government, by its normal borrowing operations, does not control the income distribution by the type of investment displaced. Lending terms are likely to be tightened by financial institutions to all classes of borrowers, and are unlikely to fall exclusively on one class, i.e., not entirely upon the corporate sector. If one is to use private sector rates of return to obtain the opportunity cost of public funds, under present institutional arrangements in the capital market, it would be a weighted average of these rates of return applying in all relevant sectors. These weights should reflect the degrees to which investment in each sector is estimated to be displaced by public sector borrowing. When government borrowing displaces private investment, the cost of such borrowing to the economy is better measured by the interest rate on government bonds plus the tax loss on the income foregone because of the displaced investment, rather than by the overall yield productivity of the displaced investment. Harberger's calculations account for the effects of government borrowing on sales, excise, and property taxes. He contends that the tax changes really represent external effects of the government's borrowing, and if, as federal tax revenues are changing, there exists simultaneous changes for state and local governments, then these additional changes should also be counted.

Comparing the merits of the opportunity cost approaches under the tax scheme vs. the federal borrowing scheme, Eckstein feels that both derived rates are pertinent but heavier weight should be given to the estimate based upon tax financing because: 1) the bulk of federal financing comes from taxation; 2) a sector-by-sector approach, assuming a specific incidence of marginal taxation, is more trustworthy because it corresponds to the actual conditions under which public capital is raised; and 3) after the money sources are identified, the return on capital in those sources has to be estimated only once (17-67). Actually the relevant consideration is where the marginal dollar comes from for the public projects. This is not known except for the case of earmarked taxes. However, since the far greater proportion of federal funds comes through taxation, the contention that more weight should be given to the tax scheme seems plausible. The problems with this model include: 1) deciding what weights should be assigned to the opportunity costs of funds raised by each of the innumerable possibilities of increasing tax revenues may be quite troublesome; 2) determining the true incidence of all taxes is a problem still to be solved; and 3) there is simply no standard pattern in administrative recommendations or congressional decisions about changes in tax rates, tax bases, and the like.

The federal borrowing method, in effect, is a budgetary concept of the discount rate reflecting the revenue and spending impact of government borrowing. It would be appropriate if one viewed the government as having the primary objective of maximizing its net worth. Harberger's model does possess the economic logic that when attempting to measure the cost to society from government borrowing, there is no ground to distinguish between whether the taxes foregone on the income from displaced investments would have accrued to the federal, state, or local governments. By focusing on federal taxes alone, a report unduly narrows its focus. However, Harberger's model also faces apparent problems, e.g., 1) the federal long-term borrowing rate presupposes that the entire cost of projects is financed out of voluntary bond purchases, and that the risks attached to projects are borne by the buyers – two conditions that do not hold (17-91) and 2) the rate is relatively risk free. Why this may understate the proper social discount rate will be covered in Part II; 3) as a consequence of additional borrowing, the yield on capital increases. This results, in effect, in a transfer from the consuming public to the capital owners. Since B/C analysis does not incorporate distribution theory, the social optimality of such transfers is not indicated in the analysis; 4) L. E. Lynn, Jr., the deputy Assistant Secretary of Defense in 1968, stated the belief that the government can be assumed to finance its activities out of tax revenues, and in the long-run, the alternative to more government spending is lower taxes, not less borrowing. The amount that the government plans to borrow each year should be assumed to be determined mainly by how much the government wants to stimulate or restrain aggregate demand by varying the size of its deficit or surplus, not necessarily by the level and composition of government investments; and 5) to calculate the tax loss by displaced investment, one still must calculate the overall yield productivity displaced.

B. Social Rate of Time Preference

The social rate of time preference scheme refers to a radical departure from the opportunity cost approach. This proposal, as described here, rejects the judgment of the private market as a basis for determining the discount rate and advocates that the rate ought to be a tool of policy, specifically reflecting governmental objectives. One of the objectives most referred to is concern for future generations who can not express their desires in the private market, but whose welfare should be no more discounted than that of the present generation. Another concern is growth, in terms of both income and social well-being on a per capita basis. Therefore, the government should endeavor to provide for the welfare of future generations and the future welfare of the present generation in a more rational way than the people would themselves. This corresponds to Pigou's contention that "...our telescopic faculty is defective" (6-366), and that government is the guardian of the interests of both present and future generations.

In defense of this position it can be argued that in a perfectly competitive economy, the opportunity cost of public funds could be represented by the market interest rate, but in our economy no single interest rate, or rate of return, can fully measure the social opportunity cost of funds. More importantly, even if a perfect market interest rate could guide private investors to maximize their welfare over time, it would not necessarily produce socially optimal investment decisions. A perfect market would equate private demand (investor's rate of return) and net supply (willingness to save) schedules. However, to produce "socially" optimal decisions, an interest rate would have to equate the social productivity of investment schedule with a politically determined, socially optimal, saving supply schedule. Therefore, the social opportunity cost depends upon the source of the particular funds and must reflect the social time preference (STP) function. In short, a society may wish to replace weights given to the opinions of individuals by the distribution of income and wealth with other weights, such as those given in the ballot box (6-364). Further, divergence of the STP from market-expressed time preference need not reflect conflicting opinions of different people. An individual's own time preference may depend upon whether he is acting alone, or collectively. The public discount rate may be less than the private discount rate because of the substitution of a collective time preference for the financial cost of borrowed money. Marglin has suggested that individuals, in their public role as citizens, may be willing to save for future generations if others are willing to do so (20-99).

