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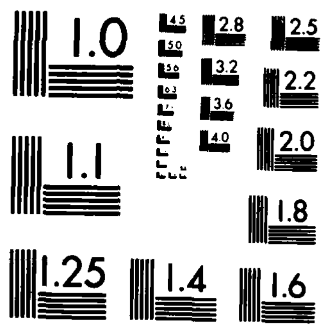
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AN ASSETS APPROACH TO ESTIMATING THE DISCOUNT RATE FOR PUBLIC INVESTMENTS

THESIS

Danny T. Coats
First Lieutenant, USAF

AFIT/GOR/OS/84D-2

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AN ASSETS APPROACH TO ESTIMATING THE DISCOUNT RATE FOR PUBLIC INVESTMENTS

THESIS

Presented to the Faculty of the School of Engineering
of the Air Force Institute of Technology
Air University
In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Operations Research

Danny T. Coats, B.A.
First Lieutenant, USAF

December 1984

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Acknowledgements

I would like to gratefully acknowledge the support and guidance provided by my thesis advisors Professor Robert Allen and Major Ken Feldman. Their patience, understanding and concern made this thesis effort possible. I would also like to thank my family; my wife Sharon, my daughter Jennifer, and my son Thomas; for making the last eighteen months bearable and for tolerating the quick temper I often demonstrated during my course of study. Finally, I would like to thank my Lord and Saviour, Jesus Christ, who saw fit to allow me to complete my studies (Philippians 1:21; Romans 14:8), has blessed me with a wonderful family (Proverbs 18:22; Genesis 33:5) and has given me hope for the future (Romans 6:23; 1 Thessalonians 4:16-17; Revelation 20:11-15).

-- Danny T. Coats

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Abstract

This thesis effort argues that the discount rate to employ in public investment analysis is the weighted average of the rates of return available in the corporate and non-corporate sectors of the American economic market. The weights used reflect the percentage of the overall market encompassed by the corporate and non-corporate sectors. This study also presented a methodology (used previously by Jacob Stockfisch (45)) for estimating the rate of return for both the corporate sector and the non-corporate sector. This methodology incorporates the basic Mishan (32) assumption that the government is free to use funds diverted from the private sector in any advantageous way.

In this study the writer estimates the real rate of return to use in evaluating public investments to be on the order of 5 to 8 percent for the period 1970-1980. This estimate is compared to the 10 percent real rate of return employed by Department of Defense (DoD) analysts, and the impacts of employing an incorrect discount rate are assessed. The writer concludes that the findings of this study raise serious questions about the 10 percent real discount rate employed by DoD analysts, but a strong conclusion is not possible without additional study and analysis.

AN ASSETS APPROACH TO ESTIMATING THE DISCOUNT RATE FOR PUBLIC INVESTMENTS

I. Introduction

Background

Benefit-cost analysis is an integral part of decision making for the Department of Defense (DoD). Such analysis necessitates using a discount rate to compare total costs and measurable benefits associated with proposed projects and programs. Such comparisons are not possible without using a specific discount rate. The discount rate is used to compute the net present values (present value of total costs subtracted from the present value of total benefits) of given projects. One chooses among alternatives by selecting the option with the greatest net present value and also satisfies effectiveness requirements. The costs associated with most government projects are measurable; however, in many cases the benefits associated with a program are not so easily measured.

Benefits associated with DoD projects generally fall within one of four categories: direct cost savings, efficiency/productivity increases, other quantifiable measures of output, and nonquantifiable measures of output.

The final two categories are the most difficult to measure in terms of a dollar value. Quantifiable measures such as engines repaired each year and the number of new recruits per month cannot be easily translated to a dollar value. In such cases the analyst usually sets effectiveness (engines repaired, for example) at a constant level and compares the discounted costs of alternatives. Nonquantifiable measures (for example, reduced racism in the officer corps) cannot be assigned dollar values, but they must be included in the economic analysis. At a minimum, the analyst will provide careful qualitative statements concerning the details of such benefits.

For those benefits that are measurable, the problem of determining the discount rate remains. In recent years as the DoD budget has exceeded 250 billion dollars, the use of the correct discount rate has become essential. DoD analysts currently employ a 10 percent real discount rate when evaluating projects whose costs and/or benefits extend for more than three years (as directed by Office of Management and Budget (OMB) Circular No. A-94 (March 1972)). Consider a military construction project requiring an initial outlay of 10 billion dollars and outlays of 10 billion dollars a year for five years. The present values of the cost of this project using discount rates of 5, 10, and 20 percent are 53.9, 47.9, and 43.1 billion dollars respectively. If DoD were constrained by a 50 billion dollar limit on the project or if several other projects (alternatives) are also being considered, the initial project may or may not be undertaken depending on the discount rate used. There exist two schools of thought regarding the calculation of the discount rate to use when evaluating public investments: the social time preference position and the social opportunity cost position.

The social time preference position (which will be discussed more thoroughly in the next chapter) argues that individuals do not provide for the future in a rational manner. An individual with an uncertain life span places a higher value on consuming resources today than he does on postponing consumption today in order to ensure consumption at some future time (30:96-97). Proponents of this position contend that this problem can be remedied by increasing the amount of funds diverted (by direct and indirect taxes) from the private sector, and thereby increasing public investment in order to decrease consumption. This increase in public sector investment can be accomplished by the government's use of a discount rate lower than the observed private sector rate when evaluating investments. Such an action would ensure that the government would approve projects which would not be undertaken using the private sector rate of return. Thus, future generations would benefit from projects (such as dams or improved defense systems) funded by the current generation.

This position, however, presents the problem of determining by how much (and by what monetary instruments) the private sector discount rate should be lowered (43:7).

The opportunity cost position states that funds diverted from the private sector for public investments must yield at least as much as they would if they had been left in the private sector. Proponents of this position contend that the government's role as an investor is to maximize the overall general well-being of society. In other words, the government should not divert funds from the private sector, where they return r percent, unless it can invest them elsewhere for a greater (or at least an equal) return (2:203-204). It must also be decided if it is feasible to provide funds for future generations to relieve the problems of poverty and hunger when the current generation is plagued by the same problems (46:332-333).

There have been several empirical studies between 1969 and 1976 (8; 19; 26; 39; 42; 44; 45) which attempt to estimate the correct discount rate for public investment analysis. The estimates of the real discount rate differ substantially, ranging from 6 to 13 percent. The different techniques and initial assumptions employed by the authors account for the widely different measurements of the discount rate. The theoretical background for estimating the discount rate is developed in the next chapter, and a brief review of the results of several of the empirical studies is also presented.

The debate over the appropriate discount rate for public investments is an ongoing one. The American economy has been relatively unstable (when compared to the period 1960-1970) during the last decade. Fluctuations in interest rates, tax rates, and the inflation rate since 1970 may have significantly changed the discount rate DoD analysts should employ. The DoD policy of employing a 10 percent real discount rate has been in effect since 1972. The military construction example presented earlier demonstrates the significant impact the discount rate has on DoD analysis. Employing an improper discount rate can result in either overestimation or underestimation of the overall cost of the project. In DoD, these errors in cost estimates could be tens of millions of dollars, depending on the size and structure of the project. This research effort reexamines the current DoD policy to determine if a 10 percent real discount rate is the correct discount rate to use in evaluating DoD projects.

Problem Statement

The instability of the American economy since 1970 and the wide range of estimated real rates make desirable an evaluation of the current DoD policy of employing a 10 percent real discount rate.

Objectives

The overall objective of this research effort is to evaluate the 10 percent real discount rate employed in DoD analysis. The subobjectives are:

1. To reexamine the opportunity cost basis of the discount rate;

2. To estimate the social discount rate for the period 1970-1980; and, if possible

3. To determine if the interest rate for long-term treasury bills, after adjustments for inflation and risk, provides an adequate "first estimate" for the discount rate.

The conceptual foundation of the "appropriate" discount rate is briefly outlined in Part II, and the rate is estimated for the period 1970 to 1980 in Part III. Finally, the conclusions and recommendations are presented in Part IV.

II. The Social Discount Rate

Discounting is a method of making consumption and/or production of resources in different time periods comparable by reducing a given stream of costs and benefits of a particular project to a single number at a single point in time. Cost/benefit streams of various projects can then be compared to determine which is the best (economically) to undertake; i.e., which has the greatest net present value. Discounting is not possible, however, without using a particular discount rate. The debate among economists over how to determine the discount rate for public investment is ongoing. This section presents a brief theoretical background as well as a discussion of the various positions in the debate.

Theoretical Background

In this theoretical model, assume that individuals are afforded one choice: consumption today or consumption at some future time. An individual will exhibit a time preference which demonstrates his willingness to forego consumption today for consumption tomorrow. For example, individuals may choose to forego consumption of 100 bushels of corn this year if they are guaranteed 110 bushels next year. Their time preference rate of return for 100 bushels of corn is thus 10 percent. However, we cannot assume that individuals will forego consumption of an additional 100 bushels of corn today for 110 bushels tomorrow. They may require 120 bushels next year implying their marginal rate of time preference is 10 percent for the first 100 bushels of corn not consumed today and 20 percent for the next 100 bushels not consumed (32:191-192). In Figure II-1, suppose U_1 represents society's indifference curve for consumption; i.e., individuals are equally satisfied with any point on U_1. This curve represents the tradeoffs between consumption today and consumption tomorrow. Thus individuals would be equally satisfied with consuming C_{01} today and C_{11} tomorrow as they would be with consuming C_{02} today and C_{12} tomorrow. The slope of U_1 at any point is given by the ratio of the change in consumption tomorrow (dC_1) to the change in consumption today (dC_0). The marginal rate of substitution for C_0 for C_1, i.e., the rate at which society as a whole will trade consumption today for consumption tomorrow, is the negative of the ratio:

$$MRS = \frac{-dC_1}{dC_0} = (1+t) \qquad (34:62-63,682) \qquad (1)$$

The variable t is also the marginal rate of time preference; i.e., the psychological level of satisfaction a society as a whole receives by foregoing one additional unit of consumption today (32:203).

