Economic Analysis of Petroleum Ventures

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PREFACE

The primary objective of this course is to make the participant more proficient in the selection, evaluation and presentation of investment proposals. Naturally, a portion of the course and text is devoted to the discussion of investment evaluation techniques and methodology. Good analysis, however, requires more than a mastering of the techniques; it requires an understanding of the evaluation process. Consequently, the course emphasizes investment evaluation from a "good business" perspective.

A brief overview of the course is presented below.

SECTION 1: CORPORATE OBJECTIVES AND PERFORMANCE

SECTION 2: CAPITAL STRUCTURE AND CAPITAL ALLOCATION

SECTION 3: PROJECT EVALUATION PROCESS

The first three sections of the text are devoted to the manner in which corporate objectives affect investment analysis.

SECTION 4: DEVELOPING A CASH FLOW MODEL

SECTION 5: INVESTMENT EVALUATION MEASURES

SECTIONS 4 and 5 cover the techniques and the methodology. However, these sections include more than mere "recipes." The emphasis is on the input to the evaluation process rather than the computations themselves.

SECTION 6: GLOSSARY OF TERMS

The last section is meant to be a reference and, while it will be used in the course, it will not be discussed in detail.

This manual is intended to be used as a general guide. While the methods discussed here will cover many of the evaluation problems that arise, there always will be exceptions. In such instances, analysts in district offices, division offices, and at corporate offices may be available for consultation. There is, in addition, a variety of supplemental reference materials to aid in project analysis.

SECTION 1

CORPORATE OBJECTIVES AND PERFORMANCE

1.1 Corporate Objectives

Any corporation is owned by its shareholders. While these shareholders are a diverse group, their expectations about the value of their investments (common stock) are similar. Owners expect management to adopt policies and make decisions which will maximize the value of their investments. Maximization of shareholder wealth is the primary objective of all ongoing businesses. The Board of Directors, which is elected by the shareholders, appoints managers whose ultimate task is to ensure shareholder wealth maximization.

Shareholders' wealth maximization may be accomplished by participation in numerous lines of business. Your company has chosen the exploration for, along with production, refining, and marketing of, energy resources as its primary line of business. Management may choose to alter the line of business if the interests of the shareholders could be served better through another, more profitable endeavor. The overall objective of maximization of shareholders'

wealth is often expressed in more explicit, measurable terms. Other criteria which are commonly used are as follows:

1. Profitability.--A firm must generate profits--revenue over and above the funds required to pay all expenses. These profits are either retained by the firm for capital investment or are paid out to the shareholders as dividends in return for the use of their capital. Specific measures of profitability often examined by investors include earnings per share, return on capital employed, and gross sales margins.

2. Stability.--Most investors are "risk averse," meaning that they prefer not to be exposed to risk without compensation in the form of increased expected return on their investments. Stability in dividend policy and earnings growth impact on investor valuation of the firm's stock.

3. Growth.--Growth may be expressed as real increases in the corporation's earnings, assets or sales, and is manifested to the investor in terms of dividends and increasing capital appreciation. Your company has selected earnings growth as a primary objective in the evaluation of operating and investment strategies by management. The operational link of this earnings growth objective to the investment evaluation criteria, such as the minimum return standard, will be discussed in SECTION 2.

4. Social Responsibility.--While the earnings growth objective provides a tangible measurable goal, management cannot ignore the question of social responsibility. Social responsibility includes such things as protecting the environment, maintaining ethical business practices, providing employees with a safe work environment, etc. While these objectives are difficult to quantify financially, many people argue that shareholder wealth and, perhaps, the corporation's very existence depend upon its being socially responsible.

Problems in this area may result in delays, high costs, lost sales, and further costly government regulation.

Government owned companies share many of the same objectives. Optional development of a country's resources is necessary for the continued development of many countries. Natural resources are used by many companies as the mechanism for creating jobs and building support industries. These objectives are consistent with the objectives of private companies, if the private and national companies work together. This manual refers to your company because principles outlined apply equally to private and national companies.