Feldstein provides an interesting graphic representation of the theory by utilizing Fisher's two-period indifference curve analysis. The indifference curves represent two-period STP functions, reflecting the social consumption-utility function in terms of total and per capita consumption, the rate of population growth, and the pure time preference discount rate. The slope of these curves at any point indicates society's marginal rate of substitution of present for future goods – the STP rate between the two years. The STP rate is, thus, defined for each point in the consumption space in terms of the STP function. This rate reflects the government's judgment of the relative social utility of consumption at different points in time. Through time, the STP rate may vary in response to changes in the consumption levels and growth rates, the rate of population growth, and the pure time preference rate. It is not unreasonable to expect the STP rate to rise as a function of time.

When one critically views the social rate of time preference approach, it is impossible to refute the argument that what appears optimal in the private sector is hardly socially optimal owing to the presence of private costs and benefits not always equalling social costs and benefits, i.e., owing to externalities. Indeed, externalities are a partial defense for the need of government investments and regulations. Also, this approach actually incorporates the opportunity cost approach by assigning shadow prices to reflect the productivity of funds in private investment along with the social time preference (6-379). Therefore, this becomes a type of systems analysis approach where both market and nonmarket information is placed before a supposedly informed, nonbiased, rational decision-maker (the government). The result may closely approximate the rate from the opportunity cost approach; however, debate seems to become exponentially more prevalent as the STP rate decreases below this private sector rate.

The social rate of time preference approach has been used as an argument in favor of low discount rates for long-term capital-intensive government projects. This has resulted in instances where the rate of return in the private sector has been two, three, even four times greater than the discount rate used by some public agencies in their B/C analyses. For example, in 1968 the average rate of return in the private sector was nearly 12 percent, while the discount rate used for federal water resources projects was 3¼ percent (16-21). This effectively taxes the present generation for the benefit of future generations. The argument by Marglin that individuals, in their public role as citizens, may be willing to save for future generations, if others are also willing to do so, has been strongly disputed by Tullock and Lind.

Tullock notes that, although the saving by one group for the material benefit of another group may be magnanimous, the idea of a present generation saving for the benefit of a future generation may be unrealistic, since the next generation will probably be relatively more wealthy, even if the discount rate used is that determined in the private sector (28-334). Baumol describes Marglin's scheme as "a Robin Hood—activity stood on its head" (3-800). Even more critical of Marglin's contention is an analysis of his so-called mathematical proof, e.g., 1) even Marglin terms his assumed value for the marginal utility an individual places upon consumption by the next generation relative to his own as "altruistic indeed" (19-102) and 2) his linear equation puts the possibility of one generation bestowing charity to both its own members and future generations in clear opposition (28-334). However, collective provision by a present generation for its poor seems more likely than investment to benefit future generations in general (i.e., the rich and poor alike). The crises of our cities, the problems of the impoverished and underprivileged minorities, and a variety of other critical issues may well require, for their resolution, increased governmental activity. But these call for investments whose yield is quickly obtainable, not long term investments, the bulk of whose benefits will become available in the more distant future. Advocacy of a very low discount rate in these circumstances is tantamount to the view that those immediate problems are not very pressing, and that society's resources are better transferred to the service of the wealthier, future generations (27-50).

Lind continues the criticism of Marglin's work by showing that so long as there exists an overlap in the life span of different generations, then, a generation which derives satisfaction solely from its own consumption may rationally undertake investments that will outlive it, since the titles to capital goods can be transferred to each succeeding generation in exchange for consumption goods in exactly the same way as private individuals complete such transactions in the market (18-337). Additionally, it follows that the government may undertake long term investments in order to maximize the utility that the electorate derives from its consumption. Projects will be chosen which offer the highest return, regardless of their longevity. Thus, the fact that a government does undertake long term investment projects does not necessarily show either that: 1) the government has violated the preferences of the electorate, 2) the electors are schizophrenic with regard to preferences revealed in the market and at the ballot box, or 3) the present generation derives utility from the consumption of future generations.

Baumol adds to this repertory of reasons to question the argument that the discount rate should be kept very low in order to induce an increase in investment today, as a contribution to the Nation's welfare tomorrow. Surely, if society's investment for the future is considered to be inadequate, the appropriate remedy is to institute simultaneous inducements to both private and public capital formation (27-500). Actually, Baumol may be over extending himself with this statement. It is questionable just how much the government can stimulate more capital formation given a full-employment economy. Nevertheless, he legitimately says that artificially low discount rates on public projects introduce serious inefficiencies into the investment process by causing the withdrawal of resources from areas of use in which the yield is high and transferring them to areas in which their return is low.