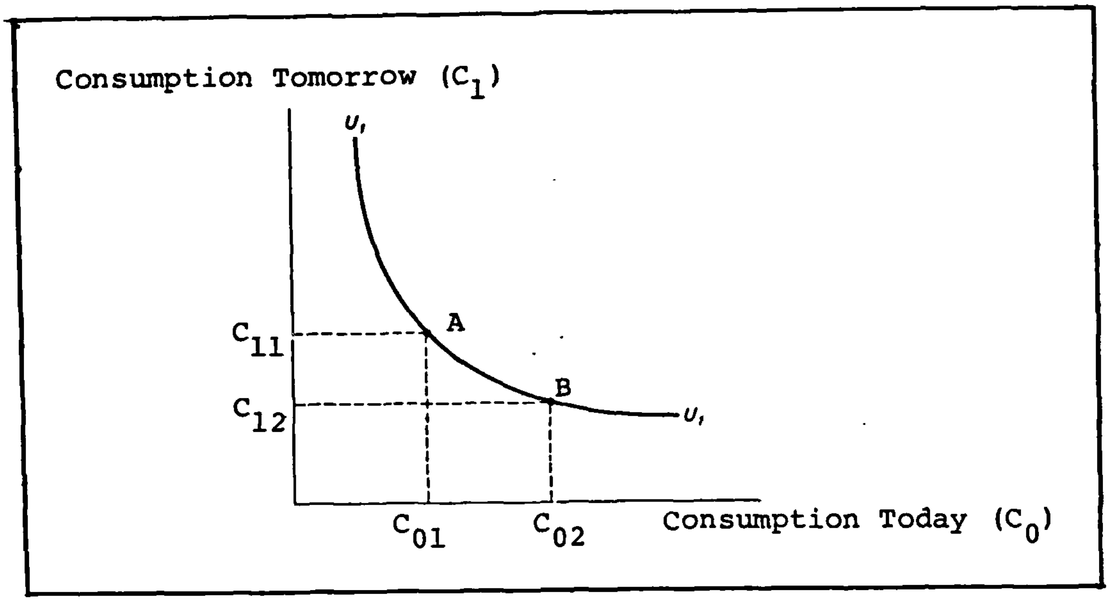

Fig. II-1. Consumption Indifference Curve (34:62)

Now suppose individuals are free to forego consumption today in order to invest in production, for example, to forego consumption of corn today in order to plant more corn in the next crop and thus produce more. In Figure II-2, curve CC is the production possibility curve which represents the physical amounts which can be produced for the future by foregoing consumption today (20:12-13). The slope of curve CC at any point, also given by the ratio of dC_1 to dC_0, represents the rate at which future consumption is produced by foregoing an additional unit of consumption today. At a point such as A, foregoing additional consumption today will produce little additional future consumption. However, at point B, a slight decrease in consumption today will significantly

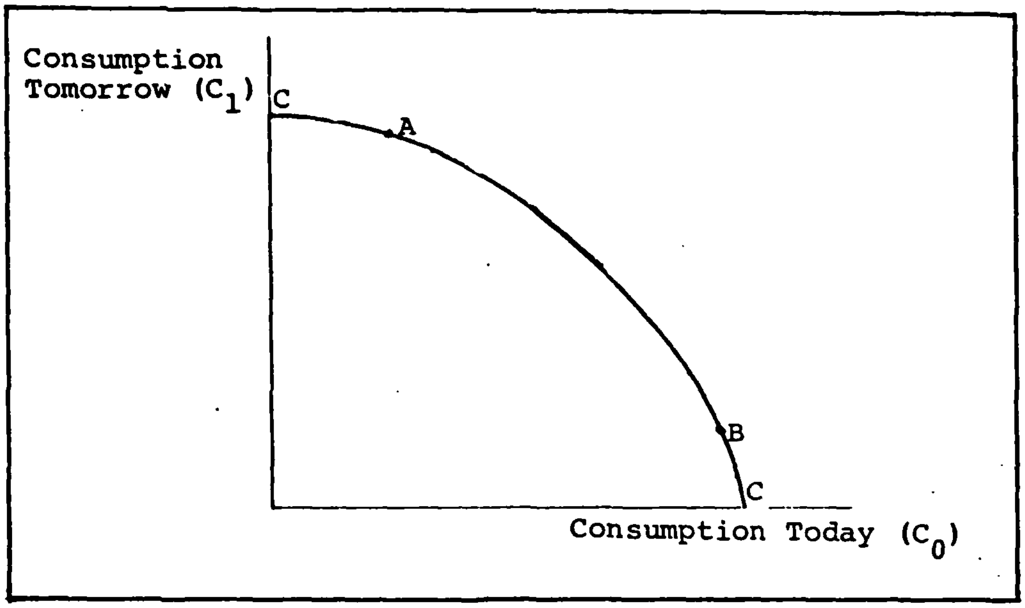

Fig. II-2. Production Possibilities for Trading Current Consumption for Future Consumption (35:467)

increase the future consumption available (35:466-467). The negative of the slope of CC equals (1+r) where r is defined to be the marginal productivity of capital or the opportunity cost of consuming today versus producing for tomorrow (20:183; 35:467).

Finally, we now can consider both the rate at which individuals are willing to exchange present consumption for future consumption and the rate at which they can transform consumption today into future consumption. As shown in Figure II-3, there exists a point E such that society's marginal rate of time preference equals the marginal productivity of capital. The curves U_1, U_2, and U_3 represent indifference curves of higher and higher levels of satisfaction and CC again represents the

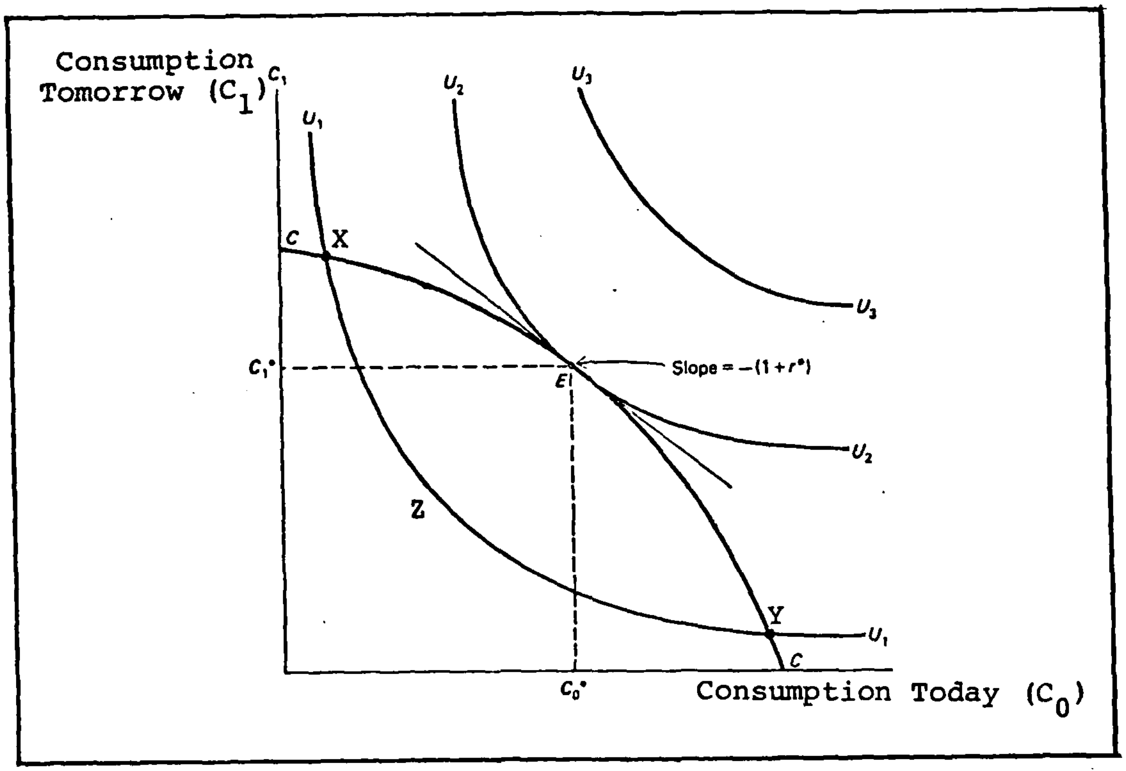

Fig. II-3. Determining the Equilibrium
Rate of Return (35:468)

production possibility curve. For example, individuals are indifferent between any two points on an indifference curve, but any point on U_3 yields more satisfaction than any point on U_2 which yields more satisfaction than any point on U_1. Individuals will be indifferent between points X and Y in Figure II-3. At point X society's marginal rate of time preference exceeds the marginal productivity of capital. In other words, at point X the increase in psychological satisfaction of one additional unit of current consumption exceeds the opportunity cost of consuming today versus producing for tomorrow. As long as the rate at which individuals can transform current consumption to future consumption is less than the rate at which they are willing to exchange the two, they should continue to increase current consumption until these two rates are equal. At point Y in Figure II-3, the rate at which individuals are willing to exchange current consumption is less than the rate at which current consumption can be transformed into future consumption. Thus, at point Y, individuals can increase their satisfaction by decreasing current consumption until the rate at which they are willing to exchange one additional unit of current consumption for future consumption equals the rate at which they can transform one to the other. Thus at point E, which represents consuming C_0* today and having C_1* of future consumption available, individuals maximize their satisfaction. Point E in Figure II-3 is the point of equilibrium, as any movement along CC by individuals will result in a loss of satisfaction (movement to a lower indifference curve) (35:467-469).