1.2 Corporate Performance--External

In order to provide shareholders and prospective investors with information about the company's performance, it periodically issues financial statements. These reports (a) summarize financial performance for the previous period (normally one quarter or one year), and (b) give the reader a snapshot of the company's financial position at a point in time (normally the end of the reporting period).

Financial reports to stockholders provide "book" measures of financial performance, as prescribed by the Securities and Exchange Commission (SEC) and accounting experts. These include a profit and loss statement, a balance sheet, and a statement of changes in financial position. While a year to year comparison of such measures shows historical earnings growth, it does not necessarily provide any indication of expected future growth.

Financial "book" results, therefore, provide only a partial picture to an investor since (a) they are not forward-looking, (b) they may vary significantly over a period of time, and (c) they are not related directly to the

goal of maximizing the firm's stock price. The investment community, however, relies on financial book measures to some extent and may use them as an aid in making estimates of future cash flows and dividends. Financial reports are mandatory for all publicly held corporations.

It is also important to understand the relationship between income, or earnings, reported in the financial statement and the net cash position of the company. This analysis is summarized in the "Statement of Changes in Financial Position" in the Annual Report. This analysis will be reexamined in SECTION 4 for an individual project.

Another measure of future profitability for companies engaged in the exploration and production of oil and gas is their success in discovering, and subsequently developing and producing, new reserves. If new reserves are not being added at a satisfactory rate, the company is liquidating its primary source of revenue and assets.

Many energy companies, concerned (a) that their revenue is generated from a diminishing asset, and (b) that they have high susceptibility to upsets in politically unstable areas, have opted to diversify into other lines of business. This diversification is based on a strategic decision by management to reduce the overall riskiness of the firm. So far, such diversification represents only a small portion of revenue for most of the major energy companies.

1.3 Corporate Performance--Internal

Since corporate objectives are more related to the future than the past, management's primary concern is the future. Thus, internal reports must deal with projections of future performance and ways to guide that

performance successfully. Such reports are the forerunners of the results ultimately achieved for the stockholders. These reports include:

Long Range Plan

Annual Operating Plan

Capital Budget

Individual Investment Evaluations (AFE, etc.)

This manual describes what is required for good investment evaluation, the last item on the list. Also, the same techniques are fundamental in development of Division Program Projections for the long range plan.

Analyzing and choosing investment opportunities well--to seek the best business opportunities and to avoid losses--is one of the most important functions of your company. This process is vital to success in accomplishing our objectives of earnings growth and wealth maximization.

The main report for analyzing performance of investment evaluation work itself is based on follow-up studies. These studies compare the results after a year or more with the initial projections used for making the decision to invest. Comparisons are made for all key factors that affect the success of a project. These include evaluation of differences in factors such as timing, production, price, expense, and capital. Thus, good feedback is developed on how well both the investment and the evaluation are contributing to corporate objectives.

Investment follow-ups often show great differences between projected and actual performance--all too often with net negative results. Many times the reasons are far beyond simply understating a capital or a cost estimate. Unforeseen problems include competitive forces that impact price, government regulations that delay projects, impact costs, and many others.

Today's business environment is more complex than ever before, and thus better and broader analysis is needed in order to compete successfully. This is why the course has been titled "Economics Evaluation." The primary question we need to answer--"Is this a good business venture for contributing to our objectives?" Answering that question requires a much more far-reaching analysis than the simple cost analyses of former times. Sound project evaluations are necessary in order to achieve the objective of "making money."

The chapters which follow are designed to help individuals do the kind of business analysis that will better achieve the objectives cited above.

SECTION 2

CAPITAL STRUCTURE AND CAPITAL ALLOCATION

2.1 Introduction

In order to "make money," management adopts operating and investment strategies which allocate a limited supply of labor and capital resources in the most efficient manner. This section deals specifically with the allocation of capital--often referred to as investment or capital budgeting.

