THE COST OF CAPITAL

Theory and Estimation

Cleveland S. Patterson

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CLEVELAND S. PATTERSON

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Preface

This book on cost of capital use and estimation is intended foremost as a practitioner's guide. In addition, many instructors will find it useful as a supplement to other material in advanced courses in capital budgeting and strategic investment. Its aim is to provide both a rigorous understanding of the theoretical issues underlying the concept of the cost of capital and an appreciation of the practical problems surrounding its use as a decision tool.

Discounted cash flow techniques for investment project evaluation are very widely employed in industry and their use is growing. These techniques require either the calculation of the net present value (NPV) of a project's cash flows, or calculation of an internal rate of return (IRR) for comparison with a specified hurdle rate. Numerous studies have been published documenting this growth and Bierman (1986) in a recent overview observed that "the most important conclusion we can draw from the surveys is that business practice relative to capital budgeting decisions has improved tremendously in the past thirty years." Klammer and Walker (1984) also documented the increasing use of "sophisticated capital budgeting selection techniques taught in business schools" between 1970 and 1980 in the United States and Scott and Petty (1984) concluded their survey of large U.S. firms by stating that "the movement towards the use of more sophisticated project evaluation procedures by major organizations is unequivocal."

Table P.1
Cost of Capital Applications

Decisions	Percentage of Respondents Applying Cost of Capital
New Projects	92.7
Abandonment of Existing Projects	44.6
Leasing Decisions	64.4
Bond Refunding Decisions	34.5
Estimating the Firm's Value	44.1

Source: Gitman and Mercurio (1982), Exhibit 10, p. 28.

Central to the calculation of the estimated net present value of a project is the discount rate used to reduce future cash flow estimates to their present value. In a 1980 survey of firms in the Fortune 1000 listing, Gitman and Mercurio (1982) found that 93% of the responding companies used a measure of the "cost of capital" for evaluating new projects. This is consistent with other studies by Schall et al. (1978) and Moore and Reichert (1983), which both found 86% of the firms responding to their survey were using discounted cash flow methods for project evaluation. Gitman and Mercurio also found that firms in their sample were using cost of capital for many other purposes, as indicated by Table P.1.

Although there appears to be widespread agreement among corporate executives that the cost of capital is an important datum for decision making, there is much less agreement with respect to how it should be measured. In a review of previous studies, Scott and Petty (1984), for example, cited a wide range of general approaches, as indicated in Table P.2. Only one of these, the weighted average cost of capital (WACC), is conceptually consistent with the goal of maximizing the value of existing shareholders' equity.

In an update of these surveys, Bierman (1993) found that 99% of firms in his sample of large industrial firms used IRR or NPV as either the primary or secondary method of evaluating investments. He also found 93% of the firms were using WACC, and 72% used a rate which reflected the risk or nature of the project.

WACC, although conceptually correct, is difficult to estimate since it requires an approximation of the equity investors' required return or "cost of equity capital." Gitman and Mercurio (1982) found a very wide variety of methods being used to attempt to solve this measurement problem, as indicated in Table P.3.

The objective of this book is to help financial practitioners and managers to make better investment and valuation decisions. It is narrowly focused since it assumes that managers are already using discounted cash flow methods for evaluation and are aware of the underlying rationale for the approach, that is,

Table P.2
Determination of the Discount Rate

Method	Percent Using	Reference
Cost of specific source of funds	26	Schall et al. (1978)
	17	Petty et al. (1975)
Weighted average cost of capital	61	Brigham (1975)
	46	Schall et al. (1978)
	30	Petty et al. (1975)
Historical rate of return (i.e., past experience)	20	Schall et al. (1978)
	13	Petty et al. (1975)
	10	Brigham (1975)
Management determined target rate of return	10	Petty et al. (1975)

Source: Scott and Petty (1984), Table 4, p. 117.