In this example the slope of the indifference curve U_2 equals the slope of the production possibility curve at point E. The negative of these slopes equals the equilibrium rate of return which emerges from this production-exchange model. Thus in a perfect economic market the equilibrium rate of return r can be determined since -(1+r) equals both the marginal productivity of capital and the marginal rate of substitution, and both are reflected in the market rate of interest. In other words, the rate of return expected by individuals to maintain a level of satisfaction equals the rate of return they can feasibly obtain through production (34:468-469). In a perfect economic market this rate r would be used in evaluating public investments (20:119-120).

However, the economic market is not perfect. For example, taxes force the marginal productivity of capital (hereafter referred to as the market rate) to diverge from the individual's marginal rate of time preference. Suppose an individual expects a return of 6 percent on his investment. Further suppose the corporation with which he invests is subject to a 50 percent corporate tax. In order to satisfy both the investors (returning 6 percent) and the government (payment of corporate taxes), the corporation must produce a product which will return at least 12 percent to consumers (2:206). Thus, a point such as point Y in Figure II-3 could reflect the actual market. At point Y the market rate exceeds society's marginal rate of time preference as taxes force the corporation to yield greater returns than those expected by investors.

Market imperfection is also evidenced by the fact that some investments are not available to all individuals. For example, an investment requiring a minimum 500-dollar investment (such as a certificate of deposit) is not open to an individual who has less than 500 dollars to invest.

As long as not all individuals have equal amounts of wealth, this imperfection will exist. Lending institutions generally allow wealthy borrowers to obtain funds in greater amounts and at lower rates of interest than they do less wealthy borrowers. The differences between these rates can be considered a risk premium charged to the less wealthy. Since (in general) the wealthy have a broader financial base and are better able to weather adverse circumstances, financial institutions consider borrowings of the wealthy to be less risky than those of the less wealthy (32:199-201).

As we discussed earlier, in a perfect economy the market rate of return and society's marginal rate of time preference are equal. However, imperfections such as taxes and limited investment opportunities for most individuals force these two rates to diverge. This divergence complicates the evaluation of public investments as new and proper discount rates for use in the evaluation must be determined.

Which Rate of Return to Use for Evaluating Public Investments

There is a wide range of observable rates of return in the American economic market. In the previous example, a market rate of 12 percent and a rate of return expected by investors of 6 percent were observed. For this research effort, it must be determined in general if the correct discount rate to use for evaluating public projects is some observable market rate, the rate of return expected by investors, or some rate between the two. In estimating the discount rate, the sources and alternative uses of the funds diverted from the private sector must be considered. Suppose that public investments can be increased by X dollars only by displacing X dollars of private resources. These displaced resources would have been used in the private sector for either private investment only, private consumption only, or both private consumption and private investment. For this example, assume the rate of return individuals can achieve in the open market is given to be r and the rate of return which provides a measure of personal satisfaction in exchanging consumption today for consumption tomorrow is given to be t. Further assume the time preference rate of society as a whole, rate t, can, in fact, be measured. This rate t will be a weighted average of the time preference rates of all the members of society where the weights express the percentage of the diverted resources which would come from each individual. For example, suppose three individuals A, B, and C have time preference rates of 5, 10, and 15 percent respectively, and they jointly undertake a project where 50 percent of the funds come from A, 40 percent come from B, and 10 percent come from C. The overall time preference rate of these individuals is given by:

t = (5)(.50) + (10)(.40) + (15)(.10) = 8 percent (32:200,213).

As was previously stated, the rates of return r and t generally diverge (with r>t). If the government had unlimited power to raise funds from the private sector, it could force individuals to reduce current consumption (by increased taxes or increased rate for borrowing) in order to increase future consumption. As individuals are forced to decrease current consumption, the marginal rate at which they are willing to exchange consumption today for future consumption (slope of the indifference curve (Figure II-1)) increases. In other words, as individuals are forced to decrease current consumption, they place a higher value on it. As was demonstrated in Figure II-3, if the government could force individuals to forego current consumption to the point at which the marginal rate of time preference t equals the market rate r, the market would be at equilibrium and the level of satisfaction for society would be maximized. However, the government does not have unlimited power to raise funds. The government is constrained by political considerations; e.g., legislators are reluctant to enhance policies of increased taxes or tight money if these policies were not popular among voters. Thus, the wedge between the market rate r and society rate of time preference t remains (32:210-211).

Now consider the different ways in which the government can use funds diverted from the public sector:

> The funds may be used in any advantageous way the agency chooses and . . . the agency has the choice of using funds for a particular project or else of not using the funds at all [32:213,215].

The second use of funds may be allowed by actions such as voter referendums to raise funds for schools and highways. For each of these uses we now consider the appropriate discount rate to use for funds obtained by displacing either private investment only, private consumption only, or both private investment and consumption. In order to simplify the argument we assume all returns for public projects are reinvested by the government (32:213).

Consider the situation in which the government may use funds diverted from the private sector <u>in any advantageous way</u> it chooses. Suppose the government's spending of one dollar reduces private investment only by one dollar. If the funds were left in the private sector, investors would expect a return of r percent on their investments. Although a one-dollar investment would amount to (1+r) dollars at the end of one year, private investors may choose to reinvest only a portion of the first year's return on the investment and to consume the remainder. Thus, the one-dollar initial investment will amount to less than $(1+r)^2$ dollars at the end of the second year if investors consume a portion of the first year's returns. If investors choose to consume a portion of the returns at the end of each year for n years, the initial investment will amount to less than $(1+r)^n$ dollars at the end of n years (32:214).

However, if the funds are diverted from the private sector (displacing investment only), the government can reinvest the one dollar in the private sector, and then reinvest the returns wholly each year. The initial investment would then amount to $(1+r)^n$ dollars at the end of n years. The government can justify reinvesting the returns each year since reinvesting a dollar yields a return of r to society, whereas consuming a dollar yields a return to society equal to the rate of time preference t. The best alternative use of one dollar available to the government is to reinvest in the public sector and to wholly reinvest the returns each year. If a public project under consideration does not return at least $(1+r)^n$ dollars at the end of n years for each dollar initially invested, there is no economic justification for undertaking the project (32:214).

Suppose once again that the government is free to use funds diverted from the public sector in any advantageous way. However, now suppose one additional dollar of government spending displaces one dollar of private consumption only. Once again the government has several alternatives to choose between. The government can divert one dollar from the private sector, reinvest it at r percent in the private sector, and wholly reinvest the returns each year. In this case, the one-dollar investment will amount to $(1+r)^n$ dollars at the end of n years. Alternatively, the government can leave the dollar in the private sector which, when consumed, yields a return of t to society where t equals society's rate of time preference. The consumers are indifferent between one dollar of consumption today, $(1+t)^2$ dollars of consumption at the end of two years, and $(1+t)^n$ dollars at the end of n years. The government's best alternative is to reinvest the initial dollar and all subsequent returns each year. Once again there is no economic justification for the government to invest one dollar in a public project unless the investment amounts to at least $(1+r)^n$ dollars at the end of n years (32:214).

Finally, assume the government is free to choose any advantageous use of funds diverted from the private sector. Also suppose one additional dollar of government spending diverts one dollar from the private sector which would have been used for both consumption and investment. As in the previous two cases, the government can choose to reinvest the diverted funds in the private sector, and to reinvest wholly the returns each year. In this case a one-dollar investment will amount to $(1+r)^n$ dollars at the end of n years. Alternatively, the government can leave the dollar in the private sector where x cents of the dollar will be consumed and y cents will be invested $(x+y=100)$.

The overall return to the private sector of the dollar is the weighted average of society's return from consumption (t percent) and society's return from investment (r percent) where the weights represent the amounts of dollar consumed and invested respectively. The overall return to society will be less than or equal to the rate of return from investment r. The best alternative available to the government is to reinvest in the private sector and to reinvest wholly the returns each year. As in the previous two cases, there is no economic justification for the government to invest one dollar in a public project unless the investment will amount to $(1+r)^n$ dollars at the end of n years. These three cases indicate that if the government is free to use funds diverted from the private sector in any advantageous way, public investments should be evaluated using the rate of return from private investment r regardless of how the funds would have been used in the private sector (32:214-215).

Jacob Stockfisch (44; 45) apparently uses the assumption that the government is free to use funds diverted from the private sector in any advantageous way, and estimates the discount rate to use in evaluating public pro- ·cts by computing the marginal productivity of capital in the private sector. In other words, he estimates the percentage increase in net national income and net national product that would not be realized if a public project diverted one additional dollar from private investment (44:193). Stockfisch estimates the before tax (income and, if applicable, property taxes) rates of return in corporate manufacturing, in railroads and other transportation, for public utilities, and in the non-corporate sector (agriculture and non-farm unincorporated business). These rates are weighted by the percentage of the overall economic market they encompass. He then adjusts this rate for inflation to obtain a real discount rate of 10.4 percent (45:v-vi).

J. A. Seagraves (42) estimates a discount rate by summing the effects of various factors, e.g., taxes and inflation, with the rate of return for short-term corporate bonds. He uses the corporate bond rate rather than the treasury bond rate because some states do not tax income from treasury bonds and because the diversity of investment available with corporate bonds greatly reduces any inherent risk associated with investments. He also adds an additional risk effect which represents the additional return expected by investors to offset any uncertainty associated with a particular investment (42:440-441,448). Seagraves estimates a real discount rate between 8 and 13 percent (depending on the values of the various effects), and concludes that this is the methodology for estimating the discount rate to use in evaluating public investments (42:448-449).

We now consider the situation in which the government can use funds diverted from the private sector either for a particular project or not at all. First consider the case in which one additional dollar of government spending displaces one dollar of private investment only. If we make the further assumption that private investors wholly reinvest the returns at the end of each year, each additional dollar invested then amounts to $(1+r)^n$ dollars at the end of n years. In this case each dollar invested in a public project must yield $(1+r)^n$ dollars at the end of n years in order for the project to be acceptable (32: 215). The case in which investors can consume a portion of the returns each year is considered later.