Investment budgeting involves (a) identifying the funds available for investment, (b) forecasting the cash flows (both positive and negative) for ongoing and future investment projects, (c) establishing a consistent system of valuation for investment projects such that they can be compared on a reasonable and efficient basis, and (d) choosing those investments (subject to the available capital) which contribute most to that company's objectives. Steps (a) and (b) involve the sources and uses of funds (capital). Steps (c) and (d) involve the cost of capital (required rate of return). Both of these concepts will be discussed in this section.

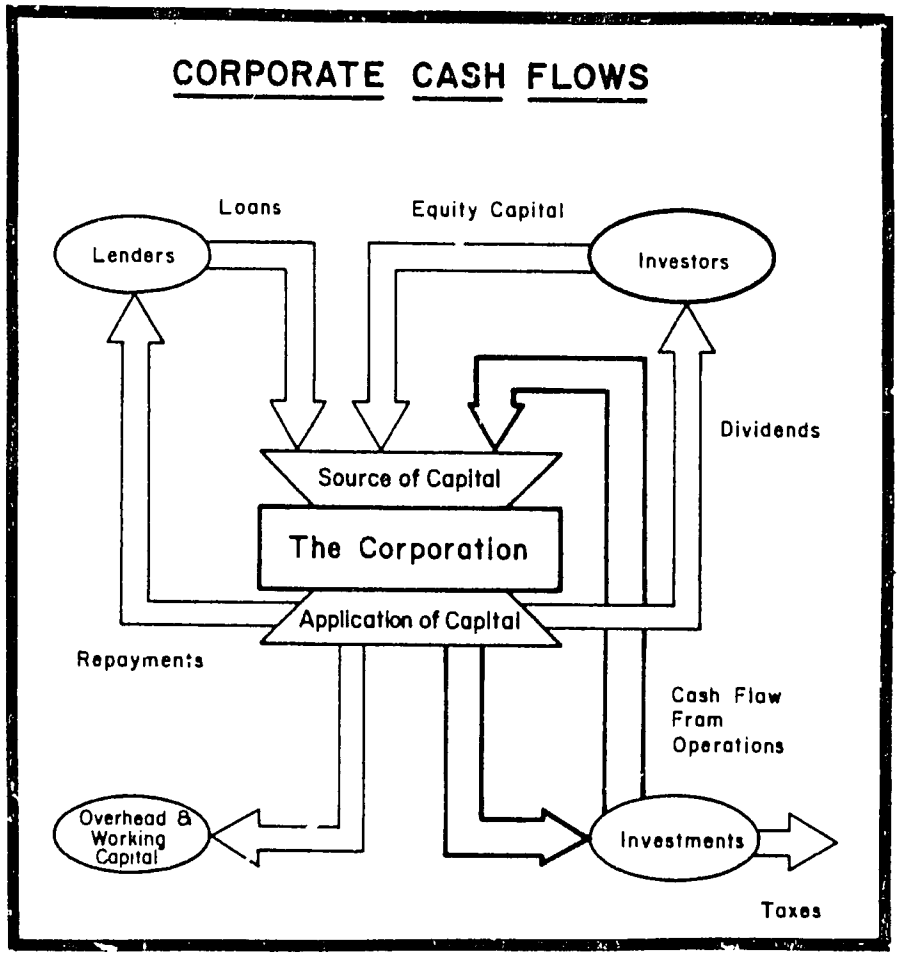
2.2 Sources and Uses of Funds

A firm typically uses a mix of debt and equity in funding investment projects. The principal components of debt are long-term bonds (debentures), capital leases, and commercial paper (short-term debt). Equity may be generated from increases in retained earnings (profits not distributed to shareholders) or from the issue of new shares of common stock. Preferred stock, a hybrid security exhibiting aspects of both debt and equity, can be an additional source of funds. The methods by which all of these funds flow through the corporation are shown in Exhibit 2.1.