Table P.3
Cost of Equity Calculation Procedures

Procedure	Percentage of Respondents
Historical dividend yield plus estimate of growth	3.4
Return required by investors	35.6
Current dividend yield plus estimate of growth	26.0
Dividend yield estimate only	1.7
Cost of debt plus a risk premium for equity	13.0
Earnings/price ratio	15.8
Market return adjusted for risk	22.6

Source: Gitman and Mercurio (1982), Exhibit 2, p. 24.

maximization of the value of existing shareholders' equity. The specific questions it addresses are therefore largely limited to the following:

1. What do we mean by "the cost of capital" and how can we define it conceptually in a manner consistent with the goal of equity value maximization? In short, before venturing out with our yardsticks, what is it precisely that we are attempting to measure?
2. More specifically, in the context of the valuation of future expected cash flows, how do we define the cost of capital in a manner internally consistent with the definition of the cash flows, taking into account such factors as inflation expectations, transactions costs, taxes, interest payments, and so forth?
3. Having pinpointed what it is we are trying to measure, how can we do it in practice? What theoretical models are available for relating observable data to the cost of capital? What simplifying assumptions do they rest on? How good are they by the measure of how well they predict real-world phenomena?
4. All cost of capital estimation techniques inherently depend on the use of observable proxies for unobservable investor expectations. What are the crucial issues in selecting reasonable proxies? What techniques are useful in selecting and measuring appropriate proxies in different situations?
5. All cost of capital estimates are necessarily imprecise. How can we assess the degree of imprecision? To what extent does imprecision matter in specific instances?
6. What is the relationship between the cost of capital for a project and the characteristics of the project? In particular, how do such factors as the uncertainty of project payoffs and their correlation with the firm's other activities, or with general economic cycles, impinge on the cost of capital? Asset acquisitions also affect the firm's debt capacity and its taxable income; how are these characteristics reflected in cost of capital estimates?
7. Finally, what relationships exist among cost of capital, net present value, riskiness, and the broader sweep of corporate strategy including the creation of options to respond to future changes in conditions?

In attempting to provide answers to these questions, the following chapters are written on the assumption that readers are practicing financial managers, government regulators, or students, who are already familiar with the basic financial concepts typically covered in an introductory MBA corporate finance course or its equivalent. Therefore, although basic ideas, such as the definition of risk and the difference between systematic and non-systematic risks, are reviewed at an elementary level for the benefit of readers who have been "out of school" for some time, the treatment assumes that the concepts are not being encountered for the first time.

The structure of the book also deliberately separates theory from practice, while at the same time providing easy linkages between them. For example, Chapter 2 describes the theory underlying the development of the capital asset pricing model (CAPM), Chapter 3 reviews the empirical tests of the model that justify the validity of its use as a management tool, and Chapter 5 discusses the practical problems involved in its implementation. Sufficient repetition of the material is provided in each of the three chapters so that readers who are willing to "take the model on faith" can read Chapter 5 on its own, providing that they have a broad knowledge of the topic from other sources. Others who wish to develop a deeper appreciation of the strengths and weaknesses of the model can, and should, read the relevant material in all three chapters in conjunction with each other.

Each chapter also attempts to separate "the forest from the trees" by concentrating on a broad understanding of the issues and the most useful estimation techniques in the body of the text and relegating more technical material and peripheral issues to a section entitled "Notes." This material is organized by the chapter section headings but, to avoid annoying distractions in the main text, it is not specifically footnoted. Finally each individual chapter includes an extensive list of references for those readers who wish to explore the issues and techniques discussed in greater depth.

Financial economics is a dynamic and rapidly developing field of inquiry and many of the discoveries and insights that have evolved during recent years are directly related to the questions posed in this book. They also are helping both academics and practitioners to find better and more useful answers. The progress being made is reflected in the composition of the references that follow each chapter. Many of these are to classic papers written during the 1970s and early 1980s when the most prominent paradigms of financial theory were being formulated and tested. However, it is noteworthy that about half of them are to papers written since 1985 and more than 20% of the references are to articles published in 1990 or later. Thus, the book should be of particular value to those who already have a broad working knowledge of the subject but who have not been systematically exposed to recent developments in the academic literature.

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The Cost of Capital

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1

The Concept and Uses of the Cost of Capital

This chapter introduces the concept of the opportunity cost of capital and reviews its use for corporate and public policy decisions. It also briefly discusses some of the difficulties involved in the estimation of its magnitude for an individual asset or firm.

I. THE CONCEPT OF THE COST OF CAPITAL

Most productive enterprises require a mixture of inputs to make them viable. Some of these inputs, such as labor, have clearly identifiable out-of-pocket annual costs associated with them in the form of wages, salaries, benefits, or directly assignable overheads. Others, however, take the form of capital inputs or investments. Essentially investments represent decisions to defer present consumption until a later date, and their "cost" is largely an opportunity cost rather than an out-of-pocket cash cost.

