The Interest Rate for Use in Water Resource Investment Planning

An Analysis of Alternatives

Prepared by the

Economics Committee

for the

Water Resources Council

October, 1967

TABLE OF CONTENTS

Summary

The purpose of this report is to review the theoretical and practical aspects of the interest rate for use in planning water resource projects and programs. No recommendations are presented as to the most appropriate theory on which to base such a rate or as to the actual numerical value and its method of calculation. The report discusses the alternatives and their implications, and is intended to provide a basis for evaluating alternative interest rate standards.

Most theories regarding the interest rate which should be used require some reference to market rates of interest or to market rates of return on capital. Market rates are determined through interactions of the supply and demand for investment funds. A complex set of factors involving individual time preferences in consumption, opportunities for profit, the general state of the economy, fiscal and monetary policy, the dynamics of speculation, inflation, risk, time of maturity of a bond, its tax status, and other determinants, influence the general level of market interest rates and the differentials among these rates at any given time.

Theories for determining the interest rate can be placed in four broad categories: the cost of borrowing money, the opportunity cost of capital, the social rate of time preference, and eclectic theories which are variations on combinations of the first three.

The cost of borrowing money theory is the one most closely associated with market rates of interest and has a practical advantage over the others

in that time series are available on which to base a numerical value. Two broad categories of alternatives within this theory are the interest rates paid on the Federal Government debt, or the interest rates which private industry pays in its bond financing.

The concept of opportunity cost signifies the rate of return which would be received if the resources were employed elsewhere. One type of opportunity cost is the internal rate of return of a marginal project within the sponsoring agency's own budget or within the total Federal budget for public works. Another type of opportunity cost is the marginal internal rate of return of investments undertaken in the private sector.

The social rate of time preference is the percentage difference between the value of a dollar payable today and the value of a dollar payable tomorrow in the collective eyes of society.

The eclectic theories include:

The "social cost of federal financing," that is, the average of interest rates faced in the borrowing and lending decisions by individuals and corporations who pay the taxes raised pay for public works.

A method recommended by consultants to the Bureau of the Budget whereby the social rate of time preference is used in converting costs and benefits to a common time basis but each dollar of capital cost is evaluated at its opportunity cost in other (private) uses.

A method whereby a long term social rate of time preference is used in project design, but a short term opportunity cost is used in deciding which set of designed projects should be included in the current program.

If a "market equivalent" is desired for use in evaluating public projects, actual market rates should not be used as such, but should be

corrected to account for differences between the market context and the public investment evaluation context. For example; market interest rates include an implicit allowance for inflation; however, if costs and benefits of public investment are to be evaluated in constant dollar terms, this allowance should be subtracted from the market rate to determine its "equivalent" in a public investment evaluation context.

Present water resource policy, as stated in Senate Document 97 of May 29, 1962, specified the weighted average coupon rate on bonds outstanding whose original maturity was 15 years or more. This calculated rate lags behing the time series of current yields on long-term government bonds and at present is about 1½ percentage points below this yield. This has been the official policy since the Bureau of the Budget Circular A-47 was issued in 1952. The "Green Book" recommends the average yield on Federal bonds of maturity roughly comparable to the life of the project.

Numerous time series for market rates are regularly published and can be used as bases for the interest rate. Various formulas such as moving averages, moving regressions, average coupon rates on bonds outstanding etc. can be applied to these time series as a basis for calculating the current value to be used. Though published time series lend themselves most directly to use in the "cost of borrowing money" theory, there is no conceptual reason why other time series corresponding to the other theories might not be constructed and used in an analogous way.

The use of different numerical values for the interest rate can have important effects on both project design and program planning. Using a higher interest rate will result in the justification of fewer and smaller projects at the design stage and will tend to shift priorities from capital intensive, late yielding, relatively "postponable" projects. to their opposites, at the program planning stage. Some empirical evidence indicates raising the interest rate from the rate historically used on water resource projects would have resulted in a considerable number of projects showing a benefit/cost ratio less than 1.0. It is difficult to deduce the impact that raising the rate will have on the size of the budget of "justified" projects in water resources, since the backlog may be so great that a substantial number of projects would continue to have benefit/cost ratios greater than 1.0. On the other hand, it is evident that relative project priorities would be severely altered, so that certain projects would replace others in the budget.

Historical series on interest rates reveal a correlation with the general state of the economy but also indicate the influence of Federal fiscal and monetary policy, which does not necessarily reflect priorities for public works. For example, in World War II monetary policy kept rates depressed in order to finance the war without high interest burdens. Using such low rates would tend to justify more public works, giving them implicit priority, even though the exact opposite was true in World War II. In fact, fewer projects were undertaken because public works budgets were small.

2. Introduction

The purpose of this report is to provide information for use by the Water Resources Council in reviewing its policy on interest rates. No recommendations are presented; the report is intended to provide a basis for discussion.

This introduction contains a brief discussion of the determinants of interest rates. It is followed by a discussion of the three principal theories and variations of these for determining the rate that should be used in public investment evaluation, and by a discussion of precautions to be taken regarding the use of market interest rates in the context of public investment planning. These theories are: the cost of borrowing money, the opportunity cost of capital, and the rate of time preference. Several official statements are cited, which specify the interest rate to be used in water resource planning. This is followed by examples of mechanical procedures which might be used for computing the interest rate using time series data. Following this is a discussion of the theoretical and practical implications of using different numerical values for the interest rate. An appendix contains a brief historical summary of market rate behavior.