Lenders and investors each provide funds with the expectation of eventually receiving compensation from the firm for the use of their money. The lenders, which may consist of banks, individuals, or trusts, are compensated for lending funds by the payment of interest. Equity investors--frequently individuals, pension funds, and insurance companies--expect to receive dividends and stock price appreciation. The firm, in turn, uses these funds to invest in projects, to pay interest, to repay loans, to pay dividends, and sometimes to repurchase shares of stock.

The mix of debt and equity which is employed by a firm is called the capital structure, which seeks to minimize the firm's cost of capital. The cost of capital is a function of several factors including interest rate, dividend payout ratio, riskiness of the business environment in which the corporation operates, etc. Most firms in the oil industry tend to maintain a capital structure which is 15-30% long term debt and 70-85% equity.

Exhibit 2.1 Corporate Cash Flows



2.3 Cost of Capital

Since lenders and stockholders provide the funds necessary for investment, the cost of capital concept insures that both lenders and stockholders are adequately compensated for providing funds to the company. Therefore, a project is acceptable only if it is expected that the investment will generate a return large enough that the providers of capital will receive their minimum required rate of return. If a project yields a rate of return less than the cost of capital, investors won't loan money to the company and eventually the firm will go out of business. Therefore, the cost of capital is the minimum rate of return necessary for the company to accept a project.

The cost of capital depends upon the risk of the project being analyzed so that the greater the risk of the investment, the greater the cost of capital. Although this risk-return relationship is difficult to measure, the cost of capital is still applicable for the evaluation of investments. Several methods exist for determining the appropriate cost of capital. One method weighs the average of the cost of debt and the cost of equity. The cost of debt is merely the price (the interest rate) paid to raise money from lenders. Since interest payments are deductible for income tax purposes, the after-tax cost of debt is used. The cost of equity is the price paid to raise equity capital in the market. It represents the minimum rate of return that stockholders expect from their investment in the company. Unlike debt, the cost of equity is very difficult to measure, since it is not set in contractual terms as are interest rates. However, techniques exist which approximate the cost of equity from the financial markets. The cost of capital is then determined by combining the cost of debt and the cost of equity as a weighted average based on the fraction of each in the firm's capital structure.

Another method for determining the cost of capital is to look at each asset as a separate entity. Since the cost of capital depends on the level of risk, if a project has a level of risk different from the firm's average, the asset may have a different cost of capital. In addition, each asset itself may have a unique capital structure. Therefore, there may not be one cost of capital for the firm, but several, depending upon the nature of the asset.

Yet another way to view the cost of capital is to consider its two parts: the real and the inflation component. The magnitude of the real component depends on the risk of the investment. A project or firm with a higher

level of risk will require a higher real rate of return than an investment with a lower level of risk so that investors are compensated according to the risk they bear. Inflation adds another component to the cost of capital. Since inflation erodes the purchasing power of money, investors must also be compensated for providing funds during a period of inflation. Therefore, the inflation component is added to the real rate of return to derive the cost of capital used in investment analysis.

2.4 Capital Rationing and the Minimum Return Standard

Only investments which return at least the cost of capital should be accepted. The example which follows summarizes two investment scenarios and the options available to the firm under each.

	Situation		Options
1.	Investments returning at least the cost of capital exceed available funds (capital constraint).	A.	Forego some projects, scale project down, or utilize joint ventures and partner participation.
		B.	Obtain more funds from capital and/or debt markets.
		C.	Sell assets to raise funds.
2.	Available funds exceed investments returning at least cost of capital.	A.	Seek more investment opportunities, including the buying of other businesses.
		B.	Interest in short term securities and/or pay off debt.
		C.	Pay out surplus funds to stockholders.