Next consider the case in which the government can use funds diverted from the private sector either for a particular project or not at all, and one additional dollar of government spending displaces one dollar of current consumption only. If the government diverts one additional dollar from the private sector, the satisfaction foregone at the end of the first year is (1+t) dollars where t is the social rate of time preference. The satisfaction foregone for each dollar diverted from the public sector at the end of n years amounts to $(1+t)^n$ dollars. In this case, since the government can choose either to undertake a particular project or to leave the funds in the private sector, the public investment must yield at least $(1+t)^n$

dollars at the end of n years in order to be economically justified (32:216).

Finally, we can consider the case in which the government can use funds diverted from the private sector for a particular project or not at all, and one additional dollar of government spending diverts funds from both private consumption and private investment. The overall return to the private sector had an additional dollar been left in the private sector would at the end of n years be between $(1+t)^n$ (return if the dollar would have been entirely consumed) and $(1+r)^n$ (return if the dollar and subsequent returns were wholly invested). The overall rate of return would be a weighted average of the upper and lower limit where the weights reflect society's marginal propensity to consume and society's marginal propensity to save, respectively (32:216). If a proposed public project would not yield at least a rate of return as large as this weighted average, the government should leave the funds in the private sector.

Baumol (2; 3) asserts that public investments displace both current consumption and current investments. Resources used for public investments often can be used by either consumers or investors. Resources diverted from the private sector to construct a dam could have been just as easily used either to build a new plant for an automobile manufacturer or to put food on the table to feed

Joe Smith's family (2:204). However, if the government's goal is to yield the greatest return available, the appropriate discount rate

> . . . should then be set by the market and the needs of public policy . . . and no attempt should be made to subsidize the future by artificial reductions in discount rates designed only for that purpose [3:802].

Baumol does not estimate a discount rate, but he contends the discount rate to use for evaluating public investments must be between the rate of return on long-term government bonds (representing society's rate of time preference t) and the overall rate of return (rate r) from private investments (2:211-212).

Burgess (8) and Jenkins (26) estimate the public sector discount rate for Canada by computing a weighted average of the observable rates of return found in the source from which funds are diverted for public use. The weights assigned to the rates of the sources of funds, displaced private investment; foregone domestic consumption; and funding from sources abroad; represent the percentage of the diverted funds withdrawn from a particular source (8:383; 26:225-226). Jenkins and Burgess agree on the four sources of funds mentioned above, but they disagree on the weights associated with each source to use in estimating the overall discount rate. Jenkins estimates the discount rate to be 9.5 percent and Burgess estimates it to be 7 percent (8:384; 26:229). The difference between these two estimates is the result of Jenkins and Burgess using different weights in estimating the overall discount rate.

There is no general agreement among professional economists about the correct method of estimating the discount rate to use in evaluating public projects. The case discussed earlier in which the government is free to use diverted funds in any advantageous way may not be an acceptable alternative to some. Assuming the government can become a part owner of private business (such as steel mills and automobile manufacturers) through investments is not consistent with the real world. However, DoD uses this assumption when establishing department policy for using a discount rate. DoD uses a discount rate that reflects the rate of return on private investment regardless of the source of funds (37). Under the assumption that the government is constrained by having to use funds for a particular project or not at all, an estimate of the discount rate is more difficult because the percentages of funds displaced from investment and from consumption are not easily determined. For the purpose of this reexamination of the DoD discount rate, this study follows Stockfisch and assumes that the government has total freedom when making public investments. The rate of return from private investment (r) is taken as the appropriate bases of the discount rate for public policy. The rate estimated in this study should be considered an upper limit to the appropriate discount rate. Estimates made using the assumption that the government is constrained when making public investment will be less than (or at most equal to) the rate of return from private investments (4) and greater than (or at least equal to) the social rate of time preference (t).

III. Estimating the Discount Rate for Public Investments

This chapter presents an assets approach to measuring the appropriate discount rate for evaluating public investments, a rate which measures the marginal productivity of capital in private investments. The methodology of this study is the same as that used by Stockfisch (44) except for one exception which is discussed later. This methodology requires measuring the earning assets and earnings for various subsectors of the corporate sector of the American economy. The ratio of the earnings to earning assets for each subsector is taken to be the rate of return for that subsector. The overall rate of return for the corporate sector is estimated using these subsector rates of return. This estimated rate of return for the corporate sector, in conjunction with the estimated rate of return for the non-corporate sector, is used to estimate the overall rate of return for private investment.

The Rate of Return in the Corporate Sector

In determining the earning assets for firms in the corporate sector, inventory, net plant and equipment, land, and accounts receivable were included, while cash and other short-term liquid assets, securities and long-term debt held by a company were not. Stockfisch justifies the exclusion of these elements from the assets base as follows.

> From the point of view of the overall economy cash is not a "productive" resource. . . . The marginal cost of cash to society is zero, since the supply of money can be increased or decreased by bookkeeping transactions and banking operations. As such, cash is not an asset the existence of which causes a displacement of real resources from the point of view of the economy as a whole, nor does cash create any real product in the economic system. Other legal claims such as bonds and stocks are not physical, real resources; rather, they are claims against physical resources. Their creation, and their existence, therefore, do not involve the displacement of physical resources. . . . For these reasons such assets should not be considered part of the assets associated with the operations for which its physical investment is undertaken [45:194-195].

While accounts receivable are also legal claims and not physical assets, they are "part of the 'stock in trade' necessary for the conduct of business operations: they reflect displaced physical resources" (45:195). The exclusion of cash and legal claims from the asset base causes the asset base to be smaller and the rate of return (ratio of earnings to assets) to be larger than would be estimated using a methodology which includes them in the asset base (45:195).

For the purpose of this study, the corporate sector is divided into seven subsectors: manufacturing, mining, commercial and other, public utilities, communications, railroads and transportation other than rail. Two of the subsectors--public utilities and transportation other than rail--are further subdivided into electric utilities and gas pipelines; and motor carriers, oil pipelines, and airlines. The corporate sector is divided in this way in order to incorporate the available data (5; 6; 7; 9; 13; 14; 15; 22; 23; 24; 36) more easily into the study. The rates of return from the various subsectors must be estimated in order to obtain an overall estimate for the corporate sector. The following is a summary of the elements included in both the asset bases and earnings estimates for these subsectors. The elements included in the asset and earning bases are taken directly from various annual government reports. Appendix B presents a year-by-year summary of the assets, earnings, and rates of return for the various subsectors of the American economy.

Manufacturing. The earning assets equal the sum of "total receivables," inventories," and "total property, plant, and equipment (net)." The data available for earnings ("net profit from operations") is a profit measure which excludes interest charges (15). A firm may employ two types of capital: equity capital where the return is net income and debt capital where the return is interest on outstanding debt. Assets obtained with debt capital are included in the asset base; hence, the actual earnings would be underestimated if interest charges were not included. The amount of the interest charges must be estimated and summed with the profit value. The method of measuring the amount of interest paid is discussed in Appendix A.

Electric Utilities. The elements of the asset base are "net total utility plant," "notes and accounts receivable less accumulated provisions for uncollected accounts," and "materials and supplies." The earnings equal the net operating income before both interest charges and income taxes (36).

Natural Gas Pipelines. Earning assets consist of "net gas utility plant," "gas stored underground-non-current,""notes and accounts receivable less accumulated provision for uncollected accounts," "materials and supplies," and "gas stored underground-current." The earnings equal the new operating income before both interest charges and income taxes (13).

Telephone Communications. The asset base consists of "total communications plant-net," "materials and supplies," and "accounts receivable from customers, agents and others." Earnings equal the annual operating income before both interest charges and income taxes (22).

Railroads. Earning assets equal "total properties less recorded depreciation and amortization," "materials and supplies," net balance receivable from agents and conductors," "miscellaneous accounts receivable," and "accrued assets receivable." Earnings equal annual operating income before both interest charges and income taxes (22).

Oil Pipelines. The data available on oil pipelines is less detailed than that for other industries. Physical plant is estimated as the value of "carrier property" minus both "accrued depreciation-property" and "accrued amortization-property." Receivables and inventories were estimated as "total current assets" less "cash." As a result of this estimation the total earning assets are somewhat overstated which results in an underestimation of the rate of return. The earnings for each year equal the annual operating income before both interest charges and income taxes (23).

Motor Carriers. The earning assets are estimated as the sum of "net carrier property" and 50 percent of "current assets-total." The 50 percent figure is recommended by Stockfisch for an estimate of receivables and inventories as more detailed data is not available (44:26). Earnings equal annual operating income before both interest charges and income taxes (24).

Airlines. Earning assets equal the sum of "net value of operating equipment," "materials," "net value of spare parts," and "accounts receivable." Earnings equal annual operating income before both interest charges and income taxes less federal subsidies (5).

The rate of return for each subsector was computed as the ratio of earnings on assets. The rates of return listed in Table III-1 are for the period 1970-1980 (or for all years in which data was available). The earnings from each year were summed and divided by the sum of the assets for each year to estimate the average annual rate of return.

Once the rates of return for these selected subsectors have been computed, the relative importance of each (as a percentage of the overall corporate sector) must be determined. Table III-2 lists the total allocation for new plant and equipment for the years 1970-1980 and the percentage of the total allocation for each subsector. The allocation for new plant and equipment is taken to be a reflection of private investment made in the various subsectors. We can now estimate an overall rate of return for the corporate sector as the weighted average of the rates of return from the various subsectors. The weights reflect the portion of the total allocation for new plant and equipment invested in each subsector.