Those who maintain that there exists inadequate provision for the future often draw incorrect inferences from irrelevant particular cases. It is hard to argue with the conservationists' view that the destruction of irreplaceable natural resources imposes a heavy cost on posterity. The destruction of a portion of a canyon, the extinction of a wildlife species, and the extreme erosion of soil are all matters of serious concern because they are carried to the point of irreversibility. This is the point where conservationists and economists merge in urging increased care in avoiding depletion of our resources. However, it is not legitimate to jump from this valid point to the questionable conclusion that each generation is constrained to engage in "overall" efforts to support its posterity far beyond the level indicated by a free market system.

III. INCLUSION OF RISK AND UNCERTAINTY, TAXATION, INTANGIBLES AND INFLATION IN THE DETERMINATION OF THE DISCOUNT RATE.

Any discussion of discount rates used in B/C analysis mentions risk and uncertainty, taxes, intangibles, externalities, and inflation. These factors were often improperly incorporated into the B/C framework. Therefore, it is appropriate to discuss these areas and to try to clarify a situation left unclear by the general literature.

Risk and Uncertainty

While risk and uncertainty have different connotations ("risk" suggests the potential variability of the objective configuration of events, while "uncertainty" underlies our subjective lack of knowledge as to which configuration will become reality), Hirshleifer and Shapiro's approach will be adopted – no formal distinction will be made between them (26-506). Both terms will be used to express a situation in which, whether for objective or subjective reasons, analysis requires us to take account of the possibility of a number of alternative outcomes, or consequences of actions.

One tradition in the literature attempts to distinguish between risk and uncertainty on the basis of ability to express the possible variability of outcomes in terms of a probability distribution. According to this tradition, when one does not know the specific outcome, but does know the probability distribution, there exists risk; when one does not even know the probability distribution, there exists "uncertainty." This distinction has proven sterile. One cannot, in practice, act rationally without summarizing his information (or conversely, his uncertainty) in the form of a probability distribution (27-508). Actually, even all probability distributions contain subjectivity. It is only when there exists a general consensus concerning a certain probability of an event that the variability of the event is said to exhibit an objective configuration.

The word "risk" exists in two different senses that are often confused. In one sense, risk is the danger that reality might somehow fall short of expectation. A more neutral use of the word in technical literature refers to the fact of variability of "outcome," whether favorable or unfavorable. From now on, "risk aversion" will be used synonymously with this case. The distinction can be clarified by the concept of "expected value." Given a probability distribution of numerical (dollar) outcomes, the expected value is the probability-weighted-average. Use of the mathematical expectation can be regarded as a "correction for optimistic or pessimistic bias," and must not be confused with adjustments that might be made to allow for variability of "attitudes" toward risk. From now on, "attitudinal risk aversion" will be used synonymously with this case.

Hirshleifer and Shapiro believe that in dealing with attitudinal risk aversion one is no longer in a position to make allowances, or corrections, merely in terms of mathematics because an element of taste enters through the investor's degree of risk-preference. While the expected value represents a correction or allowance for bias, an allowance for attitudinal risk aversion leads to the concept of the certainty-equivalent value of an uncertain outcome (29-507).

One important issue, where the two concepts of risk have caused confusion, concerns the ability of the government to "pool" a large number of independent investments, and, thereby (it has been alleged), to "ignore risk." The underlying idea here rests upon the statistical law of large numbers. This law states that if there exists a large number of independent projects, no project(s) so large as to affect the overall results, then the average outcome obtained will approximate the mathematical expected value. This generates the idea that the government may sometimes be in a position to ignore risk in the sense of variability of outcome. The mathematical expectation of return on government investments becomes almost a certainty overall. However, if the risk in question is because the returns from government projects are typically stated in an over–optimistic way, then the law of large numbers is not applicable. The fact that the government engages in many such projects will in no way eliminate bias. Haveman (1972), found this problem of over optimistic estimation of benefits to be quite prevalent in public water resources investments[2] (10-13).

Turning to authors who seem to accept that risks from variability in outcome are a social cost to be considered in government investment decisions, the vast majority agree that adjustment has to be via the discount rate. However, Arrow argues for the exclusion of a risk premium from the public discount rate:

> ...it is argued that the government should not display risk aversion in its behavior. Hence, the proper procedure is to compute the expected values of benefits and costs, and discount them at a riskless rate,...(1-28)

Fred Hoffman, the 1968 Assistant Director of the Bureau of Budget, testified:

> While I certainly do not wish to argue that Government programs are riskless—on the contrary, they are often subject to considerable risk—I believe that better decisions are likely to result from considering risks explicitly by adjusting the expected costs and benefits than by attempting to relate the average risk of peculiarly public programs to "similarly risky" investments in the private sector (16-27).