In theory, a firm should move to a point of equilibrium where the requirement for funds to support proposed projects returning at least the cost of capital equals the funds available.

Capital rationing refers to the situation in which funds are insufficient to finance all recommended investments or, for strategic reasons, has

chosen not to distribute all these funds to the operating subsidiaries. Your company may elect to forego short or intermediate-term profits in order to launch a new venture or to acquire a new line of operations. The end result is that a particular division may not receive as much capital as it could profitably invest and, hence, becomes capital constrained.

The options available under this scenario are equivalent to those listed for the Situation 1, above. Either more funds must be raised or some projects must be foregone, scaled down, or delayed. In the past, capital rationing has resulted in some firms establishing a minimum rate of return standard somewhat above the cost of capital.

SECTION 3

PROJECT EVALUATION PROCESS

3.1 Introduction

In the previous section a brief discussion of investment budgeting and its relationship to the earnings growth and worth maximization objectives was presented. It is the responsibility of management and their delegates to meet these corporate objectives through the management process.

3.2 Role of the Technical Professional in the Capital Budgeting Process

While the role of technical professionals (engineers, geologists, business analysts, etc.) is not as explicitly defined as for management, nonetheless, it is vitally important. The technical professionals ultimately (a) prepare the individual project appropriation requests (AFEs), (b) "manage" the project from its inception to completion, (c) prepare data for the monthly investment budget status reports and cash forecasts, and (d) prepare Investment Project Follow-ups.

Perhaps the most important responsibility assumed by the technical professional is that of identifying potential capital investment opportunities, and presenting management with sufficient information regarding these opportunities so that an intelligent decision can be made about acceptance and implementation.

The methodology for the evaluation process is fairly straightforward and is discussed in SECTIONS 4 and 5. However, follow-ups which show big discrepancies in actual performance have uncovered some real traps. Major shortfalls often occur from factors not even considered in the original analysis--environmental delays for example. This is particularly troublesome when the factors causing the problems were foreseeable to some degree. It has been observed that professionals tend to emphasize what they know--not what needs to be studied. Engineers analyze production factors but tend to shortcut marketing ("just give me a price"). Marketers analyze competition and sales, but tend to ignore engineering ("just give me a cost"). And, it seems everyone tends to underestimate the impact of new factors, such as the degree of impact from governmental regulation on our business. Thus, when preparing an investment project evaluation, the technical professional must consider <u>every</u> aspect of that project that can have a significant impact on its profitability. He must give particular attention to those aspects which go beyond his area of technical competence and draw on all resources available.

The risk analysis procedures described in CHAPTER 8 of <u>Mineral Property Economics</u> assist management in assessing the uncertainties associated with a project. However, these procedures <u>do not</u> relieve the technical professional of the responsibility of basing the evaluation on all of the information which can be acquired reasonably. In other words, risk and uncertainty

analysis does not "bail out" an ill-conceived or inadequately researched project.

The remainder of this section will consider the evaluation process in detail, along with many of the pitfalls to avoid in that evaluation.

3.3 Evaluation Process

The objective of an evaluation is to inform management, the decision maker, of the potential economic consequences of investment. This objective is generally satisfied when an evaluation contains:

1. Analysis of an investment's worth so investments may be compared on the basis of economics and with company financial return objectives.
2. Identification and analysis of an investment's uncertainties and potential losses so investments may be compared on the basis of risk and with the company's view of an "acceptable" risk.
3. Assurance that alternatives were fully explored before the investment was presented to management for a decision.
4. Evidence that all data are valid.
5. Information (technical, environmental, political, etc.) which allows management to relate the investment to overall strategic objectives, and evidence that the company is capable of undertaking the investment.

When an evaluation reflects these key considerations, investment sponsors are in a position to present and justify their recommendations.