We define the opportunity cost of a particular investment, A, as the expected return on the best comparable alternative, B, which is foregone as a result of the decision to commit capital to A. Although costs are normally thought of as dollars paid out, dollars not received have exactly the same effect on the ability to purchase goods.

For example, assume that a firm decides to invest $100,000 in a productive asset, which promises, with certainty, to yield a payoff in constant dollars of

$120,000 at the end of one year. Investors usually require an inducement to defer consumption and the specific rate of return that they require for a riskless one-year investment is established by supply and demand conditions in capital markets. Let us say that it is possible to obtain a guaranteed annual return of 10% by investing in traded market securities such as one-year discount government bonds. Then the opportunity cost of investing in the project is 10%. If there are no transactions costs or taxes, this is also the project's cost of capital. It is important to note that the cost of capital, when thought of simply as an opportunity cost, is determined by the characteristics of the *asset,* even though "capital" appears on a firm's balance sheet as a liability, in the form of debt, or as shareholders' equity. It is the return that the firm could obtain by investing in the best available alternatives that have comparable characteristics to the machine, factory, or security that is being purchased. Thus, in the example, the opportunity cost of capital is 10%, even if the capital invested is a free gift. No matter what the source of capital is, the cost of investing it in the chosen asset is the $10,000 return that the firm does not receive because it did not use the money to buy government securities having similar riskless investment characteristics.

In an important sense, the phrase "cost of capital" is misleading because it focuses attention on the right-hand side of the balance sheet and on the presumed financing mix. A better term, albeit longer, which captures the *opportunity* nature of the cost would be "the cost of a decision to invest in a given asset." This perspective yields a ready answer to the question, "What is the cost of source X of capital dollars (where X is short-term funds, long-term debt, depreciation, deferred taxes, etc.)?" It is the wrong question. The cost of capital is a concept related to *uses* of capital, not its sources. If the capital is invested in asset j, its cost, for *any* source X, is the opportunity cost of this decision.

It should be noted that, although the characteristics of an asset, such as the uncertainty of its returns or its investment life, serve to identify comparable alternatives to use as a benchmark, its own return has no bearing on the opportunity cost. In fact, it is the difference between the asset's expected return and the anticipated returns available from the next best alternatives that makes the asset attractive, or not attractive, as a potential investment. Thus, in the example, it is the difference between the productive asset's 20% guaranteed return and the cost of capital of 10% that adds value to shareholders' equity and makes it a good investment.

II. THE DETERMINANTS OF THE COST OF CAPITAL

II.A. Real Risk-Free Rates

In a simple world with no taxes or inflation and no uncertainty with respect to future investment payoffs, we can define a real, risk-free interest rate (RRFR), which reflects the price that investors charge to exchange current consumption for future consumption. It is determined in part by investors' subjective preferences and in part by the nature and availability of investment opportunities in the economy. Although it is difficult to infer its level at any point in time, or even its average value over longer periods, its order of magnitude appears to be around 0–5% per year in most developed economies.

II.B. Nominal Risk-Free Rates

In the presence of inflation, it is necessary for investors to price securities in a way that protects them from anticipated changes in the purchasing power of nominal dollars. Assume, for example, that the RRFR is 4%, that is, investors require an anticipated increase of 4% in purchasing power to induce them to defer current consumption for a year. If investors anticipate, with certainty, that the purchasing power of a dollar will decrease by 10% during the year, they will require (1.04)×(1.10), or 1.144, nominal dollars at the end of the year to meet their needs. The resulting required rate of return is referred to as the nominal risk-free rate (NRFR), that is,

$$\text{NRFR} = (1 + \text{RRFR})\,(1 + I^e) - 1 \tag{1.1}$$

$$\approx \text{RRFR} + I^e \tag{1.1a}$$

where I^e is the inflation rate, or loss of dollar purchasing power, which is expected by investors over the life of their investment.

The so-called "Fisher effect," represented by Equation (1.1), has been extensively tested empirically and found to be a reasonably good predictor of observed nominal rates, particularly when other factors, such as taxes and money supply effects, which affect both real rates and the coefficient of I^e are taken into account.