According to the data in Table III-2, approximately 64 percent of the investment in new plant and equipment flows into the unregulated areas of manufacturing (42 percent), mining (3 percent), and commercial and other (19 percent). Stockfisch makes the assumption that the rate of return revealed in manufacturing should equal the rates of return for all unregulated industries in general. This

TABLE III-1

SUMMARY OF THE RATES OF RETURN FOR SELECTED CORPORATE SUBSECTORS

Subsector	Average Annual Rate of Return (1970-1980)	Average Annual Rate of Return (1961-1965)
Manufacturing/ Other Unregulated	16.6	15.4
Electric Utility	6.4	9.3
Gas Pipelines	14.4	8.6
Telephone	10.0	11.9
Railroads	4.4	4.1
Motor Carriers	16.9	14.7
Oil Pipelines	10.4	15.6
Airlines	3.0	8.2

Note: A summary of yearly assets and earnings for each subsector is found in Appendix B. The rate of return here is the ratio of total earnings to total assets (for the periods 1961-1965 and 1970-1980) for each subsector. The rates of return from the period 1961-1965 are those estimated by Stockfisch (44:7).

TABLE III-2

ALLOCATION OF BUSINESS INVESTMENT SPENDING ON PLANT AND EQUIPMENT (1970-1980)
(billions of dollars) (6)

	1970	1971	1972	1973	1974	1975	1976
All Industries	79.71	81.21	88.44	99.74	112.40	120.78	120.49
Manufacturing	31.95	29.99	31.35	38.01	46.01	47.95	52.48
Mining	1.89	2.16	2.42	2.74	3.18	3.79	4.00
Commercial and other	16.59	18.05	20.07	21.40	22.05	20.60	20.99
Public Utility	13.14	15.30	17.00	18.71	20.55	20.14	22.28
Communications	10.10	10.77	11.89	12.85	13.96	12.74	13.30
Railroads	1.78	1.67	1.80	1.96	2.54	2.55	2.52
Transportation other than rail	4.26	3.26	3.92	4.07	4.12	5.02	4.93

	1977	1978	1979	1980	11-Year Total	Percentage
All Industries	135.80	153.82	177.09	194.63	1,356.1	100
Manufacturing	60.10	67.62	78.92	89.55	573.4	42
Mining	4.50	4.78	5.56	6.18	41.2	3
Commercial and other	22.97	25.71	29.35	32.51	250.3	19
Public Utility	25.80	29.48	32.56	32.94	247.9	18
Communications	15.45	18.18	20.56	22.51	162.3	12
Railroads	2.80	3.32	3.93	3.96	28.8	2
Transportation other than rail	4.13	4.73	6.20	6.99	51.6	4

equality would be the result of competition among unregulated industries (45:195-196). The assumption that all unregulated industries behave "on average" as do all manufacturing industries has a significant impact on an estimate of the discount rate. One cannot assume that since both automobile manufacturing and coal mining are not regulated, the rates of return from both industries should equalize through competition. Jenkins (26) estimates the rates of return for manufacturing, wholesale trade, and mining to be 15.1, 15.7 and 10.2 percent respectively which implies that equalization does not necessarily occur through competition. However, since sources which detail the assets and earnings for mining and commercial and other were not readily available, the equalization assumption is made.

The data in Table II-2 also demonstrates that 18 percent of investment in new plant and equipment was invested in public utilities and 4 percent was invested in transportation other than rail. As discussed earlier, public utilities is comprised of electric utilities and natural gas pipelines. It is necessary to determine on average what percentage of public utilities is encompassed by electric utilities and natural gas pipelines. Using the asset data provided in Appendix B, the average total public utility assets are determined as the sum of the average yearly electric utilities assets and the average yearly natural gas pipeline assets. These averages were determined by summing asset values for each year that data was available and dividing by the number of years involved. It was necessary to compute a yearly average since data was not available for electric utilities and natural gas pipelines for all years. It was thus determined that electric utilities and natural gas pipelines encompass 88 percent and 12 percent of the public utility subsector. The overall rate of return for the public utilities subsector is the weighted average of the rates of return from electric utilities and natural gas pipelines. The overall rate is computed to be (.88)(6.4%) + (.12)(14.4%) = 7.4 percent. Similarly, the transportation other than rail subsector is comprised of motor carriers, oil pipelines, and airlines which encompass 23 percent, 20 percent and 57 percent of the subsector. The overall rate of return for the subsector, transportation other than rail, is a weighted average of the rates of return of the subsector components. This overall rate of return for transportation other than rail is (.23)(16.9%) + (.20)(10.4%) + (.57)(3.0%) = 7.7 percent.

The overall rate of return for the corporate sector is now estimated as the weighted average of the rates of return observed in the various subsectors. The weights, which reflect the portion of new plant investment flowing to each subsector, are (.64) for manufacturing, (.18) for public utilities, (.02) for communications, (.02) for railroads, and (.04) for transportation other than rail. The overall nominal rate of return for the corporate sector is estimated to be (.64)(16.6%) + (.18)(7.4%) + (.12)(10%) + (.02)(4.4%) + (.04)(7.7%) = 13.5 percent.

The estimated rate of return for corporate sector presented here does not account for property taxes. Taxes such as property taxes notify an industry or firm that the accumulation of new physical assets incurs new tax obligations. These tax obligations will directly affect the earnings on the physical assets of an industry; i.e., reduce the rate of return on them (44:5). Stockfisch makes an estimate of what he calls an "effective property tax rate" (44:9). The term "effective property tax rate" is best defined by an example. Suppose the pre-tax rate of return for the corporate sector is 10 percent and that all corporate earnings are subject to a property tax of 20 percent. For this example, each dollar invested in the corporate sector yields 10 cents. However, 20 percent of that 10 cents must be used to satisfy the property tax obligation. Thus, the after-property tax return on the initial investment is 8 cents. The after-property tax rate of return (ratio of after tax return to investment) for the initial investment is 8 percent. The difference between the pre-tax rate of return and the after tax rate of return is defined as the effective tax rate. In this case, the effective property tax rate is 2 percent (10 percent - 8 percent). Thus, once the effective property tax rate can be determined, that rate can be added directly to the after tax rate of return to obtain the pre-tax rate of return. As can be seen by this example, the effective property tax rate is simply the ratio of property tax payments to total property assets.

In 1956 the overall effective property tax rate was 1.2 percent (33:231). This rate was determined using data provided by Goldsmith (17) for property values. Stockfisch attempts to estimate the effective property tax rate for the period 1961-1965 by first assuming the effective property tax rate was 1.2 percent in 1956. He then compares the increases in property tax payments and the value of capital stock (estimated by Stockfisch to be one-fourth of net national product). Since property tax payments doubled between 1956 and 1961, and since the value of capital stock increased (but did not double), Stockfisch estimated the effective property tax rate to be 1.5 percent (44:9).

The Stockfisch methodology (estimating the value of capital stock as one-fourth of net national product) is not followed here in estimating the effective property tax rate. Between 1956 and 1973 property tax payments increased by an average annual rate of 6 percent (10:323). During the same period the value of capital stock increased by an average annual rate of 2.7 percent (9:680). The year 1973 served as the cutoff point here because

Christensen (9) did not include the years after 1973 in his study and no known subsequent work exists. Assuming the effective property tax rate was 1.2 percent in 1956, and assuming property tax payments have continued to grow at a rate of 6 percent per year and the value of capital stock has increased at a rate of 2.7 percent per year, the effective property tax rate for 1973 is estimated to be 2.1 percent. This estimate is computed by multiplying the effective property tax rate from 1956 by the annual rate of growth of the effective tax rate. This annual rate of growth is computed as the ratio of the annual rate of growth in tax payments to the annual rate of growth in the value of capital stock. In this example, the annual growth rate is given by the ratio $\frac{(1.06)}{1.027}$. During the seventeen years from 1956 to 1973, the effective property tax would grow from 1.2 percent to $(1.2)(\frac{1.06}{1.027})^{17}$ or to 2.1 percent. Thus, the before tax rate of return for the corporate sector is 15.6 percent (13.5 percent after tax rate plus 2.1 percent effective property tax rate). This estimate of the overall pre-tax rate of return is very sensitive to the effective property tax rate. If the rate of annual growth from 1956 to 1973 remained the same through 1980, the effective property tax rate in 1980 would have been on the order of 2.6 percent. The effective property tax rate for 1973 is used as no known estimates of the increase in capital stock from 1973 to 1980 exist. Using this methodology to estimate the effective property tax rate for the years of the Stockfisch study, the effective property tax varies from 1.4 percent in 1961 to 1.6 percent in 1965 (as opposed to the 1.5 percent estimate by Stockfisch).

Rate of Return for the Non-Corporate Sector

There are investment opportunities available in the private sector which cannot be included in any of the subsectors of the corporate sector. Investments in agriculture, partnerships, proprietorships, and non-farm housing are available, but measuring the earnings on physical assets and estimating a rate of return for any of these investments is extremely difficult. However, if one follows Stockfisch (44:13) and assumes that in a competitive market the rate of return for the non-corporate sector equals the rate of return for the corporate sector after corporate taxes, the non-corporate sector rate is easily estimated. The argument against this assumption is that there are many different rates of return available in the competitive market. One cannot assume the rate of return for garment manufacturing equals the rate of return for auto manufacturing, even though both are part of the competitive market. However, there are no known studies which estimate the non-corporate sector rate of return independently of the corporate sector rate of return. Although Jenkins estimates a rate of return for agriculture, he estimates the rate of return for the remainder of the non-corporate sector as the rate of return for the corporate sector minus the effective corporate tax rate (26:224, 225). Hence, the equalization assumption is made.

Investments in the non-corporate sector are not subject to corporate taxes. Using the equilization assumption from above, one need only compute the effective corporate tax rate and subtract value from the corporate sector rate of return to obtain the non-corporate sector rate of return. The effective corporate tax rate, given as the ratio of corporate tax payments to corporate assets, is computed yearly for the period 1970-1980 using the data presented in Table III-3. The effective property tax rate for the period 1970-1980 is on the order of 4.4 percent. Stockfisch estimated the effective corporate tax rate to be 4.7 percent in 1956 and 4.8 percent in 1963 (44:13); thus, the computed rate here for 1970-1980 seems quite reasonable. Thus, the rate of return for the non-corporate sector is 11.2 percent (15.6 percent corporate sector rate of return minus the effective corporate tax rate of 4.4 percent).