The following five-step procedure is recommended for investment evaluation:

Step 1--Formulate Problem

Step 2--Plan Analysis

Step 3--Examine Data and Premises

Step 4--Perform Analysis

Step 5--Report Results

In practice, the steps are interrelated and it is not unusual to perform several steps simultaneously. In the process of planning the analysis and searching for appropriate data and premises, the problem also may be reformulated. Consequently, Steps 1, 2 and 3 may be performed several times.

Step 1--Formulate the Problem

Formulating the proper investment problem is one of the most important steps in the evaluation procedure. It is in this step that feedback from follow-up studies and skills obtained from previous evaluation experience are most valuable.

To begin problem formulation, the assigned task must be understood clearly. Considerable clarification may be required.

For example, if contract terms are important to an evaluation, be sure to read the contract and all documents relating to the deal. Are new markets or new transportation facilities required for the production? If so, be certain these areas are fully evaluated. Beware of arbitrary price or cost values that are applicable to project circumstances. What government regulations impact on the venture? Many a project has come to grief over regulatory requirements. Be certain their impact is properly evaluated and designed into the project plan.

Next, the assignment should be considered in its relationship to all reasonable investment alternatives. No alternative should be routinely dismissed without serious consideration. The goal of analysis is to provide information so that a "best" choice can be made, and this only can be accomplished by a thorough consideration of all alternatives. For example, selling a property or existing asset is always an alternative. Yet this option is often ignored--even when it has the best economics!

Every investment problem should be formulated broadly in terms that relate to an overall investment objective. Many times, thinking becomes structured when an investment problem is first encountered. Such thinking leads to a narrowly formulated problem which often limits consideration of alternatives. Subsequently, a less than thorough evaluation results. For example, the assignment "evaluate the economics of waterflood on this lease" structures thinking. The apparent problem seems to be: what injection pattern, well spacing and water injection rate is appropriate? However, the underlying problem is: what can be done to the lease to yield a maximum return? When the problem is formulated in this way, many more investment alternatives are recognizable. Now, some of these alternatives are: (a) continue primary production as is, (b) institute some type of secondary recovery, being cognizant of government incentives for certain types of recovery, (c) continue primary production but add some more development wells, or (d) sell the lease. Each of these alternatives needs to be analyzed and discussed. Again, none should be routinely eliminated unless its lack of profitability is obvious.

Step 2--Plan the Analysis

Once the investment problem is well formulated, a plan for analyzing it should be developed. Generally, a good plan for analyzing investments includes at least the following:

1. An outline of the cash flow model's overall structure.--All required computations must be understood, including tax considerations and deal structures (e.g., joint venture, carried interest). Opportunities which involve investment choices usually require several cash flow models. Many times this step requires consultation with other departments, such as the tax and legal departments.

2. Listing needed information along with its expected source.--This information includes developing the initial data to begin calculations and the premises for projecting cash flows. This task is vital to the analysis. In addition to the tax and legal departments mentioned above, other departments such as accounting, environmental, safety, and research can supply fundamental information required for the analysis. For example, the total cost of many projects has been seriously underestimated, due to a failure to properly consider both current as well as future environmental costs associated with the project. Under the current legislation, a company is required to install pollution prevention equipment with the Best Available Technology (BAT). Since the technology in this field is changing rapidly, only consultation with environmental experts (both legal and technical) can insure a reasonable assessment of environmental costs.

3. An approach for evaluating uncertainty in the project.--All investments are uncertain, but some are more uncertain than others. Be sure that the approach to uncertainty analysis considers the level of uncertainty in all key factors that affect the investment. This topic will be discussed in more detail later; however, it is important to recognize the need for risk assessment. Management can make effective decisions about the viability of projects only if they are supplied with some measure of the riskiness of the cash flows associated with the projects. The methods discussed in CHAPTER 8 of Mineral Property Economics are quantitative, and they require the technical professional to evaluate the uncertainty of the parameters which are used in the project evaluation. For example, in a steam flood operation, a new process (untested in the field) may result in the highest projected oil recoveries. However, the uncertainty associated with its use may make the riskiness of the project unacceptable vis-a-vis the "tried and true" process. It is important that the engineer recognize and attempt to make a quantitative assessment of this uncertainty.