2.1 Determinants of Interest Rates

Since most reasoning in support of a given interest rate for use in public investment evaluation involves some reference to market phenomena or market analogies, the following short discussion is presented by way of introduction.

2.1.1 Classical Equilibrium Theory

In classical equilbrium theory, investment funds are treated as if they were a commodity having a "supply curve," a "demand curve"

and the equivalent of an "equilibrium price," which is the interest rate. The demand curve describes the relationship between the interest rate and the amount of funds that enterprises are willing to commit to investment programs if the funds are offered at this rate. The downward sloping relation of interest rate plotted against amount of funds invested is said to arise from the decreasing marginal productivity of capital; that is, as more and more funds get invested, the marginal funds become less productive and the projects are undertaken only if the funds can be raised at lower rates. The upward sloping supply curve results from the unwillingness of savers to lend larger and larger amounts of money unless they get larger interest returns.

The demand curve is associated with the opportunity cost of capital at given levels of total capital expenditure. The supply curve is associated with the rate of time preference of individuals supplying the funds, i.e., with the marginal rate at which they are willing to substitute future consumption for present consumption at given levels of total consumption sacrificed.

2.1.2 Other Determinants

In addition to the forces recognized in classical theory, there are other forces which determine market rates of interest. The theory of these forces is too complicated to be discussed here and will therefore be described in general terms. The amount of funds entrepreneurs are willing to commit to investment (the "demand") is heavily dependent, at least in the short run, on factors such as prospects for profits, business

confidence, new inventions and other factors besides the interest rate. There is some question as to whether the "supply curve" really plays a role in the short run or whether what people save depends more on their disposable income and on other factors than on the interest rate offered them. Also, the phenomenon of speculation, which affects and which is affected by interest rate changes, cannot be explained in a simple static content of the intersection of supply and demand curves.

Against this background of forces, we have the Federal Reserve Board which can, in effect, raise or lower interest rates by its open market operations, bank discount rate policy, or reserve requirement policy. Federal Reserve Board monetary policy has as its principal goal the stabilization of the economy and of the balance of payments rather than the maintenance of an interest rate which is appropriate for use in economic evaluations of public investments. The Appendix contains some discussion of the historic role of the Federal Reserve Board monetary policy.

3. Theories of the Interest Rate for Use in Public Investment Planning

There are three broad groupings which can be said to categorize the different theories: the "cost of borrowing money" theory, which advocates the use of the market rate of interest which would be faced if one tried to borrow money to finance the public investment; the "opportunity cost of capital" theory which advocates the use of a rate which reflects the return which would be generated by alternate uses of the resources; the "time preference" theory which advocates the use of a

rate which reflects an individual's, or society's, relative evaluation of the same dollar benefits received this year against next year. Each of these theories is discussed below along with different variations and combinations of the principal ideas.

3.1 The Cost of Borrowing Money

The cost of borrowing money manifests itself in the market interest rate which must be paid to bond holders in order to attract this capital. Since there are many types of bonds, there are also many different market rates, as evidenced by the examples in figure 2.

3.1.1 The Federal Cost of Borrowing Money

The simplest rationale for the interest rate is to base it on the interest rate which the government pays as part of its regular operation. It is argued that the Federal Government is an institutional entity, its purchases accounting for about one-tenth of Gross National Product, that this important sector has its own cost of borrowing money in the market, and that this market rate is the appropriate one to use in evaluating government investments.

Given this rationale there are still a number of possible government market rates from which to choose. One possibility is to use market yield rates for Treasury obligations. Since the rates tend to differ for different maturities, it is necessary to specify the range of outstanding maturities over which the average yield is to be calculated. This range is typically chose to correspond as closely as possible to the average life of projects which are to be evaluated. This yield would be approximately equal to the rate which the government would have to pay if it were to borrow money for a comparable term. In fact, the

government has not issued long term bonds since 1963. In the current money market it could not issue such bonds because of a statute which sets an upper limit of 4-1/4% on the interest rate of long term bonds.

A second possiblity is to use the coupon rates on recent Treasury issues, say over the last year or so, regardless of maturities, on the grounds that this better represents the cost of money than a theoretical rate.

A third possibility is to use the average interest rate (of the coupon rates) now being paid on the entire national debt. Within this possibility there is the alternative of considering only marketable obligations instead of the entire debt.

A fourth possibility is to use the average coupon rate on Treasury issues outstanding whose original maturities fell in a certain range. To this fourth category belongs the currently specified interest rate for use in water resource investment evaluation.

Despite its apparent acceptance over the last 15 years, objections continue to be raised to the theory of using the Federal cost of borrowing money.

One important objection is that the government generally gets its revenue for water resource projects through general taxes and, to a small extent, user charges, rather than by borrowing money, so that the relevance of bond rates is questionable. Another point is that program planners should not be trying to maximize the government's "profit" in such a narrow sense; this would be impossible in practice in any case since the benefits accrue to the general public and are not directly returned to the government. Thus it would seem that for maximizing

"social profit" some sort of social rate of interest would be more relevant. There is some question as to whether federal borrowing rates are good measures of this rate.

3.1.2 Private Enterprise Cost of Borrowing Money

Since Treasury bonds are not directly associated with the financing of water resource projects, it would seem logical to look for non-government bond issues which are associated with water resources or with some closely related type of projects. Into this category fall the rates of interest for private power company bonds. Private power is an enterprise which is sometimes in direct competition with government sponsored water resource projects. It is argued that government projects should compete on equal terms with private ones in the same field, so that the private bond rate should be used. Here it is important to distinguish between the yield on all obligations and the yield on recent obligations since, for a given industry, there may be differences. The yield on recent obligations would seem to be the more reflective of the industry's current cost of borrowing. Another way of having the projects compete on equal terms is to evaluate both public and private projects as alternatives and to use the same interest rate (but not necessarily the private bond yield). Of course, if the rate used were lower than the private rate, there is a possibility that the private project would be superior and yet not be built because it did not measure up to the requirements of private investors.