The Overall Nominal Rate of Return

After estimating the rate of return for both the corporate and non-corporate sectors, one can estimate the overall rate of return as the weighted average of these

TABLE III-3

CORPORATE ASSETS, CORPORATE TAX PAYMENTS AND EFFECTIVE CORPORATE TAX RATES, 1970-1980

Year[a]	Corporate Assets[b] (billions of dollars)	Corporate Taxes[c] (billions of dollars)	Effective Corporate Tax Rate (percent)
1970	2072	81.3	3.9
1971	2338	89.0	3.8
1972	2672	104.1	3.9
1973	2938	122.8	4.2
1974	3038	140.9	4.6
1975	3299	147.9	4.5
1977	4433	208.3	4.7
1978	5063	232.5	4.6
1979	5623	255.8	4.5
1980	5571	253.7	4.6
Totals	37,047	1636.3	4.4

Notes:

[a] Information for year 1976 was not available.

[b] From reference 21.

[c] From references 21; 10:322-323.

TABLE III-4

PRIVATE PHYSICAL ASSET HOLDINGS, CORPORATE AND NON-CORPORATE SECTORS, 1980
(billions of dollars) (7)

		Percent
Corporate Sector		
Non-financial Institutions	3556.0	
Financial Institutions	175.0	
Subtotal	3731.0	40.1
Non-Corporate Sector		
Agriculture	1004.4	
Non-farm Unincorporated	57.0	
Non-farm Households	4495.0	
Subtotal	5565.4	59.9
Total	9287.4	100.0

two rates. As shown in Table III-4, the percentage of the overall market represented by the corporate/non-corporate sector was approximately 40/60 percent in 1980. Stockfisch also determined the elative importance of the two sectors (percentage of the overall market) as 40 and 60 percent for 1958 (44:12). Stockfisch does not attempt to measure the relative importance of the two sectors for the years 1961-1965. He uses data presented by Goldsmith (17) for 1958 to estimate these percentages. Thus, we can assume that the relative importance of the two sectors has remained relatively consistent since 1956. We can now estimate the overall nominal rate of return in the private sector for the period 1970-1980 to be 13.0 percent by:

$$r = (15.6)(.4) + (11.2)(.6) = 13.0\%$$

Adjustment for Inflation

Inflation, an increase in the general price level of goods, can have a significant effect on estimating the overall rate of return. Many of the physical assets providing earnings today may have been accumulated at earlier times at lower prices. Hence, expressing the values of physical assets and earnings in constant dollars would decrease the overall real rate of return. For example, suppose an individual invested 100 dollars for one year in hopes of increasing his actual purchasing power by 20 percent. Also suppose the inflation rate is known to be 10 percent for the next year. Thus, considering inflation only, 100 dollars today is equivalent to 110 dollars in one year. If the individual were to increase his real buying power by 20 percent, he must earn 32 dollars with his initial investment of 100 dollars. This earning would increase his actual buying power at the end of one year from 110 dollars to 132 dollars or 20 percent. Although the individual appears to have earned a return of 32 percent on his initial investment, this 32 percent is a nominal rate and must be adjusted for inflation (11:114). This adjustment of the nominal rate of return can be accomplished using the following formula.

$$1 + r = (1+R)(1+I) \qquad (2)$$

where r = nominal rate of return,

R = real rate of return, and

I = annual rate of inflation.

By solving Equation (2) for the real rate of return (R) we have:

$$R = \frac{(r-I)}{(1+I)} \qquad (3)$$

For our example we have $R = \frac{(.32-.10)}{1.1} = \frac{.22}{1.1} = .20$. This 20 percent rate represents the real rate of return. A similar adjustment must be made to the estimated private sector rate of return of 12.9 percent in order to determine the real rate of return.

In order to make an adjustment for inflation to the overall nominal rate of return a means of estimating the annual rate of inflation must be determined. Following Stockfisch's methodology, the annual rate of inflation was determined using the personal consumption expenditure deflator (CED). Stockfisch defends his methodology as follows:

> We do not use the GNP deflator itself. . . . The overall GNP deflator is a weighted average of price indexes for gross domestic investment, and government spending components, as well as consumption spending.

> The former indexes are not especially meaningful since they are mainly indexes of input prices, and consequently have a strong inflationary bias [44:15].

The CED is used as follows to estimate the average annual inflation rate. The annual average rate of inflation between year A and year B is the CED for year B minus the CED for year A all divided by B minus A. The problem of determining the appropriate time period over which to estimate the annual rate of inflation must be resolved.

Many of the physical assets measured in the estimation of the discount rate were most probably accumulated during previous years. Assets such as property, plant and equipment may have been accumulated over periods of 20 years or longer. Since detailed data was not available, the actual years of accumulation of assets are not known. However, we can still estimate lower and upper bounds for the real discount rate. As shown in Table III-5, the average annual inflation rate was 5.1 percent for the period 1960-1980 and 7.9 percent for the period 1970-1980 (10:236). The period 1960-1980 was chosen to account for the effects of inflation on any assets accumulated between 1960 and 1970 which yielded returns over the next decade. The real rate of return in the private sector for the period 1970-1980 is estimated to be between 4.1 and 7.2 percent. These limitations were estimated using Equation (3). Similarly, Stockfisch uses the average annual inflation rate for the period 1949-1965 to adjust his

TABLE III-5

SUMMARY OF THE OVERALL RATE OF RETURN

Corporate Sector Rate of Return		15.6
Non-Corporate Sector Rate of Return (corporate rate minus effective tax rate)		11.2
Overall Nominal Rate of Return (weighted average of the rates[a] for the two sectors)		13.0
Average Annual Inflation Rate[b] (1960-1980)		5.1
Average Annual Inflation Rate[b] (1970-1980)		7.9
Overall Real Rate of Return[c]	Min.	4.1
	Max.	7.2

Notes:

[a]The overall nominal rate of return is a weighted average of the rates of return for the corporate and non-corporate sector. The weights used were 0.4 and 0.6 respectively.

[b]Yearly inflation rate derived from the personal consumption expenditures deflator (10:236).

[c]Equation (3) was used to adjust the nominal rate for inflation.

estimate of the nominal rate of return. However, the annual inflation rate for the period 1961-1965 is also on the order of 1.6 percent. Thus no upper and lower limits are included in this study for the Stockfisch estimate.

A Year by Year Analysis of the Private Sector Discount Rate

Estimating a rate of return over a period of eleven years can be deceptive if the rate of return fluctuated wildly from year to year. Table III-6 presents a brief year by year summary of the rates of return on private investment for the period 1970-1980. Table III-7 presents a year by year summary of the rates of return for the various segments of the corporate sector. A weighted average of the rates found in Table III-7 were used to estimate the overall corporate sector rate of return for each year. The weights used in computing this average reflect the percentage of total investment in new plant and equipment invested in a particular subsector for a given year. This modification in the methodology (using yearly rates of return rather than the rates of return across the period) will allow the comparison of yearly overall rates of return for the entire period 1970-1980.

The estimations of the yearly rates in Table III-7 are based primarily on the asset and earnings data found in Appendix B. However, asset data was not readily available for each subsector for all years. When this data was

TABLE III-6

SUMMARY OF THE YEARLY RATES OF RETURN 1970-1980

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Corporate Sector[a]	13.0	13.8	14.7	16.3	16.2	15.1	16.6	16.9	17.6	16.5	15.3
Non-corporate Sector[b]	9.1	10.0	10.8	12.1	11.6	10.6	12.0	12.2	13.3	12.0	10.7
Overall Nominal Rate of Return	10.7	11.5	12.4	13.8	13.4	12.4	13.8	14.1	15.0	13.8	12.5
Mean:	13.1 percent										
Standard Dev.:	±1.3 percent										
Inflation Rate[c]	4.1	4.0	3.5	5.7	10.6	8.9	6.4	7.9	9.6	13.2	16.6
Real Rate[d]	6.2	7.0	8.5	7.3	1.4	2.4	6.6	5.1	4.0	-1.2	-6.1
Mean:	3.7 percent										
Standard Dev.:	±4.4 percent										

Notes:

[a]The yearly rates of return for the corporate sector were derived using the data found in Appendix B.

[b]The yearly rates of return for the non-corporate sector were derived using the methodology of Section III.

[c]The yearly rates of inflation were derived using the personal consumption deflator (10:336).

[d]Equation (3) was used to adjust the nominal rate for inflation.

TABLE III-7

YEARLY NOMINAL RATES OF RETURN BY SUBSECTOR, 1970-1980[a]

	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Manufacturing/ Other unreg.	12.6	13.3	14.8	17.2	17.3	15.6	18.0	18.2	18.6	18.1	16.0
Elec. Util.	6.4	6.4	6.8	6.6	6.1	6.7	6.6	6.6	6.5	6.1	6.5
Gas Pipelines[b]	20.9*	21.8*	21.8*	23.0*	13.4*	11.8*	7.4*	15.4	14.1	12.1	16.5*
Telephone[b]	9.6	9.8*	9.8*	9.5	9.6	8.8*	10.1	10.1	10.7	10.1	9.0
Oil Pipelines[b]	12.9	11.9	11.4	11.8	10.3	9.5	8.4	7.0*	14.0*	11.7*	12.3*
Motor Carriers[b]	11.3	21.6	20.5	18.0	17.3	15.8	17.0	18.5	18.9	11.2	15.7*
Railroads	4.6	5.2	5.7	6.0	5.3	3.7	4.3	3.6	2.2	3.6	4.9
Airlines[b]	.05*	4.3*	7.1*	6.4*	8.8*	1.4*	5.0	5.9	7.3	0.5	-1.1

Notes:

[a]The annual rates of return for the subsectors were derived using the data in Appendix B.