Most authors, while possibly arguing that such procedure might be desirable in principle, rule it out as impractical; e.g., Hirshleifer, DeHaven, and Milliman state:

> Unfortunately the logically purest method has a fatal flaw. Who is to say when project benefits and costs have been estimated so conservatively as to be effectively riskless? Probably all agencies, if asked, would assert that their own B/C estimates are highly conservative. The trouble is that there is no outside check on the reliability of the estimates (13-144).

The mainstream of debate on the evaluation of risky government investment projects has turned upon the selection of the appropriate discount rate to allow for "optimism bias." The different views may be classified according to whether they presume that divergence in observed interest rates fundamentally represents: a) the influence of market segmentation or other imperfections or b) the systematic and predictable influence of differing riskiness. Any such classification can not be entirely hard and fast. Some authors may maintain an intermediate position, and others may not pose the issue clearly one way or the other. Nevertheless, it is possible, at least as a first approximation, to classify those whose views are primarily based upon the "market" imperfections hypothesis vs. those of the harmony hypothesis (27-515).

For those following the market imperfections approach, the inclination is to apply some across-the-board addition to the discount rate for all government projects. Eckstein proposes a general risk premium of ½ to 1 percent (5-86). In another work, Krutilla and Eckstein conduct an elaborate analysis to determine the social opportunity cost of federal tax financing. They examine the differential impact upon the various investing and consuming sectors to provide weights for averaging typical yields in these various, sectors. The government discount rate derived incorporates some degree of risk premium—in terms of both optimistic bias and variability of attitudes (17-93, 102).

Those authors following the harmonistic hypothesis are led to seek a discount rate in the private market that is somehow related to, or reflective of, the same type of risks as are the government projects considered. According to Hirshleifer, DeHaven, and Milliman:

> ...attempt to determine the real marginal opportunity rate which the market insists upon in providing capital to private companies whose investment

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[2]Haveman only viewed direct benefits and costs in his expost analysis (10-XIV).

decisions are most comparable to those of public agencies in water supply (13-146).

Harberger testified:

> ...a better approach would be to try to identify especially risky Government investments, investments of medium risk, and investments of demonstrably low risk and to make separate risk adjustments for each of these three categories, ...have a higher than average discount rate for those... being highly speculative and a lower than average discount rate for those types with assured histories of proven payoffs (16-72).

Bains, Cover, and Margolis seem to espouse a similar harmonistic viewpoint:

> Briefly, however, it would appear that, in order to secure the optimal or best attainable suboptimal allocation of resources to water development (given existing organization and performance in the private sector, including the organization of markets for funds), the appropriate discount rate should be roughly equal to the marginal rate of return in marginal long-term investments in the private sector and also equal to the marginal rate of time preference of the taxpayers of the agency who ultimately finance the bulk of investments in water projects. These two rates tend generally to coincide and to be approximated by the going net rate of interest on private savings invested in real estate (26-516).

Baumol continues with this opportunity cost approach by proposing that the very absence of real risk in government projects means that the private discount rate should also enter the social discount rate (3-795).

The different authors quoted were concerned only with risk in variability of outcome. Arrow and Hoffman were correct in believing that these risks should be incorporated directly into the cost and benefit streams for public projects. Given the probability distribution of an outcome, the expected value is the probability weighted average for a benefit or cost, e.g.:

Value B_{10} (net) $\$106$	Probability of occurrance
0.7	0.1
0.9	0.2
1.1	0.3
1.3	0.3
1.5	0.1

The expected value (E B_{10}) is $\$1.12$ x 10^6. This should be placed into the net benefit stream, rather than have any adjustment in the discount rate, to present the clearest possible picture of project effects. The idea that raising a discount rate will alleviate the problem of fudging the net benefits is unsound. There exists little possibility of preventing any agency from overstating benefits to compensate for any increase in the discount rate.

However, under the opportunity cost approach one coordinates public and private sector rates of return. When one views the private sector, he discovers that there also exists "attitudinal" risk aversion. To be more specific, the only valid distinction to be made between public and individual investments is one resting upon the magnitude, variety, and number of investments undertaken. In virtue of its investment in a large number of projects, decisions on government investments should tend to be rational in an "actuarial" sense (i.e., based purely upon the expected value); whereas, many private concerns, in virtue of their limited resources, can be expected to make rational decisions also in a "utility" sense (i.e., there exists attitudinal risk aversion), (22-301) tending toward nonspecialization in investments (12-255). The greater resources at the disposal of the government enables it to bear losses that could be fatal to a private firm. Therefore, risk in the private sector due to variability of outcome should also be incorporated into the net benefit stream. However, one is still left with the problem of determining the proper procedure for incorporating attitudinal risk aversion into the present value analysis.