It is not easy to find other examples which are as relevant as private power to which this theory might apply since other public water resource projects do not have as much functional competition. An

extension of the theory would require that public projects in general complete in the market for capital on equal terms. In this case it would seem appropriate to use one of the average yields on corporate bonds as shown in figure 1 to 4.

3.2 The Opportunity Cost of Capital

The opportunity cost of capital is the return which the capital would yield if invested elsewhere instead of in the project or program being evaluated. The rationale is that this opportunity cost should be used as an interest rate in the evaluation so that the project or program would not be undertaken unless it were to return more than any rivals which compete for the funds. This would theoretically assure that the project would have an efficiency advantage over alternative uses of resources. Clearly the interest rate would then vary depending on what "opportunities" are considered. There are opportunities within the public investment sphere of the agency having responsibility for the project; there are opportunities elsewhere in the Government; there are opportunities in the private sector. In each of these cases it can be debated whether the money for the water resource project would actually displace such investment opportunities. The theories described below are variations of the opportunity cost concept. Section 3.4 also contains related ideas.

3.2.1. Marginal Internal Rate of Return

Let us first assume that each project has only one feasible size or design, so that the interest rate is used only to determine whether a project is worth building. Assume further that we have given interest rate and that the "optimal set" of projects is that set of (independent) projects each of which has a positive net present value at the given

interest rate. Each of these projects would then have an internal rate of return (the discount rate which makes its net present value just equal to zero).

A budget restraint might not allow the "optimal" set of projects to be built. In this case the internal rate of return of the marginal project is greater than the interest rate used in determining the optimal set of projects without the budget restraint.

McKean (2)* advocates the use of the internal rate of return of the marginal project (implied by the budget restraint) as the interest rate for use in determining whether a project should be built. This amounts to the same procedure as ranking projects by their internal rates of return and choosing the set with the highest rates and which still fits into the restrained budget. McKean admits that this criterion is appropriate only if the proceeds of the projects can be reinvested at that same marginal internal rate of return and if one's goal is to maximize the worth of the projects and the reinvested proceeds at the end of the planning period. From this steams the principal theoretical argument against use of the marginal rate; the fact that typically the proceeds of public investment projects are not returned to the government and are more likely consumed or, in any case, not invested at the marginal rate, so that the reinvestment assumption is not valid. Another argument against this procedure is the difficulty and sometimes the ambiguity in calculating internal rates of return.

If we drop the assumption that each project has only one feasible design, then the size of a project can be influenced by the marginal internal rate of return, i.e., by the size of the total budget. In the

* Numbers in parentheses refer to citation on page 34.

general case of interdependent projects which may have different designs, the problem is a very complet one of jointly determining the interest rate and the constrained optimal set of optimally designed projects; i.e., the set which maximizes the net present value at the interest rate which just exhausts the restrained project design (project size) and the choice among projects is simultaneously determined using the same interest rate, as discussed at the end of section 6.3.

A more general case of this method is one in which there are several budget restraints, one for each future budget period. Marginal internal rates of return are generated between each successive set of budget periods by consideration of the opportunity cost of postponing the marginal project in each period to the next period. In effect this results in a variable interest rate which can be used to generate the appropriate discount factors for each year. These discount factors are then used for project design. This is an iterative process even more complex than the iterative process required for a single time period.

3.3.3 Opportunity Costs in Private Sector*

One school of thought claims that the interest rates used to evaluate projects should be the same in both the public and the private sector to avoid misallocation of resources into inferior projects in either sector. The observation is often made that private sector projects are usually not undertaken unless their rate of return is at least 20% before corporate profit taxes. Since this is clearly much higher than the interest rates commonly used by public agencies, it would seem to indicate

*See Raumol's paper (10) for a discussion of this concept.

that public agencies should use higher rates than they are using now.

Even if one accepts the theory of using a private sector opportunity cost it is necessary to consider making adjustments for the following factors when applying it to public investment evaluation.

(1) Inflation

(2) Risk

(3) Monoploy profits

(4) Technological externalities

Points (1) and (2) are discussed in section 3.4 below. Both would indicate that private opportunity costs should probably be adjusted downward. As to points (3) and (4) it is difficult to tell whether the private bias would lie on the cost side or on the benefit side, hence whether the correction to obtain the "equivalent" rate for public investment should be positive or negative. One would think that if the opportunity costs in all industries were somehow averaged, then points (3) and (4) would have no effect.

Another problem is measuring the private sector rate of return. Theoretically one would think of it in terms of the internal rate of return of the marginal private project. There would appear to be three ways of measuring this in theory. One is to ask industry planners the interest rate which they use to decide which projects are justified. This clearly presents problems. The second is to measure the historical experience of industries in terms of actual returns on "marginal" projects. The latter method is clearly not feasible since the returns on such projects would be negative and would represent outcomes which may

have had a very low probability and would not represent the expected value of returns to the marginal project. A third way would be to convert deflated dividends plus corporate taxes plus capital gains for all common stock to a rate of return. The latter method would yield an average (higher) opportunity cost rather than a marginal opportunity cost.