The nominal rate, NRFR, is the risk-free rate that can be observed and estimated in capital markets. The closest approximation to it is the annualized yield to maturity on discount government bills or bonds, although these are not wholly risk free in the presence of fluctuating interest rates and uncertain inflation. Note that NRFR is the returned *required* by investors to induce them to invest for a year, given their time preferences and inflation anticipations. If the market prices at which one-year government bills are offered are too high, so that they yield less than NRFR, they will not be purchased. Their prices will fall until the *expected* return from purchase is equal to the required return. Thus, when markets are in equilibrium, that is, the requirements of all investors are satisfied, expected returns equal required returns. Moreover, both are equal to the opportunity cost of capital as defined previously since, in equilibrium, the return foregone by investing in a government bill is the expected returns on alternative bills. Henceforth, the terms "investors' expected return," "investors' required return," and "opportunity cost of capital" are used synonymously, with the term chosen being determined by context. In addition, unless noted otherwise, returns are assumed to be nominal.

II.C. Investment Horizon and Term Structure

The return required by investors to induce them to defer consumption may vary with the length of time that they are contemplating deferral, that is, their investment horizon. Such variations can be observed by investigating the term structure of nominal interest rates on risk-free discount government securities, which differ from each other only in their respective terms to maturity.

Several theories have been developed to explain and predict the shape of observed term structures. The most useful of these for understanding and applying the concept of cost of capital is the "pure expectations hypothesis." Consistent with the discussion so far, this hypothesis assumes that there is no uncertainty associated with future investment payoffs or opportunities. It states simply that the yield to maturity on an n-year discount bond is determined by the yields on one-year discount securities that are expected by investors during the n-year period, that is,

$$(1 + {}_nY_0)^n = (1 + {}_1Y_0)(1 + {}_1y_1) \ . \ . \ . \ (1 + {}_1y_{n-1}) \qquad (1.2)$$

where ${}_nY_0$ and ${}_1Y_0$ are the yields currently observed at $t=0$ on n-year and one-year debt, and ${}_1y_1 \ . \ . \ . \ {}_1y_n$ are the yields on one-year securities that are expected by investors in future years 1 to n.

As an example, assume that the current yield on one-year treasury bills is 11% and that investors expect future one-year rates to be 10% beginning a year from now and 9% beginning in two years. If an investor were to invest in these short-term bills, rolling them over at the end of each year, and if the future rates were certain, then he would have (1.11)(1.10)(1.09), or \$1.33089, at the end of the third year. An alternative investment strategy is to buy a three-year discount bond at time zero. Given the assumption of certainty, these two strategies must be exactly equivalent in an efficient market so that the term $(1 + {}_3Y_0)^3$ must equal 1.33089, and the yield on the three-year bond, ${}_3Y_0$, must be 10.0%. A similar calculation determines ${}_2Y_0$ as $[(1.11)(1.10)]^{1/2} - 1$, or 10.5%. The current rate ${}_1Y_0$ of 11% is directly observable, resulting in a falling yield curve over the three years from 11% to 10%.

It is sometimes useful to employ observed yield curve data the other way around to estimate implied forward rates of interest. In the preceding example, if it is observed that ${}_2Y_0$ is 10.5% and ${}_3Y_0$ is 10%, then the inferred investor expectation with respect to one-year rates two years from now is $(1.100)^3/(1.105)^2 - 1 = 9.0\%$.

II.D. Risk Premiums

Based on the discussion so far, if all future real payoffs and opportunities are certain, then the opportunity cost of capital on an n-year investment, NRFR(n), is

$$\text{NRFR}(n) = \text{RRFR}(1) + I^e(1) + \text{MP}(n) \tag{1.3}$$

where RRFR(1) and $I^e(1)$ are current one-year real rates and inflation expectations and MP(n) is a maturity premium for an n-year investment, which reflects anticipated real rates and inflation rates in future years.

If the assumption of perfect certainty is relaxed, then it is necessary to add a risk premium term, RP(n), to Equation (1.3) and to express the investors' required (and expected) return on the risky investment, $E[R]$, as

$$E[R] = \text{NRFR}(n) + \text{RP}(n) \tag{1.4}$$

This risk premium reflects investors' subjective reaction to a variety of investment uncertainties over the investment horizon, n, and will be positive if investors are risk-averse.