Actually, it is unclear how the risk-loving and risk-avoiding preferences of individuals should be composed into an overall factor. One argument could be that since such risk cannot be considered on the basis of an objective configuration of events, they should be included into the present value calculations through an adjustment to the discount rate. Contrarily, since all probabilities contain subjectivity, and a discussion upon the degree of subjectivity present is possibly futile, there exists a valid argument that such risks should logically be incorporated into the net benefit stream. If this latter case is accepted as the most logical approach, them a policy of adjusting the discount rate disguises the present problem and hinders its proper solution. However, thus far, the supposed impossibilities of cardinal utility measure and interpersonal utility comparison have prevented development in this area of risk analysis.

Given the opportunity cost approach, if the private rate of return is adjusted for the attitudinal risk aversion factor, then this same rate could be proposed for the public sector.[3] If the public sector used this private discount rate, it may be argued that its behavior, effectively, becomes attitudinal risk averse also. If the public sector does not adopt this premium to its discount rate, then the government should in no way appear averse to risk.

Before leaving the subject of risk, two more areas should be clarified. First, Arrow and Lind state:

> The implication is that if a risky investment in the private sector is displaced by a public investment with a lower expected return, but with a higher return when appropriate adjustments are made for risks, this represents a Hicks-Kaldor improvement (2-375).

They give the example:

> ...a private individual had an investment opportunity with a 10 percent expected rate of return. However, after the investor made a risk adjustment, his rate of return was 5 percent. Simultaneously a government could invest the same money with a 6 percent expected return. Since risk would be spread over all taxpayers, the cost of the risk-bearing would be negligible, and the true rate of return would be 6 percent. Further suppose that if the public investment were adopted, it would displace the private investment... Given the private investor is indifferent between the investment with the expected return of 10 percent, and a certain rate of 5 percent, and the public investment has a certain rate of 6 percent, by undertaking the investment the government could more than pay the opportunity cost to the private investor of 5 percent associated with the diversion of funds from private investment.

Such an example hardly indicates a Hicks-Kaldor improvement for a society. The 6 percent expected return is actually no more certain than the 10 percent expected return. The example states that the investor is indifferent between the certain 5 percent and expected 10 percent returns, but for society to witness a Hicks-Kaldor improvement the investor would have to prefer the certain 5 percent return over 80 percent of the time, compared with the expected return, e.g.:

$$.05\ (.80) + .10\ (.20) = .06 = \text{government return}$$

The Arrow and Lind example also lays the groundwork for a last point. When Government finances a project, the cost of the risk is spread over all the taxpayers, thus becoming negligible. However from the point of view of society, a private project is equally riskless as a public project. Society benefits from the entire set of investment projects, whether public or private. When the summation is taken of all private projects,

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[3]Note: If all private entities would follow the procedure of adjusting their net benefit streams for risk aversion, then possibly the market average amount of adjustment to the discount rate for the remaining risk would serve as a proxy for the weights by which the net benefit streams should be adjusted for attitudinal risk aversion.

then the law of large numbers can be applied to the private sector also. From society's viewpoint, all investments should be evaluated at their expected (value) earnings. Transfer into Government hands does not alleviate risk as some literature may indicate (3-795). Transfer into Government hands only minimizes the cost of risk on an individual human basis.

Taxation

For any private sector whose returns are taxed at a rate such that the fraction, 1/M, of the returns remains after taxes, to adjust the opportunity cost rate for resources withdrawn from this sector, multiply M times the nontax rate of return, r, e.g.:

	tax rate	net returns: 1/M	adjustment: Mr	
Corporate sector	50%	½	2r	
partnership	25%	¾	4/3r	(15-494)

Given the diverse opportunity cost figures for resources withdrawn from the different sectors, one could possibly take the summation of a weighted average of the separate opportunity costs to calculate a single discount rate for evaluating a government project. Note must be taken, however, that the table shown utilizes a present value formula regarding the stream of net benefits constant and infinite. Granted that it is impossible to say exactly when the reverberations from an investment stop, one may not pragmatically say the net benefit stream will be constant throughout infinity.

To be more specific, assume the corporate sector experiences a 50 prcent tax rate, and individuals are free to invest in either corporate stocks or Government bonds at 5 percent. The corporate sector must receive at least a 10 percent rate of return. Assuming that the investments generate constant benefit streams over infinity, the present value (PV) formula becomes:

$PV = S/i$ S = benefit stream

i = interest rate (Government) (G)
(Corporate) (C)

For the PV of the two sectors to be equal, the discount rate used by the public sector must be twice that of the private sector:

$$\frac{1000}{iG} = \frac{500}{iC} \qquad \text{Assume } iC = 0.1$$

$$(0.1)\ (1000) = iG(500);\ iG = 0.2$$

Therefore iG = 2 iC

However, what if the time period is only one year?

$$\frac{1000}{1+iG} = \frac{500}{1.1C}$$

Then iG = 12 iC

These two cases show the possible extremes with respect to time. One should actually consider the PV formula for a project with a finite life. Given a constant benefit stream, the formula becomes:

$$PV = S/i\ [\ 1- \frac{1}{(1+i)^n}\ ] \qquad n = \text{No. of years}$$

Regardless, it is obvious that the opportunity cost approach based upon PV analysis may dictate that the public sector should adjust its discount rate by more than the reciprocal of the fraction of returns left after taxes.