Instead of using some sort of industry wide opportunity cost, it might make more sense to examine the experience of industries which compete functionally with water resource projects. Private power and railroads are two examples.

Much of the argument for basing public rates on private rates of return is concerned with possible misallocations between public and private sectors. As a matter of fact public agency budgets have levels which tend to be set by criteria other than the interest rate, so that the budget limitations tend to make academic such misallocation. On the other hand, if the budget level were too high and the public agency interest rate too low, there would definitely be a slautary effect in using the higher rate of interest to point out the loss involved in maintaining the high budget level. Also, budget limitations usually do not have equivalent effects on the choice of a project design, so that in this field a possible misallocation is at the mercy of the interest rate, so to speak.

3.3 The Social Rate of Time Preference

The social rate of time preference may be, but is not necessarily, an interest rate. The social rate of time preference is the term used by academic economists for the weights to be given to consumption in different time periods by whomever sets the objectives for the economic

planners. In a dictatorship or monarchy this is determined by asking the ruler. In a democracy it might be defined as an average of the private rates of time preference of the individuals in the society and determined through a poll, the voting process, or market behavior. There has been much discussion of whether society should have a different rate of time preference than the individuals in it. It is argued that society as a whole is more concerned about the welfare of future generations than are the individuals in society. Another argument is the very simple one that people are too improvident in their day-to-day decisions, and that the government should look after them. Thus, for reasons of the superior wisdom or arbitrary decision of the government, externalities in consumption, or externalities in investment, the social rate of (government) time preference may differ from individual rates of time preference.

If the government attempts to decide on a social rate of time-preference by judgment, how might this be done? The first problem would be whether there is a pure rate of time preference. Is there any reason for a difference in preference for consumption now versus consumption in the future for individuals of identical income and other qualities? The answer would probably be no. The next problem would be how much richer will we be in the future? Given that future generations will be richer than current generations, how much are we, the poor, willing to sacrifice in order that richer future generations may consume more? As how rich the future generations will be depends on how much we sacrifice today, an iterative process would be called for.

An alternative approach would regard the social rate of time preference as an average of the individual rates of time preference. The basic argument is that each individual knows best how to weight consumption in different time periods. In equilibrium each individual adjusts his investing or borrowing so that there is no change in the time pattern of consumption open to him that will leave him thinking himself better off. In this situation (ignoring externalities) the government can leave the individual feeling better off only if it can transfer consumption between time periods in a way not open to the individual. In this situation it is suggested that the government determine the average rate at which individuals can exchange present consumption for future consumption, and build all projects which yield more than this. In this formulation the social rate of time preference is the average of the individual rates of time preference. It is used directly as an interest rate.

The individual rate of time preference can be measured by the after tax rate at which an individual is borrowing or lending and deducting the rate of inflation expected by the individual. If the individual is holding other than risk free investments, the part of the after tax rate of return that is a risk premium must be determined and deducted. A knowledge of the rates of return on risk free investments open to him can be useful here. Individuals who have negative net worths are usually presumed to use additional income to pay off debts. There is a problem in how to weight the time preferences of different individuals in deciding on a single social rate of discount. Are they weighted equally,

in proportion to how a tax cut would be distributed, or in proportion to benefits received? Different weighting may be appropriate for solving different problems.

3.4 Eclectic Theories

3.4.1 "Social Cost of Federal Financing"

The above is the title of a chapter in the book by krutilla and Eckstein (3) in which they argue that private preferences should rule and that these can be derived from market behavoir. They attempt to estimate the average time preferences of the individuals who would supply the funds used to finance water resource development. The rate applicable to funds used for consumption is the after tax borrowing or lending rate, depending on whether the individual is a net borrower or a net lender. (This corresponds conceptually to the private rate of time preference discussed under the Social Rate of Time Preference heading above). For funds which would otherwise be invested in the private sector, they used the before tax rate of return which is an opportunity cost concept. A weighted average of the various rates of return was suggested for use as an interest rate. What they measured is neither a rate of time preference nor an opportunity cost of capital, but a weighted average of the two. The two differ because of the income tax and risk premiums. This, however, would probably make little difference in the numerical value since the portion of funds invested turns out to be small in their formulation. They concluded that an interest rate of between 5 and 6% was appropriate in 1955.

3.4.2 Bureau of the Budget Consultants' Approach (4)

A panel of Consultants to BOB in 1961 developed an approach involving the use of a social rate of time preference with adjustments based on the

opportunity cost of capital. It rejected the argument that the social rate of time preference should be used directly as an interest rate without considering alternative use of the funds. It recommended computing the present value using the social rate of time preference, and choosing the alternative with the highest present value. Leaving the money in the private economy is included as one alternative. If the private rate of return exceeds the social rate of time preference, the present value of private investment foregone by investing a dollar in water resources exceeds the present value of the benefits foregone by the process of raising the funds. This opportunity cost depends on how the funds are raised, whether by borrowing or by a tax increase. If through taxes, it depends on who pays the increased taxes and whether they meet the taxes through reducing consumption or investment. Determining this opportunity cost is regarded as a technical economic question requiring further study. If there is an effective constraint on total public expenditure, the opportunity cost of foregone public expenditure is used if it exceeds the private opportunity cost. If there is an effective constraint on the water resource budget, the opportunity cost of foregone water resource investment becomes the limiting opportunity cost if it exceeds both the private and general public investment opportunity cost.