[b]Information was not readily available for each subsector for each year. If the data for a particular year was not available, the rate of return for each subsector with missing data (noted with an asterisk (*)) is estimated by the procedure outlined in the text.

available for a subsector for a particular year, an estimate of the subsector rate of return was needed to use in estimating the overall rate of return for that year. The subsectors of gas pipelines, telephone communications, oil pipelines, motor carriers and airlines all had missing data for at least one year during the period 1970-1980. For the years in which data was not available for a subsector, the yearly rate of return was estimated as follows. The ratio of total earnings to total assets (A) (where earnings equal net income (NI) plus interest payments (I)) was determined using the available data. This ratio $(\frac{NI+I}{A})$ equals the product of the ratio of earnings to revenues $(\frac{NI+I}{R})$ and the ratio of revenues to assets $(\frac{R}{A})$. Earnings and revenue data is available for each year for each subsector (7), hence the ratio $\frac{(NI+I)}{R}$ can be computed for each subsector for each year. The average ratio of revenues to assets $(\frac{R}{A})$ can be computed for the years in which asset data is available for a subsector by dividing $\frac{NI+I}{A}$ by $\frac{NI+I}{R}$. The ratio $\frac{R}{A}$ reflects the revenues generated by each dollar of assets. Using the assumption that this ratio is constant, the rate of return for a subsector (for a year in which asset data is missing) can be estimated by the product of the constant ratio $\frac{R}{A}$ and the ratio $\frac{NI+I}{R}$ which varies from year to year. The years in which the subsector rate of return was estimated in this way are noted with an asterisk (*) in Table III-7.

The average of the eleven yearly nominal rates of return (estimated by the methodology) is 13.1 percent which is approximately equal to the 13.0 percent nominal rate of return from 1970-1980 estimated using the Stockfisch methodology. Stockfisch (44) estimated the overall nominal rate of return for the period 1961-1965 to be 12 percent. The annual rate of inflation (based on the consumer expenditure deflator) during the period 1970-1980 fluctuated from 3.5 percent in 1972 to 16.6 percent in 1980 (see Table III-6), and, as a result, the real rate of return fluctuated from -6.1 percent in 1980 to 8.5 percent in 1972. This year to year fluctuation in the annual inflation rate and overall discount rate is not observed during the years of the Stockfisch study. The average annual inflation rate was 2.5 percent during the 1940s, 1.4 percent during the 1950s, 1.7 percent during the 1960s, and 7.0 percent during the 1970s. The relatively high inflation rate during the 1970s is not typical for any period between 1940-1970. If the years 1974, 1975, and 1978-1980 (years of high inflation) are excluded from this study, the real rate of return varies from 5.1 percent to 8.5 percent and the average annual inflation rate is on the order of 5.2 percent. Thus, the decade of the 1970s (except for years of high inflation) may better typify market conditions of the future (anticipated inflation rate of 5 to 6 percent through the 1980s) than the decades of the 1950s and the 1960s.

DoD currently employs a 10 percent real discount rate for evaluating DoD projects, a rate which is not consistent with this study. Except for years in which the inflation rate was approximately 10 percent (or greater), the real rate of return for the period 1970-1980 is on the order of 5 to 8 percent. If DoD analysts employed a 5 or 8 percent real discount rate, many of the DoD projects rejected using a 10 percent real discount rate would be undertaken.

IV. Summary, Conclusions, and Recommendations

Summary and Conclusions

Resources diverted from the private sector for public investments should earn at least as great a return as would have been realized by leaving them in the private sector. For example, diverting resources earning 15 percent from the private sector in order to invest them in a public project earning 5 percent is not an efficient use of resources. The rate of return which resources would have yielded in the private sector is the discount rate that should be used for evaluating public investments. As was demonstrated earlier, the discount rate used in evaluating projects will have a significant impact on the analysis. A project which is approved using a discount rate of 5 percent may not be approved using a discount rate of 10 percent.

This study attempts to estimate the discount rate to use in public investment analysis as the marginal productivity of capital in the private sector. This estimate is sensitive to the assumptions employed during the course of this study. The assumption that the government has total freedom in using funds diverted from the private sector is the basis of using the marginal productivity of capital in the private sector as an estimate of the discount rate for public investments. As discussed in Chapter II, the correct discount rate (under this assumption) is the rate of return on private investments (rate r) regardless of how the funds would have been used in the private sector. The estimate of the discount rate included in this study can be considered an upper limit to the "correct" discount rate. Any constraints placed on the government which limit its freedom in using funds diverted from the private sector would dictate that the discount rate for public investment analysis be between society's marginal rate of time preference (rate t) and the marginal productivity of capital, depending on how the funds would have been used by the private sector.

The second assumption employed in this study, assuming the rates of return for nonregulated industries are "on average" equal due to competition, may have a significant impact on the estimate of the discount rate. This assumption implies the rate of return realized by an automobile manufacturer should equal that realized by the coal mining industry. However, Jenkins (26) demonstrated that the rates of return realized by non-regulated industries can vary widely. Since investments in new plant and equipment for mining and commercial and other account for approximately 22 percent of total investment during the period 1970-1980 (see Table III-2), the assumption that the rates of return of these industries equals the rate of return realized in the manufacturing industry adds a significant degree of uncertainty to the estimate presented in this study.

The rate of return in the non-corporate sector is assumed to equal the rate of return in the corporate sector minus the effective corporate tax rate. This assumption was made due to the difficulty involved in estimating earnings in the non-corporate sector. This assumption is consistent with the methodology of Stockfisch (44) and Jenkins (26); however, the impact of this assumption is similar to the impact of the assumption for the non-regulated industries. Since the estimate of the overall rate of return is the weighted average of the rates of return from the corporate and non-corporate sectors, and since the relative importance of these two as part of the private sector is 40 percent and 60 percent respectively; any error in estimating the rate of return for the non-corporate can have a significant impact on the overall estimate.

The final assumption made in this study involves dealing with missing data. Since asset data was not readily available for all subsectors of the corporate sector for all years, estimates of the rates of return were made for the subsectors for each year in which data was not available. Earnings and revenue data were available for all subsectors for all years. Since the ratio of earnings to revenue times the ratio of revenues to assets equals the ratio of earnings to assets (or the rate of return), the assumption is made that the ratio of revenues to assets (revenues generated by each dollar of assets) for the years in which asset data was available is constant, and therefore the same for each year in which data was not available. This estimated ratio of revenues to assets is then used to estimate the rate of return for a subsector with missing data. These estimated subsector rates of return were then used to estimate the overall rate of return.

The combined effects of these assumptions may have a significant impact on the estimate of the discount rate. The estimates of the real rates of this study (except for years of high inflation) were on the order of 5 to 8 percent (see Table III-6) which are not consistent with the 10 percent real rate of return currently employed by DoD analysts. This study raises serious questions about the appropriateness of the current 10 percent real rate; however, more extensive data and analysis are necessary to reach a strong conclusion.

Recommendations for Further Study

The debate surrounding estimating the private sector discount rate has been ongoing more than 20 years, and it is unlikely that the differences in opinions will ever be completely resolved. However, analysis of public sector investments continues and an estimated discount rate is an integral part of this analysis. Further analysis is possible if the missing data and data for mining and wholesalers which does exist but was not readily available for this study were used to estimate the yearly rates of return to determine if the results of the study would have been different. Further analysis is also possible if a method of estimating earnings in the non-corporate sector can be established. Such analysis and additional study would eliminate much of the uncertainty associated with this study. Further study is also possible to determine if any decisions within DoD (such as the lease-buy decision involving the CT-38 aircraft) may have been different if DoD analysts employed a 5 or 8 percent real discount rate rather than a 10 percent real discount rate. Further studies in these areas would be very beneficial in improving the effectiveness of public investment analysis in both DoD and the government as a whole.

Appendix A: Computing the Interest Component for Manufacturing Earnings

As was discussed in Chapter III, the data from the Federal Trade Commission (FTC) for manufacturing earnings ("net profits from operations") does not include interest charges. The amount of interest paid must be estimated in order to determine the rate of return for the manufacturing subsector. Otherwise, the earning assets and the rate of return will be underestimated.

The interest charges paid were estimated following Stockfisch's methodology. FTC documents do provide data on both long term and short term debt of manufacturers. The quarterly averages of both short term debt ("short term loans from banks") and long term debt (sum of "installments, due in one year, on long term debt" and "long term debt due in more than one year") were multiplied by the appropriate interest rate to estimate total interest payments. The short term interest rate for each year was estimated by the average of the sum of the prime rate charged by banks and the rate on four to six month prime paper. The long term interest rate for a particular year was estimated as the mean of Moody's composite yield on industrial bonds for the ten year period preceding the year in question (44:26-27). Table A-1 provides a year by year summary of both long term and short term interest rates. Table B-1 in Appendix B provides a listing for the total interest paid.

TABLE A-1

INTEREST RATES EMPLOYED TO ESTIMATE THE INTEREST COMPONENT OF MANUFACTURING EARNINGS (9:B-67)

Year	Prime Rate	Prime Commercial Paper: 4-6 Months	Ave	Moody's Corporate Yield on Industrial Bonds
1970	7.91	7.71	7.81	5.60
1971	5.72	5.11	5.42	5.86
1972	5.25	4.73	4.99	6.14
1973	8.03	8.15	8.09	6.46
1974	10.81	9.84	10.33	6.89
1975	7.86	6.32	7.09	7.35
1976	6.84	5.34	6.09	7.71
1977	6.83	5.61	6.22	7.96
1978	9.06	7.99	8.53	8.21
1979	12.67	10.91	11.79	8.47
1980	15.27	12.29	13.78	8.88

Note: The industrial bond rates listed for each year are an average for the ten year period preceding the year in question. For example, the bond rate for 1970 is the average of the rates for the period 1960-1969.