Intangibles

Intangibles will be defined as consequences which cannot be assigned a monetary value but which should be considered when deciding whether or not to invest in a project. Some intangibles cannot be quantified, and others, although they can be quantified, cannot be valued in any market sense. Intangibles include life saving, improvement of health, improved environmental esthetics, and the preservation of areas possessing unique natural beauty and scenic, historical, or scientific interest.

When intangibles are present, a benefit/effectiveness analysis is used to indicate a project's economic feasibility. When intangibles are not present, the traditional B/C analysis is used to indicate financial feasibility. Financial feasibility means the investment is self-liquidating, generating revenues which cover all costs (15). Essentially, this is what a private investor is concerned with. Economic feasibility means the economic valuation of benefits and costs. This may diverge from actual market outlays and receipts. The relevant decision-maker decides if the open market has done justice in its valuation from society's point of view in determining whether or not there should be an investment.

On December 21, 1971, the *Federal Register* published the preliminary proposals indicating the position of the Water Resources Council. Although these proposals never entirely became effective, they included a 10 percent discount rate but an actual usage of a 7 percent rate to allow more comparable consideration of environmental quality objectives. Such an adjustment to the discount rate shows a high premium placed upon intangibles.

Regardless of the degree to which intangibles are a legitimate major factor in cost/effectiveness analysis, they do exist and should be properly handled. Ecological aspects should be considered along with the economic, demographic, political, and sociological aspects in the decision-making process. Their logical point of incorporation is in the benefits and costs. Their measurement through social indicators and other proxies is far from complete, but habitual adjustment of the discount rate can easily preclude intensive study in this important area. If a direct cardinal measure is impossible, dollar weights could be assigned to ordinal measures derived from some type of voting, sampling, sensitivity analysis, etc. processes. Actually, specifying a 3 percent reduction in the discount rate used against the net benefits could easily be transformed into a dollar value that could be applied to the benefit stream, but, if an agency is uncertain as to the actual benefit stream generated, how can it be certain about the discount rate adjustment to compensate for the original uncertainty?

An upward adjustment in the discount rate for the economy would bring forth faster the exhaustion of stock resources. If the rate of discount for water projects is lower than the general discount rate in the economy, because of the limited suitable sites, the rate of exhaustion will be reduced. It appears that the rate of discount for material resource projects should be in line with the discount rate in the economy and risk and preservation be included in the benefit and cost calculations.

Pigou felt (along with the conservationists) that the future welfare of society (at least as it depended upon the endowment of scarce exhaustible resources) needed protection and was not adequately reflected in private time preferences. His solution, a lower discount rate, was vague, however, in that is not clear whether the lower rate was to apply solely to some particular projects in the public sector, to all such projects, or even to all of the investment opportunities in an economy. Fisher and Krutilla (7) argue that attempts to tinker with an otherwise appropriate social discount rate for the purpose of conserving material resources are at best arbitrary and are in fact likely to result in more rapid exploitation of at least some of these resources as well as particularly wasteful use of what they call as environmental resources.

Externalities

Turning the attention to externalities, it can be said that externalities are a function of space, time, and structural variables.[4] They exist whenever one entity, through its production and/or consumption, knowingly or unknowingly, affects the utility and/or production function of another entity, such that there exists an inequality between private and social benefits and costs.

The inability of the private market to efficiently cope with external effects is a major argument for government intervention. The public viewpoint incorporates all costs and all benefits to whomsoever they may accrue. Therefore, the costs and benefits of externalities should be incorporated directly into the net benefit stream in any PV calculation. Baumol is wrong when he says that the discount rate should be the adjustment mechanism (27-498). Again, this would only prevent the presentation of the

[4]Pecuniary externalities are not considered here because they effectively, are transfer payments. Economic efficiency is not affected but income distribution is. The evaluation of pecuniary externalities is in the scope of 1st-but not 2nd-order efficiency (15-108).

true picture and discourage the development of optimal valuation techniques.

Inflation

PV calculation compares relative values by expressing consequences in commensurable units. The most satisfactory value unit is money expressed in constant dollars, specified by date. Trends in general level should never be incorporated in economic analyses. Indeed, the PV does not change whether the net benefit stream and discount rate incorporate an inflation factor or not.

Example: Let r be the discount rate applicable in the case of steady prices:

B_i = net benefits

$$PV = -Co + \frac{B_1}{(1+r)} = \frac{B_2}{(1+r)^2} + \ldots + \frac{B_n}{(1+r)^n}$$

Now assume there exists a general inflation of G percent per year. B_i increases, and the discount rate incorporates an inflationary premium.

$$PV = -Co + \frac{B_1\ (1+G)}{(1+r)\ (1+G)} + \ldots + \frac{B_n\ (1+G)^n}{(1+r)^n\ (1+G)^n}$$

Obviously the inflationary terms factor out, and the equation remains in constant terms.