This standard is equivalent to using the social rate of time preference as a discount in project design but evaluating capital cost at its dollar value times a factor greater than unity. If it is desired to evaluate capital cost at its actual dollar value, it is possible to derive an equivalent interest rate which will give the same

results for a project yielding a specified stream of benefits for a specified number of years. The use of this interest rate for projects or project increments having different time streams of benefits than those used in deriving the rate can lead to incorrect decisions, since the equivalent rate would vary with the shape of the actual time stream of benefits. The rate derived in this way is the best single rate available for project justification. It will not be the best rate for choosing between equally costly projects having different shapes for the time stream of benefits, however.

The Consultants felt that this method would give a rate of 4 to 5% at the time of their study. They do not state the social rate of time preference implied by this rate. If changes in the water resource budget result in tax changes rather than changes in borrowing, the above method can be expected to give a rate close to the social rate of time preference, if the private and public alternatives are evaluated on a comparable time basis. The examples in the report compare private investments giving a perpetual stream of benefits with 50 to 100 year government projects. Their government interest rates derived include the amortization factor. Rates discussed by other authors do not.

3.4.3 Use of Two Interest Rates

Under most interest rate theories the interest rate appropriate for deciding which projects to build now will vary over time depending on monetary and fiscal policies, the tightness of budgetary constraints, the state of the economy, and other factors. For the decision on whether or not to build a project the current interest rate is appropriate.

Yet it is very difficult to recompute benefit/cost ratios every time interest rates change. There may be a long lag between project design and project construction. Thus, it has been suggested that a long term average rate be used for project design, and the current rates for project selection. (5) There is some question as to what one might use for a long term average rate that might be valid 50 to 100 years from now, i.e., whether there is a long term decline or a long term increase in interest rates. If there is a long term decline, then, as time goes on, earlier projects would appear to be undersized and to not utilize the site fully. On this basis it could be argued that it is necessary to use a long term average interest rate for project design even though a higher rate is being used for project selection in the first years.

3.4.4 The use of Market Rates in the Context of Public Investment Planning

The following discussion is applicable not only to the "cost of borrowing money" theory but also to the theories of sections 3.2 and 3.3 since, in all of the theories, it is possible to use market rates as bases for determining the interest rate to be employed. One must keep in mind the following points and make the necessary adjustments to conform to the particular theory or theories to which they apply.

(1) Market rates of return include an allowance for expected inflation. If an investment will return 8% when evaluated in future dollars, the same investment returns 6% in constant dollars if the investor expects a 2% inflation. If public costs and benefits are to be evaluated in constant dollar terms, the market rate should be reduced accordingly.

(2) Market rates of return may be quoted before corporate taxes or after corporate taxes. The appropriate position depends on the interpretation. The "before tax" rate is most appropriate if the market rate is used to reflect the productivity of capital in the private sector, while the "after tax" rate is most appropriate as an indication of a rate of time preference.

(3) Market rates of return include risk allowances of varying degree. This can have two interpretations:

(i) One element of risk allowance indicates simply that the computation of market rate is not based on expected value of benefits in the probabilistic sense but on some expectation "if all goes well". For this reason, high risk bonds have higher rates to compensate for the higher probability that the payments to the bondholders will not materialize. The expected value of the rates is actually somewhat lower. Since evaluation of public projects should be based on expected value of benefits, this element of risk allowance should be subtracted from the market rate.

(ii) A second element of risk allowance is principally applicable to the "opportunity cost" theory and depends on the size of firm which is undertaking the private sector projects upon which the rate of return is based. If such a firm is small then

not losing a large sum would be more important than gaining the same large sum since a loss could mean total failure.* Whether or not to subtract this element of risk allowance becomes a philosophical question. It should not be subtracted if we believe funds should not be diverted to the government just because the government happens to be a large institution which can pool its risks. It should be subtracted if we believe the government should undertake needed projects which the private sector will not build simply because it cannot pool risks.

(4) Market interest rates are influenced by Federal monetary policy, which has primary goals only remotely related to public investment evaluations. Thus, we may want to use a long term average of certain market rates so as not to reflect unduly the policy of the moment, or we might want to apply a correction to even long term averages to remove what might be considered long term bias such as the artifically low interest rates of World War II.

4. Official Statements Relative to Water Resources

From December 31, 1952, to May 29, 1962, the official position on the interest rate was contained in Bureau of the Budget Circular A-47 (6). From May 29, 1962, to the present it has been embodied in Senate Document 97 (7). Since 1950 several semi-official have been prepared, the most important is which was the "Green Book," (8) originally issued in 1950 and revised in 1958.

* This phenomonon is related to the "St Petersburg Parodox", in which it is shown that a man will not pay very much money to enter a betting game even though the expected value of his earnings is infinite.

4.1 Bureau of the Budget Circular A-47

Bureau of the Budget Circular A-47 states that the rate of interest should be the average rate payable by the Treasury on marketable securities outstanding at the end of the preceding fiscal year having terms of maturity not more than 12 months longer or 12 months shorter than the economic life of the project. For projects with economic life longer than 15 years the rate should be for Treasury bonds outstanding with 15 years or more maturity. It makes an exception, however, for the interest rate on project costs to be financed by non-federal sources.

4.2 Senate Document 97

Senate Document 97 prescribes essentially the same cirterion as Circular A-47 but does not make an exception in the case of non-Federal sources of financing. It does add, however, that "This procedure shall be subject to adjustment when and if this is found desirable as a result of continuing analysis of all factors pertinent to selection of a discount rate for these purposes." This very provision is the rationale under which this paper is being prepared.