For such investors, the impact of uncertainty on required returns can be seen by asking the question, Would I rather have \$1000 guaranteed a year from now, or a lottery ticket that has a 50% chance of paying me \$4000 and a 50% chance of a negative pay-off of \$2000 (i.e., I will have to pay \$2000 in this event)? The expected pay-off of the lottery ticket, or average outcome over a large number of purchases, is $(0.5 \times \$4000) + (0.5 \times -\$2000)$, or \$1000, the same as the guaranteed amount. However, most people faced with this choice would pay \$909.09 (i.e., \$1000/1.10) for the guaranteed future amount if risk-free interest rates were 10%, but something less than this for the lottery ticket with its uncertain payoff. If they were only willing to pay, say, \$869.57, for the lottery ticket, this would imply that their required return was 15% rather than 10%. The five-percentage-point difference in required returns is their required risk premium.

Risk premiums may be required by investors in a given security or asset for a wide variety of reasons, including,

1. *Business risks* arising from the operating characteristics of an investment in real assets. These risks are independent of the means by which the asset is financed and include such elements as revenue uncertainty, operating leverage due to the existence of fixed costs, labor cost uncertainty, regulatory or political uncertainty, or the possibilities of technological obsolescence.

2. *Financial risks* arising from the means by which operating assets are financed. When investments are partially funded by borrowing, for example, there exists the possibility of costly bankruptcy or restructuring in the event of default. Even in the absence of such a terminal event, the variability of returns to equity holders is magnified by the existence of fixed charges on debt or preferred financing. In addition, when a firm is close to default, conditions of financial distress may lead to suboptimal operating and investment decisions, which adversely affect its cash flows.

3. *Inflation uncertainty*. Even if investors are able to protect themselves against the expected rate of inflation over their investment horizon by adjusting

nominal rates, they may not be able to protect themselves from unanticipated deviations from inflation expectations, which will affect their net real returns.

4. *Interest rate uncertainty*. If a discount government bond is held to maturity, the return in nominal terms is guaranteed. However, if the bond must be sold prior to maturity, the price realized will vary inversely with the level of interest rates at the time of sale. Similarly, if there are intermediate coupon payments on the outstanding principal, the rate at which such payments can be reinvested, and therefore terminal wealth at a given horizon date, will vary with uncertain future interest rates.

5. *Liquidity risk*. In a liquid market, assets can be sold almost instantaneously at close to the prevailing, and known, market price. However, when markets are not liquid, there is uncertainty with respect to both the amount that will be received on sale and the timing of its receipt.

It is useful to think of the risk premium, RP(n), as being the product of two factors, perceived risk and the market price of risk:

$$\text{RP}(n) = (\text{perceived risk}) \times (\text{market price of risk}) \tag{1.5}$$

The first factor is a measure of the risk that is perceived by investors as being relevant to their assessment of required investment returns. The second factor reflects their consensus or average subjective reaction to this risk perception. For example, the market price of risk might be expressed as five return percentage points per unit of standard deviation of returns if the latter were considered to be the relevant risk measure. This breakdown of the risk premium into its two components is further discussed in Chapter 2.

II.E. Taxes and Transactions Costs

The discussion so far has assumed away taxes and transactions costs and has defined the opportunity cost of capital for an asset simply as the return foregone in the next best alternative investment having a similar degree of risk, maturity, and so forth. Acquisition of an asset, however, may have important tax consequences. In the case of depreciation tax shields or investment tax credits, these consequences are generally taken into account by amending the asset's estimated cash flows. It is possible to take the same approach with the tax deductibility of interest on debt, but it is more common to reflect the latter through appropriate adjustments to the cost of capital. For example, the opportunity cost of capital for a risk-free asset is NRFR, but the net cost to the firm is only NRFR $(1-T_c)$ if it is financed with debt and interest payments are tax deductible at the corporate tax rate T_c.

Similar considerations apply to asset-related subsidies and to the transactions costs that are required to acquire the capital for asset purchases. Again, these may be reflected in the estimates of the asset's cash flows or they may be incorporated through adjustments to the cost of capital figure.