Only when dealing with goods and services subject to differential inflation – whose price is expected to change relative to the general price level – does the current normalized price in constant dollars need adjustment. This is done by calculating the value of the transaction as the product of the expected future cost and the ratio of the present to the future value of money.

Example: If the value of money changes from 100 to 150 (determined by a general price index) while the value of an item changes from 100 to 200 (determined by a specific cost index), the future cost in present dollars will be ($200) ($100/$150), or $133. Uncertainty in predicting future differential inflation precludes extending this adjustment more than 10 years into the future (15-210).

Just as for economic analyses, trends in general price levels have little place in financial analyses, except for short-term changes between the appropriation and expenditure of funds. A bond issue, or appropriation, based upon current prices may not be adequate at the time funds are expended. Also, during a period of general inflation, a public investment financed through a bond issue may effectively have an inflationary factor built into its discount rate since these government bonds must compete with private issues that incorporate an inflationary factor. However, this would be the only case when the discount rate for a federal project could correctly include an inflationary factor, and it is rare that a federal water resources project is financed in this manner.

IV. INSTITUTIONAL FACTOR

Federal agencies concerned with the use of water and related natural resources have witnessed its development with respect to economic demands and social objectives at least since the Flood Control Act of 1936, which provided for the authorization of federal activities in regard to navigation and flood control: "if the benefits to whomsoever they may accrue are in excess of estimated costs...". In October 1961, President Kennedy called for an "up-to-date set of uniform standards" that resulted in Senate Document 97, published in May 1962, providing that:

> The interest rate to be used in plan formulation and evaluation for discounting future benefits and computing costs...shall be based upon the average rate of interest payable by the Treasury (i.e., the coupon rate) on interest bearing marketable securities of the United States, outstanding at the end of the fiscal year preceding such computation which upon original issue had terms to maturity of 15 years or more (16-12).

Six years later, the Budget Message that President Johnson sent to Congress on January 29, 1968 informed Congress that the Water Resources Council was developing a more appropriate interest rate to be applied in formulating and evaluating water projects. President Johnson referred, in this regard, to the Council, owing to Section 103 of the Water Resources Planning Act that provides:

> The Council shall establish, after such consultation with other interested entities, both Federal and non-Federal, as the Council shall find appropriate, and with the approval of the President, principles, standards, and procedures for Federal participants in the preparation of comprehensive regional or river basin plans and for the formulation and evaluation of Federal water and related land resources projects (16-11).

The work of the Council resulted in a change from the policy set out in Senate Document 97. The formula for the discount rate was now based upon the yield rather than upon the coupon rate of the same set of securities. This raised the discount rate used from 3¼ to 4-4/5 percent as of December 24, 1968.

On December 21, 1971 the Water Resources Council published new proposed principles and standards in the *Federal Register*. The proposed discount rate was 10 percent, approximating the average of the marginal returns on physical investment in the non-federal sector. However, this was to be reduced to 7 percent in the actual PV calculations to allow more comparable considerations of environmental quality within a multiple objective framework. These proposals did not meet sufficient approval of all the required sources to become officially advocated by the Council.

In 1973 the Council met jointly with the Federal Treasury to define a new formula for deriving the proper discount rate. The number of legitimate government securities under the old formula was becoming scarce. A new formula was devised which the Council and Treasury perceived to be more appropriate. This formula was made part of the official 1973 Standards for Planning Water and Related Land Resources. The new formula changed the then present discount rate from 5-5/8 to 6-7/8 percent. This appeared in the *Federal Register* on September 10, 1973 and became effective on October 25, 1973. However, its life span was short. Section 80 of the Water Resources Planning Act of 1974 (P.L.–93251) amended the 1973 Standards for Planning Water and Related Land Resources, and became effective as of March 7, 1974. Relevant portions of Section 80 are as follows:

> The discount rate will be established in accordance with the concept that the government's investment decisions are related to the cost of federal borrowing.
>
> (a) The interest rate to be used in plan formulation and evaluation for discounting future benefits and computing costs...shall be based upon the average yield during the preceding fiscal year on interest bearing marketable securities of the United States which at the time the computation is made, have terms of 15 years or more remaining to maturity: provided, however, that in no event shall the rate be increased or decreased more than ¼ of 1 percent for any year. The average yield shall be computed as the average during the fiscal year of the daily bid prices. Where the average rate so computed is not a multiple of 1/8 of 1 percent, the rate of interest shall be a multiple of 1/8 of 1 percent nearest to such average rate.
>
> (b) The computation shall be made as of July 1 of each year, and the rate thus computed shall be used during the succeeding 12 months. The Director shall annually request the Secretary of Treasury to inform the Water Resources Council of the rate thus computed (32-30-253).