4.3 The Green Book

The Green Book's interest criterion is as follows: "It is recommended that estimates of benefits and costs accruing at various times should be made comparable by adjustment to a uniform time basis through the use of projected long-range interest rates. Pending the development of such rates, the average rate of return; i.e., yield, on long-term Federal bonds over a sufficiently long period of time to average out the influence of cyclical fluctuations is considered appropriate for uniform application by all agencies on the condition

that adequate allowance has been made for uncertainties and risks. If such allowance is not possible, a component for risk should be included in the interest rate as may be the case for irregularly accruing benefits and associated costs. In comparing the cost of a project or increment thereof with alternative means of accomplishing the purposes involved, the treatment of interest for the alternative should be on a basis comparable with that of the project, with any necessary adjustments for differences in risk."

Note that the "adequate allowance for uncertainties and risk" means to subtract "predictable risks" from benefit estimates and to allow for unpredictable risks by using safety margins or conservative estimates. Note also that this is a different positon from A-47 and Senate Document 97 since it uses yield rather than the coupon rate.

4.4 Other Documents

There are other reports, guidelines and recommendations which have been issued since 1950, only two of which will be mentioned here. In 1961 the panel of consultants to the Bureau of the Budget recommended an interest rate of 4 to 5 percent, "synthesizing a social rate of discount and opportunity costs, . . . pending a full scale investigation." A letter from the Secretary of the Treasury to the Secretary of the Interior dated November 17, 1964, reads as follows:

> "In this Department's judgment the interest rate most appropriate for cost-benefit analysis and the determination of reimbursement and cost-sharing arrangements should reflect the Government's current borrowing costs and therefore should be determined on the basis of current market yields on outstanding long-term Treasury obligations."

5. Formulas for Specifying the Interest Rate

In order to implement a given interest rate policy, regardless of which theory is adopted, it is necessary to specify how the rate is to be calculated. The "cost of borrowing money" theory lends itself to such a formula more easily that either "opportunity cost" or "time preference" since it depends directly on published time series. On the other hand, though the other theories are based on more abstract concepts both can be related in some way to time series data. The difference is that such time series would probably be more difficult to construct.

This section is intended to be a discussion of the different ways of calculating the numerical value of the interest rate for use in water resource investment evaluation.

5.1 Alternative Concepts

(1) A "constant" value can be chosen and altered from time to time without reference to a specific mechanical formula. The initial value might be a consensus position based on market values and other considerations.

(2) A value can be computed mechanically as a specific function of any number of published market rates and some constant corrections thereto.

(3) A value can be computed mechanically as a specific function of any number of published market rates and or variable corrections which depend on phenomena other than interest rates, such as rate of inflation, current tax policy, current monetary policy, etc.

5.2 Some Illustrations

By way of illustration some simple functions of type (2) have been specified, and calculations of the interest rate time series since 1950 resulting from the use of these functions have been made. These are plotted in Figure 5. They are intended to be illustrations only, without implying an endorsement of the use of government bonds or of any of the methods of calculation.

The functions shown in Figure 5 are:

1) The average yield on long term government bonds for that year.
2) The moving average of this yield for the last five years including the current year.
3) The moving average for the last fifteen years including the current year.
4) The value for the current year determined by the regression line through the last fifteen years' values, including the current year.*
5) The rate which is the official policy for water resource projects, based on yield rate the average rate of government bonds outstanding of 15 years or more maturity.

Each of the series shows an upward trend since 1950. The moving averages are generally below bond yields during this period because they are weighted by earlier (lower) rates. The 15 year moving average is an extreme example. In general, the moving averages and the regression

*This is analogous to the concept of the "current normalized price" used by the Water Resources Council.

show a much smoother trend than the raw bond yield statistics. The regression is much more faithful to the overall trend than the moving averages while still smoothing out the peaks and troughs of the yield statistics. The rate currently used on water resource projects is heavily weighted towards earlier years when the long term bonds were actually issued, hence is below even the 15 year moving average.

6. Theoretical and Practical Implications of Using Different Rates

6.1 Overall Criteria for Project Design and Program Planning

Water resource projects are evaluated in such a way that the design alternative is chosen which has the highest net present value among the alternatives considered. Once the projects are designed they are ranked according to the ratio of annual benefits to annual costs. Generally, all positive effects of the project are in the numerator and all negative effects and resource inputs are in the denominator except for "associated costs," (costs required to make available the primary project output) which are subtracted from the numerator. While it is not the purpose of this paper to review the overall criteria, it should be noted that these can influence the choice of interest rate. For example, in the current evaluation criteria very little consideration is given to project timing. It can be argued that priorities should be related to the postponability of the different projects. In effect, those projects whose major benefit/cost ratios might be rather high. This would then make room for non-postponable projects within the current budget. An index of non-postponability might be the ratio of the reduction in net

present value (due to postponement) to the budget restrained cost. Instead of changing the overall evalution criteria in order to lower the priority of postponable projects this goal might be accomplished by a particular interest rate policy, namely by using a high interest rate.

6.2 Effect of Interest Rate on Project Design

The economics of project design consists of a choice among alternatives based on net present value (or average annual benefits minus costs, which amounts to the same thing). The discount rate influences the relative weighting of benefits and costs which occur in different points in time. As discount rates decrease, future benefits and costs tend to acquire more importance relative to capital costs and near term costs and benefits. For example, if two alternatives have the same capital cost but the first has a benefit stream which is always above that of the second, then the first is favored over the second at all discount rates. For very high discount rates neither alternative would be justified. If the benefit streams cross, then the one with the higher benefit stream in later periods becomes less favorable with higher discount rates.