III. USES OF THE COST OF CAPITAL

III.A. Investment Decisions

The most common use of cost of capital estimates is for making decisions as to whether or not to invest in productive assets such as plant and machinery, corporate acquisitions, research and development, working capital, and the like. The usual normative assumption is that the objective of such investments is to maximize the value of the existing shareholders' equity investment. In the absence of conflicts between debt and equity investors in the firm, this is conceptually accomplished by accepting all projects that are expected to have positive net present value (NPV), defined as:

$$\text{NPV} = -C_0 + \frac{E[C_1]}{(1+K)} + \cdots + \frac{E[C_n]}{(1+K)^n} \tag{1.6}$$

where C_0 is the initial investment outlay, $E[C_1]$ . . . $E[C_n]$ are expected values of future risky cash flows over years 1 to n resulting from the asset acquisition, and K is the appropriate cost of capital for the asset. It is assumed in this simple formulation that K and C are consistently defined and that K is constant for all n.

An alternative approach is to estimate the asset's internal rate of return (IRR) defined as the discount rate that makes the NPV of the cash flow stream equal to zero, that is,

$$0 = -C_0 + \frac{E[C_1]}{(1+\text{IRR})} + \cdots + \frac{E[C_n]}{(1+\text{IRR})^n} \tag{1.7}$$

and to accept all assets that are expected to have an IRR greater than K. In most commonly encountered cases, the NPV and IRR approaches will lead to the same asset acceptance/rejection decisions.

Investments that have positive NPVs (or IRR greater than K) *create value* for the firm because, by definition, the present value of expected benefits exceeds the amount required to obtain them. Similarly, value can be created by divestment of assets that have negative NPVs.

The evaluation of potential asset investments using the NPV criterion is often only a small part of the overall investment selection process. This typically begins with considerations of broad corporate strategy, which result in short lists of potentially valuable and viable projects. In many instances, potential benefits are difficult to quantify, or involve the creation of options for future actions that have a value that does not fit comfortably within the NPV analytical framework. The second step, quantitative NPV evaluation, requires careful definition of the overall incremental effects of the investment decision on the firm and estimation of the expected net cash flows, $E[C_t]$, under a variety of internally consistent and explicit assumptions. The estimation of an appropriate level or range for K is only one part of this second step, but it may be a crucial one. Sensitivity analysis should always be done in this evaluation phase to identify crucial variables and to assess the uncertainty of NPV estimates. Here K will often turn out to be a sensitive variable, particularly when $E[C_t]$ follows a rising trend or if there is a relatively large estimated terminal value. Finally, the very process of trying to estimate an appropriate K raises important questions relating to the risk characteristics of the asset, and their resolution over time, which help the process of analysis and communication within the firm.

III.B. Economic Regulation

"Fair and reasonable" prices for goods and services are often defined as having some defensible relationship to the costs of production. A major component of such costs, particularly for capital-intensive industries such as public utilities, is the cost of the capital employed to provide service to the public. Similarly, the monopoly power of firms is often assessed by reference to the estimated economic profits they make, defined as the difference between their accounting profits, variously measured, and their estimated cost of capital.

Much of the practical application of cost of capital concepts has been developed in the laboratory of public utility regulation where fair and reasonable revenue requirements are typically defined as the product of a rate base and a fair rate of return. The fair rate of return is usually identified as being synonymous with, or at least very closely related to, an estimate of the utility's cost of capital, calculated as a debt-ratio weighted average of its embedded, or historical, costs of debt and preferred capital and its current estimated cost of common equity capital. Attempts by expert witnesses to estimate these components before regulatory commissions have resulted in a very large number of individual firm and industry-generic studies of cost of capital issues and applied estimation methods. Issues arising from the use of the cost of capital concept within the specific framework of public utility regulation are discussed in Chapter 12.

III.C. Performance Measurement

Cost of capital concepts have also been widely used to measure the management performance of firms and their divisions and the economic performance of individual investment decisions or portfolios of decisions. A firm or a division may have positive accounting profits, net of interest on debt, but it is not profitable in an economic sense unless these profits, related to the firm's equity investment, exceed the cost of equity capital. Therefore, performance in this sense cannot be properly assessed without an estimate of the cost of capital that takes into account appropriate risks for the measured entity.

Similarly, various models of capital cost determination are widely used for the performance assessment of investment portfolio managers, such as those responsible for mutual funds or pension funds.