Appendix B: Yearly Summary of Assets and Earnings in Selected Segments of the Corporate Sector

Tables B-1 through B-8 present a yearly summary of the assets and earnings for selected segments of the corporate sector used in this study.

TABLE B-1

MANUFACTURING EARNING ASSETS AND RATES OF RETURN
(millions of dollars) (15)

Year	Earnings Assets	Operating Profit	Interest	Total Earnings	Rate of Return	Average Rate of Return
1970	457,253	49,535	8,117	57,651	12.6	16.6
1971	476,086	55,283	8,232	63,515	13.3	—
1972	507,807	66,452	8,861	75,313	14.8	—
1973	565,156	86,342	11,104	97,446	17.2	—
1974	548,235	82,152	12,765	94,917	17.3	--
1975	578,434	77,099	13,381	90,480	15.6	—
1976	618,239	97,298	14,195	111,493	18.0	--
1977	673,392	107,059	15,447	122,506	18.2	—
1978	756,391	121,955	18,367	140,322	18.6	—
1979	869,168	134,869	22,849	157,718	18.1	—
1980	983,043	128,488	28,396	156,884	16.0	--

Notes:

[a]Interest estimated by the method defined in Appendix A.

[b]Total earnings equal the sum of operating profit and interest.

[c]Average rate of return is the ratio of total earnings (overall sum) to total earning assets (overall sum).

TABLE B-2

EARNING ASSETS, EARNINGS, AND RATE OF RETURN FOR PRIVATELY OWNED ELECTRIC UTILITIES IN THE U.S. (millions of dollars) (36)

Year	Earning Assets	Earnings	Rate of Return	Average Rate of Return
1970	79,929	4,885	6.1	6.4
1971	89,562	5,402	6.0	--
1972	104,717	7,073	6.8	--
1973	117,682	7,744	6.6	--
1974	134,215	8,140	6.1	--
1975	147,070	9,855	6.7	--
1976	161,054	10,689	6.6	--
1977	177,866	11,665	6.6	--
1978	195,649	12,778	6.5	--
1979	218,094	13,289	6.1	--
1980	241,533	15,593	6.5	--

Note: Average rate of return is the ratio of the sum of the yearly earnings to the sum of the earning assets from each year.

TABLE B-3

EARNING ASSETS, EARNINGS, AND RATE OF RETURN FOR NATURAL GAS PIPELINES (millions of dollars) (13)

Year	Earning Assets	Earnings	Rate of Return	Average Rate of Return
1977	19,055	2,928.4	15.4	14.4
1978	21,352	3,013.6	14.1	--
1979	24,142	2,924.0	12.1	--
1980	20,836	3,434.0	16.5	--

Notes:

[a]Data was not available for 1970-1976.

[b]Average rate of return is the ratio of the sum of yearly earnings to the sum of the earning assets for each year.

TABLE B-4

EARNING ASSETS, EARNINGS, AND RATE OF RETURN FOR TELEPHONE COMMUNICATIONS
(millions of dollars) (14)

Year	Earning Assets	Earnings	Rate of Return	Average Rate of Return
1970	49,327	4,732.7	9.6	10.0
1973	67,898	6,456.6	9.5	--
1974	74,816	7,173.0	9.6	--
1976	87,683	8,849.2	10.1	--
1977	96,837	9,828.8	10.1	--
1978	106,753	11,426.8	10.7	--
1979	117,432	11,896.6	10.1	--

Notes:

[a]Data not available for the years 1971, 1972, 1975, and 1980.

[b]Average rate of return is the ratio of the sum of yearly earnings to the sum of earning assets for each year.

TABLE B-5

EARNING ASSETS, EARNINGS, AND RATE OF RETURN FOR RAILROADS (millions of dollars) (22)

Year	Earning Assets	Earnings	Rate of Return	Average Rate of Return
1970	27,618	1,263.2	4.6	4.4
1971	27,874	1,455.3	5.2	--
1972	26,726	1,525.0	5.7	--
1973	28,438	1,719.0	6.0	--
1974	29,630	1,580.2	5.3	--
1975	30,589	1,136.9	3.7	--
1976	29,348	1,272.4	4.3	--
1977	31,361	1,144.2	3.6	--
1978	30,555	678.2	2.2	--
1979	34,328	1,225.0	3.6	--
1980	37,547	1,853.0	4.9	--

Note: Average rate of return is the ratio of the sum of yearly earnings to the sum of earning assets for each year.

TABLE B-6

EARNING ASSETS, EARNINGS, AND RATE OF RETURN FOR OIL PIPELINES (millions of dollars) (23)

Year	Earning Assets	Earnings	Rate of Return	Average Rate of Return
1970	4,004.7	515.9	12.9	10.4
1971	4,514.9	537.1	11.9	--
1972	4,890.9	557.7	11.4	--
1973	5,094.3	602.0	11.8	--
1974	6,267.8	644.5	10.3	--
1975	8,759.2	835.7	9.5	--
1976	11,634.9	981.8	8.4	--

Notes:

[a]Data not available for the years 1977-1980.

[b]Average rate of return is the ratio of the sum of yearly earnings to the sum of earning assets for each year.

TABLE B-7

EARNING ASSETS, EARNINGS, AND RATE OF RETURN FOR COMMERCIAL AIRLINES (millions of dollars) (5)

Year	Earning Assets	Earnings	Rate of Return	Average Rate of Return
1976	12,809	643.4	5.0	3.0
1977	14,082	831.4	5.9	--
1978	17,755	1,299.3	7.3	--
1979	21,700	108.9	0.5	--
1980	25,446	-276.4	-1.1	--

Notes:

[a]Data not available for the years 1970-1975.

[b]Average rate of return is the ratio of the sum of yearly earnings to the sum of earning assets for each year.

TABLE B-8

EARNING ASSETS, EARNINGS, AND RATE OF RETURN
FOR INTERCITY MOTOR CARRIERS
(millions of dollars) (24)

Year	Earning Assets	Earnings	Rate of Return	Average Rate of Return
1970	3,326.3	374.3	11.3	16.9
1971	3,574.6	773.5	21.6	--
1972	4,077.7	836.8	20.5	--
1973	4,499.0	811.9	18.0	--
1974	4,554.4	787.6	17.3	--
1975	3,449.7	544.7	15.8	--
1976	3,752.4	637.0	17.0	--
1977	1,475.7	272.8	18.5	--
1978	5,003.2	945.4	18.9	--
1979	5,070.7	570.0	11.2	--

Notes:

[a]Data not available for 1980.

[b]Annual rate of return is the ratio of the sum of yearly earnings to the sum of earning assets for each year.

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REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION	UNCLASSIFIED
1b. RESTRICTIVE MARKINGS	
2a. SECURITY CLASSIFICATION AUTHORITY	
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
3. DISTRIBUTION/AVAILABILITY OF REPORT	Approved for public release; distribution unlimited.
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	AFIT/GOR/OS/84D-2
5. MONITORING ORGANIZATION REPORT NUMBER(S)	
6a. NAME OF PERFORMING ORGANIZATION	School of Engineering
6b. OFFICE SYMBOL (If applicable)	AFIT/GOR
7a. NAME OF MONITORING ORGANIZATION	
6c. ADDRESS (City, State and ZIP Code)	Air Force Institute of Technology Wright-Patterson AFB, Ohio 45433
7b. ADDRESS (City, State and ZIP Code)	
8a. NAME OF FUNDING/SPONSORING ORGANIZATION	
8b. OFFICE SYMBOL (If applicable)	
9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER	
8c. ADDRESS (City, State and ZIP Code)	
10. SOURCE OF FUNDING NOS.	PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT NO.
11. TITLE (Include Security Classification)	See Box 19
12. PERSONAL AUTHOR(S)	Danny T. Coats, B.A., 1st Lt, USAF
13a. TYPE OF REPORT	MS Thesis
13b. TIME COVERED	FROM ______ TO ______
14. DATE OF REPORT (Yr., Mo., Day)	1984 December
15. PAGE COUNT	87
16. SUPPLEMENTARY NOTATION	

17. COSATI CODES		
FIELD	GROUP	SUB. GR.
05	03	

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Discount Rate, Rate of Return, Economic Analysis, Cost Effectiveness

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Title: AN ASSETS APPROACH TO ESTIMATING THE DISCOUNT RATE FOR PUBLIC INVESTMENTS

Thesis Chairmen: Dr. Robert F. Allen
James K. Feldman, Major, USAF

Approved for public release: IAW AFR 190-17.
LYNN E. WOLAVER
Dean for Research and Professional Development
Air Force Institute of Technology (ATC)
Wright-Patterson AFB OH 45433

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT	UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐
21. ABSTRACT SECURITY CLASSIFICATION	UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL	Dr. Robert F. Allen
22b. TELEPHONE NUMBER (Include Area Code)	(513) 255-3362
22c. OFFICE SYMBOL	AFIT/ENA

This thesis effort determined the discount rate to employ in public investment analysis is the weighted average of the rates of return available in the corporate and non-corporate sectors of the American economic market. The weights used reflect the percentage of the overall market encompassed by the corporate and non-corporate sectors. This study also presented a methodology (used previously by Jacob Stockfisch (45)) for estimating the rate of return for both the corporate sector and the non-corporate sector.

In this study the writer estimates the real rate of return to use in evaluating public investments to be on the order of 5 to 8 percent for the period 1970-1980. This estimate is compared to the 10 percent real rate of return employed by Department of Defense (DoD) analysts and the impacts of employing an incorrect discount rate are assessed. The writer concludes that the findings of this study raise serious questions about the 10 percent real discount rate employed by DoD analysts, but a strong conclusion is not possible without additional study and analysis.

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