Usually, project design alternatives will have different costs. The usual case is one of diminishing returns to successive increments of construction cost, in which successive project increments get justified as interest rates get lower. One can imagine, for example, a flood control project in which a small dam has high returns in terms of preventing damage from recurring floods while a larger dam will prevent

only a small expected value of incremental damage (in a probabilistic sense) since the larger scale flood is less likely. Using a higher interest rate will typically result in smaller size projects.

6.3 Effects of Interest Rate on Program Planning

Under current procedures, benefit/cost ratios enter into the determination of project priorities. As was shown above, raising interest rates causes fewer projects and smaller size projects to be justified, so that the obvious effect would be to reduce the capital budget for water resource projects if this budget were determined by benefit/cost criteria alone. This, however, is generally not the case, since agencies tend to have a whole backlog of projects which are justified at the current interest rate, but cannot be built because of budget limitations. In this case raising the interest rate would not necessarily reduce the size of the budget but would rearrange project priorities. Consider two projects with the same benefit cost ratio at the current interest rate, the first of which has high capital cost, low operating cost, and benefits which occur far in the future, while the second has low capital cost, high operating cost, and early benefits which are greater than, and late benefits less than, those of the first project. Raising the interest rate would raise the priority of the second project at the expense of the first and others like it. In general, raising the interest rate would raise priorities of projects with low capital intensity and relatively high early returns, and would give lower priorities to projects which can be said to be "postponable."

This choice is probably not a mere academic one since there are probably water resource projects of different types. For example, irrigation and power projects are likely to have fairly constant benefit streams over their lifetime, while navigation and recreation projects are more likely to be postponable in the sense that they tend to have low initial returns and higher later ones. Ideally one would want to consider all project designs and program priorities simultaneously with the same interest rate, since this would involve relevant tradeoff between, for example, adding to a large dam to reduce flood damage, and building a small dam (in another project) to reduce flood damage.*

*Haveman (9) has conducted a study in which he shows that a substantial proportion of water resource projects built in the past would have shown benefit cost ratios less than 1.0 if interest rates of 5% or 6% had been used. Haveman did not analyze the impact on project design of using a higher rate nor did he analyze the impact on priorities within a given backlog of projects. Considering Haveman's findings in this light, and given the current backlog of projects, it is possible that increasing the interest rate would not necessarily reduce the total amount of funds for "justified" projects but would result in a decrease in the optimal size of different projects and cause a shift of priorities to less "postponable" projects.

REFERENCES

(1) Economic Report of the President, 1967, Table B-69

(2) Roland McKean, Efficiency in Government Through Systems Analysis, Wiley, 1958, pp 76-89.

(3) John V. Krutilla and Otto Eckstein, Multiple Purpose River Development, Studies in Applied Economic Analysis, Johns Hopkins Press, 1958, Chapter IV.

(4) Standards and Criteria for Formulating and Evaluating Federal Water Resource Development, Report of the Panel of Consultants to the Bureau of the Budget, June 30, 1961. The consultants were: Maynard F. Hufschmidt, Chairman; John Krutilla, and Julius Margolis, with Stephen A. Marglin serving as staff assistant.

(5) Ibd., pp. 22-23

(6) Bureau of the Budget Circular A-47, Reports and Budget Estimate--relating to Federal Programs and Projects for Conservation, Development of Water and Related Land Resources, December 31, 1952, pp 10 and 14.

(7) Report by the President's Water Resources Council, Policies Standards and Procedures in the Formulation, Evaluation, and Review of Plans for Use and Development of Water and Related Land Resources, 87th Congress,2nd Session, Senate Document 97, May 29, 1962, p. 13.

(8) Report by Subcommittee on Evaluation Standards to the Inter-Agency Committee on Water Resources, Proposed Practices for Economic Analysis of River Basin Projects.

(9) Haveman, Robert H. Water Resource Investment and the Public Interest, Vanderbilt University Press, 1965.

(10) Series of papers prepared for the Joint Economic Committee, Subcommittee on Economy in Government. Panel on Interest Guidelines for Federal Decisions Making, as part of the hearings on the Planning Programming Budgeting System. William J. Baumol's paper was entitled "On the Appropriate Discount Rate for Evaluation of Public Projects."

APPENDIX

Examples of Market Interest Rates and Their Behavior

A.1 Statistical Series of Interest Rates

A.1.1 Different Types of Series

The number of interest rate series prevailing in the market could conceivably be as numerous as the number of debt instruments. Statistical series are constructed as historical records of the behavoir of both actual and hypothetical bonds. Actual bonds are specific issues while hypothetical bond rates are weighted averages of rates prevailing at a given time for certain types of issues, such as long term government bonds. The differentials among the rates can be accounted for by the various attributes of the types of issues such as risk, time of maturity, tax status, government backing, etc.

A.1.2 Composition of Each Series

Since the values in the different series are weighted averages, they reflect the peculiarities of their component issues at any one point in time. For example, corporate bond statistics depend on the prevailing industry representation. Twenty year bonds in 1875 were largely railroad issues: in the 1880's manufactured gas and water companies were prevalent, and by 1900 street railway bonds were more important. Since World War II, natural gas transmission line bonds have become considerably more important than before the war, whereas railroad bonds have become less so. Thus the behavior of the interest rates during the different periods could be expected to reflect the peculiarities of the different industries.