Section 80, effectively, was a change back to the procedure used prior to the 1973

Standards for Planning Water and Related Land Resources.

On July 17, 1974 the Treasury informed the Council that the interest rate would be 6½ percent based upon the formula in Section 80, paragraph (a). However, paragraph (a) also limited the Council to an increase of ¼ percent, up to 5-7/8 percent. Since 1968, the Council has increased the discount rate by the full ¼ of 1 percent each year.

Decisions to invest federal funds in water resource projects are not determined by popular vote. The government avails itself with a general mandate, conferred upon it by an election, to delegate powers of decision at various levels at hierarchy. It is apparent, from the hearings of the Joint Economic Committee following President Johnson's Budget Message on January 29, 1968, that the members of the Senate Interior Committee come consistently from the Western States. The investment decisions may not be primarily motivated by the desire to advance the general welfare of the entire society, but are rather the outcome of purely political conflicts. Therefore, government may not always act as the repository and defender of social conscience on all economic questions, but rather as a complex institution composed of human beings with their own self-centered needs and desires.

V. CONCLUSION

The debate on the proper discount rate for government investments centers upon the divergence between the rate derived from the objective opportunity cost approach vs. that from the subjective social rate of time preference (STP) approach. If the rates are equal, there is no problem; however, debate seems to increase exponentially as the STP rate lowers from the opportunity cost rate. The opportunity cost approach is based upon the individual market valuations of the existing consumers within a society. The STP approach maintains that since a society is composed of future generations also, government must act as the guardian of the welfare of posterity and the present generation simultaneously. If government decides that the present generation is not bestowing proper consideration to the future, i.e., not making sufficient sacrifice through the market system, then government may redistribute more consumption to the future by using a discount rate in its investments that is less than the private opportunity cost. Since our notion of efficiency is relative to a distribution of income, redistribution to future generations causes the market interest rate to lose its usual meaning as an efficiency price. When one tries to mix distribution theory with production theory, the market system breaks down.

Actually, the decision not to abide by the market judgment need not be based entirely upon ethical considerations. The real capital market is not perfect. Consequently, the actual intertemporal choices in our market economy, including the determination of the overall level of savings and investment, may not be perfect. Another pertinent consideration is that when one accepts a market rate of interest determined by the present generation's preferences, he implicitly accepts this as his time preference. With the power of the ballot distributed differently from the power of the purse, the community — when acting collectively through the political process — may decide upon a distribution of consumption among generations different from the distribution it indicates through its saving behavior.

These arguments provide a point of contact between economic analysis and conservationist philosophy. Most of the policies advocated in the name of conservation are designed to make stronger provision for the future than the market mechanism does. It may well be that the desire to redistribute income toward future generations can provide some rationale for continued use of a low interest rate. However, this line of argument has limitations. Insofar as a low interest rate leads to the justification of some projects at the expense of others which can produce a better return, the rate will result in a social loss, even within the water resource field. Perhaps the most extreme example was the attempt by Joseph Stalin in the Soviet Union to plan an industrialization process without using any interest rate. Projects of enormous scale and capital-intensity were started. The undertaking was saved only by the ingenuity of technicians in introducing interest-like criteria under other names.

The effects on investment from lowering the discount rate include: 1) increasing the optimum project size and capital-intensity; 2) being highly favorable to project justification; 3) favoring projects with longer lives; and 4) contributing to the growth and development of a region. Technological change is probably the biggest source of risk for these long-run projects. The risk that large amounts of capital will be tied to projects unusable by future generations may defeat the entire purpose of capital formation.

Although a low discount rate is favorable to the construction of public works projects and the interests which profit by project construction, excessive diversion of resources to the public sector is detrimental to economic and social efficiency, and, thus, to the long-run welfare of the nation. Solutions to pressing, current needs may have to be sacrificed for the benefit of, probably, wealthier, wiser, future generations. It is not possible to defend dogmatically, any exact discount rate for use in government planning, but too low a rate definitely has serious adverse consequences to national economic growth.

The social discount rate should, at least, equal the yield on long term government securities. Not all investments, however, should have to pass a narrow test of economic efficiency. Certain investments may have social goals which justify some sacrifice. However, when there exists a lower than realistic discount rate, this amounts to a subsidy and should be so termed. Nothing is gained by confusing sensible economic planning through an unrealistic interest rate policy. The social goals should be stated at the beginning, and the scarce resources should be subject to a policy of induced allocation to yield the maximum social return.

This paper indicates how risk and uncertainty taxation, intangibles, externalities, and inflation are properly incorporated into the calculations.

The analysis of the institutional factors demonstrates how one must examine this constraint along with the economic and social constraints for any real world problem. Rules which ignore the significance of organizational structure and goals for the selection and operation of projects are utopian. The teleological assumption that the government and all its agencies exist to maximize national welfare simplifies the task of the analyst, but unfortunately it renders impotent the rules formulated on that basis, unless the government is organized to serve that purpose.

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