IV. PROBLEMS IN ESTIMATION OF THE COST OF CAPITAL

IV.A. Theoretical Problems

A very wide variety of methods are used by practitioners to estimate required rates of return for investments. As discussed in Chapter 6, some methods, such as historical accounting rates of return realized by the firm, or by other firms considered to be reasonably similar, are conceptually incorrect as measures of the opportunity cost of capital. For projects that are clear "winners," their use in place of more conceptually correct estimates may not change the decision. In other cases, however, the use of such measures may be inconsistent with the objective of shareholder wealth maximization and investments made using such criteria may result in erosion of the firm's value.

Unfortunately, all of the models available for cost of capital estimation that are consistent with wealth maximization are necessarily based on sets of assumptions that simplify the real world to make analysis tractable. In most cases, at least some of these assumptions are clearly unrealistic. This, however, does not necessarily make them poor models. The important question is whether or not the simplifications matter, that is, whether or not the predictions made by a given model are consistent with what we observe in the real world. Moreover, even when it is difficult in practice to use these models to make reliable quantitative estimates of the cost of capital, they are useful for gaining qualitative insights into the factors that affect its level, and therefore affect the magnitude of NPV.

A good example of such a model is the standard version of the capital asset pricing model (CAPM), discussed in detail in Chapters 2, 3, and 5. This model states that the opportunity cost of capital, or expected return, for a one-period investment in risky asset j, $E[R_j]$, is

$$E[R_j] = R_f + (E[R_m] - R_f)\beta_j \tag{1.8}$$

where R_f is the nominal risk-free rate, NRFR(n), as previously defined, and $E[R_m]$ is the expected market return on the value-weighted market portfolio of all risky assets. The quantity β_j in this expression is a measure of the degree to which R_j changes as a result of changes in R_m.

In practice, β_j, referred to as the asset's "beta," is usually estimated by relating historical realized market returns on asset j, R_{jt}, to historical returns on the market portfolio, R_{mt}, to measure the sensitivity of one to the other. A beta of one means that a 10% change in the market portfolio value in a period will result in a similar 10% change in the value of asset *j*; a beta of 2 would indicate that the same market portfolio change would cause a 20% change in asset *j*'s value. Equation (1.8), if true, can be used to estimate $E[R_j]$ if reasonably accurate estimates of R_f, $E[R_m]$, and β_j can be obtained from available data. But even if good data cannot be obtained, the predictions of Equation (1.8), if they are consistent with real-world phenomena, can improve decision making by eliciting useful qualitative answers to the right questions. The main predictions of the model are

i. The relevant perceived measure of risk that determines the risk premium for asset *j* is β_j.

ii. The market price of this perceived risk, or risk premium per unit of risk, is positive if investors are risk-averse, and equal to $(E[R_m] - R_f)$.

The first of these predictions is as important for what it omits as for what it includes. It says that the total variability of an asset's return per se is not relevant for determining its value; it also asserts that covariability of the asset's returns with the firm's other activities does not matter. Instead, the prediction of the CAPM is that only that part of the variability of the asset's returns that is caused by economy-wide factors, as reflected in the variability of R_{mt}, is important. Even if it is difficult to estimate β_j, this is a valuable insight because it points to the right questions to ask about the risk characteristics of an asset.

Good examples of the difference between total risk, as measured by return variability, and covariability risk, as measured by β_j, are investments in research and development or in new technology. The payoffs from such investments may be regarded as extremely hard to predict, and the probabilities of failure as being high. They are very risky in this usual sense. But nearly all of the risk is specific to the project and to the uncertainties of its specific technological characteristics. Very little of the risk is due to the possible impact of general economic or market conditions. The prediction of Equation (1.8) is that most of the perceived riskiness of such projects may have very little, if any, impact on the return required by investors. Therefore, the right question to ask if the CAPM model is a good one is not How uncertain are the payoffs? or What is the probability of failure?; the right question is How sensitive are the possible payoffs to general economic conditions? The answers may be significantly different.

The second prediction of Equation (1.8) is that the risk premium required by investors to invest in a portfolio with a beta of one is positive and equal to $(E[R_m] - R_f)$. Even if this quantity cannot be measured with precision, if it is substantial in magnitude, then perceived risk matters and it is worthwhile trying to make risk differentiations between assets.

Is Equation (1.8) a useful description of the real world in which financial and investment decisions are made? That is an empirical question that, as described in Chapter 3, has been investigated vigorously. The answer is not quite,