A.1.3 Institutional Change

As the economy has changed over time so have the institutional nature of capital markets and the methods of financing new facilities. Fifty years ago, bond markets were thin (had fewer participants) by today's standards; also underwritings and distributions were less complex. Financial intermediaries who accumulate and dispense funds are much more prevalent today. At that time, firms were more prone to rely on external methods of financing than today. It is also interesting to examine recent trends in the importance of different sources of financing in private industry. Internal sources have increased from 43% in 1950 to 62% in 1966. Stocks have gone from about 3% down to only .85%; bonds from about 4% to about 11%; and bank loans were about 7% in both years. (1)

A.2 Interest Rate Levels and Differentials

The general level of interest rates and the differentials among them are related to many factors. Generally speaking, high interest rates are associated with periods of economic expansion, although monetary policy can have a significant influence, such as during World War II when interest rates were pegged low to reduce the cost of financing the war.

A.2.1 Time of Maturity

Generally, it is easier to borrow money on a short term basis than on a long term basis, so that short term bond interest rates tend to be lower. This is not always the case because of the speculative nature of bond markets. If the general level of interest rates is high in the opinion of investors, then they will expect rates to go down. In this case, long term borrowing would be easier since investors will prefer to get a guaranteed high return in the face of possible interest rate

decreases. Thus long term rates would tend to be lower, as they were in 1921 and have been very recently.

A.2.2 Risk

In the bond market it is possible that an issue will default on its payments of interest or principal. For very risky bonds the market rate includes a risk premium to induce the investor to buy the security. (In effect this is measured by a lower market price which results in a higher computed yield). Thus, bonds have different ratings, starting with low risk Aaa, all the way to the highest risk C. Series are computed based on different ratings. Generally U. S. Government bonds are considered risk free since the Government itself is responsible for the payments.

A.2.3 Tax Status

State and municipal bonds have tax free interest and therefore tend to have low interest rates. This type of bond tends to be exchanged by investors with high incomes and high marginal tax rates who can take advantage of the tax status.

A.2.4 Monetary Policy

Monetary policy has a great deal of influence on the interest rate. Both fiscal and monetary policy are generally countercyclical but different emphasis may be placed on either one in different periods of time. A recent example of monetary policy is known as "operation twist," in which the Federal Reserve has raised the yield of 18 month Treasury bills above that of long term issues in order to encourage

foreignors to keep short term funds in New York banks and help the balance of payments. This pattern can probably not be kept up indefinitely, but it does indicate the influence of the Federal Reserve on the money market.

A.3 Historical Behavior of Interest Rates Since 1950

The reader should refer to graphs in figures 1 to 3 in following this discussion. Figure 4 provides a perspective of interest rates over the long run since 1900.

Interest rates, both short and long-term, maintained a general upward trend and reached a forty-year high in 1966. In 1966, yields on long term Corporate Aaa Bonds were 5.13 percent, and on U.S. Government Bonds were 4.66 percent. The average rate in 1966 on short-term business loans in 19 cities was 6.0 percent and Prime Commercial Paper sold at 5.55 percent.

Superimposed on this trend were three periods of decreasing interest rates from 1953 to 1954, 1957 to 1958, and 1959 to 1961. The declines were the result of Federal monetary and fiscal policies to combat the recessions. During the three recessions, the Federal Reserve monetary policies used were: Reducing the discount rate, buying short-term government securities on the open market, and reducing reserve requirements against demand and time deposits. Reducing Federal taxes in the 1953 to 1954 recession was the only major fiscal policy instrument used. During the other two recessions the government depended mainly upon monetary policy, the automatic decline of tax collections, and the automatic rise of government transfer payments to bolster the economy. Throughout the recessions, short-term rates declined faster

than long-term rates. The fall in short-term rates during the 1957 to 1958 recession was more intense than in either the 1953 to 1954 or 1960 to 1961 recessions. The rates on 90-day Treasury Bills and Prime Commercial Paper fell 1.5 percent. The easy money conditions prevailing in the short-term credit market were not evident in the long-term market because of an extremely large volume of new, long-term bond issues. State and local governments borrowed heavily, both to finance current expenditure and to retire short-term debt issued during the period of high interest rates. Corporations followed the same policies as the State and local governments. The Federal Government als floated several long-term issues, similarly to retire short-term debt. Over this period, long-term rates fell only two-tenths of one percent.

The four periods of increasing interest rates were associated with fiscal and monetary policies trying to prevent inflation in an expanding economy. The four periods were from 1950 to 1953, 1954 to 1957, 1958 to 1959, and 1961 to 1966.

Beginning with the Korean War in 1950 until 1953, fiscal policy was used to curb the strong inflationary pressures. This was also the period of the Federal Reserve-Treasury Accord of 1951, in which the hields on government bonds were no longer pegged by the Government at low levels as they had been before this. Defense expenditures were placed on a pay-as-you-go basis and to create the needed surpluses in the cash budget. taxes were increased. Restrictive controls over business and consumer credit were also initiated. Despite higher interest rates and substantial reserve requirements, demand for credit rose. With the cessation of warfare in 1953, monetary officials intensified their restrictive policies. The discount rate was raised to two percent,

its highest level since 1937. Monetary officials also kept the money supply stable in a growing economy. In the remaining three periods, the monetary policies used were: Raising the discount rate, selling government securities in the open market, and keeping the money supply stable.

The increase in interest rates over the four periods was more pronounced in the short-term market than in the long-term market. For example, short-term rates over the period 1961 to 1966 increased by two percent, while long-term rates rose by only one percent.

After reaching their highest levels in forty years in 1966, short-term rates began another decline during 1967, while long-term rates which declined early in 1967 have now started an upward course.