4. A procedure for checking results.--Procedures and models must be validated thoroughly to catch all major errors. All computer programs should be carefully checked and validated. Further, overall checks for unrealistically high or low economic parameters (DCF ROR or NPV) should be a flag to the user and result in a recheck of model formulation and input data.

Step 3--Examine Data

This is probably the most important step in the evaluation process. Begin this step by gathering required data and assumptions used to generate data. When adequate data do exist, they are to be developed in consultation with your supervisor or corporate representatives, and should be examined with a critical eye. For example, if only average drilling costs are available, are these costs appropriate? Does the assumption about future oil prices really apply to this specific project?

Many times product prices vary dramatically from one region to another due to local markets, transportation costs, etc. For example, NGL prices in the Mid-Continent historically have lagged Gulf Coast prices.

Look critically for any tacit assumptions which are built into the analysis. For example, is continued technological advancement in deepwater drilling being taken for granted? Does the data take into account continued or impending regulatory effects? Every such assumption needs to be brought to the surface and specified in the evaluation.

In all situations, look beneath the surface of the data and try to understand how things are put together. This is particularly true of some accounting data which can be misleading if used, as is, in a cash flow model. For example, historical book expenses on a producing lease cannot be used directly for cash flow projections when they include amortization accounts (write-offs) which require different treatment in a cash flow analysis.

Finally, when examining data it may become apparent that there is a good chance for error in some (or perhaps all) of the data. In these situations, the effect of the potential data uncertainty on financial return criteria should be shown.

Step 4--Perform Analysis

This step is discussed in detail in SECTIONS 4 and 5, and is the one in which the basic evaluation calculations are performed, either by hand or by computer. Generally, most fundamental evaluation errors have been committed before this step is reached. For this reason, this step not only involves calculations, but also systematic questioning and reassessment of data, premises and assumptions. Typically, this is done as each calculation is performed.

After financial return calculations are complete, examine the data checks that were built into the analysis to be sure that there are no arithmetic errors. To check further, go through the analysis for a typical year to be sure that the results are consistent with the presumed net cash production model.

Now, compare financial return criteria results with a "common-sense" knowledge of the situation.

Do the calculated returns look reasonable?

An 85% DCF ROR for an initial offshore development program is certainly desirable, but such a return seems suspect. Recheck the data, assumptions and calculations.

Are unreasonable looking numbers to be expected?

An analysis of an obligatory or environmental investment may show present worth to be negative. For these investments, such a value does not seem potentially unlikely, but the best of available alternatives should be developed.

Next, begin uncertainty calculations. The calculations are generally performed after all other calculations are complete and have been checked;

otherwise, there is a risk of developing sensitivity analyses using incorrect base data. When these calculations are complete, again check for arithmetic errors. Lastly, reexamine the sensitivity assumptions used in the uncertainty analysis, looking for inconsistencies.

Step 5--Report Results

The final step in the investment evaluation procedure is to report results. Always remember that it is the evaluation report, whether in written or in oral form, which is the device for communicating the efforts and findings of the evaluation process. Well developed reports may not cover up poorly executed evaluations; but slovenly, overly detailed, disorganized reports do make sophisticated evaluations come across inadequately. Therefore, be prepared to spend some time organizing the report.

Assumptions, alternatives, investment returns and risk criteria all should be clearly highlighted. The overriding consideration is to communicate clearly the decision making information and its potential consequences. This should be accompanied by an indication of the quality of the information.

In many situations, the format for reporting results is predefined. In other situations, such as a preliminary evaluation of a new venture, a free hand may be used to determine how best to report results. Then, the following suggestions may be helpful:

1. Tailor the report to the audience.--For example, when an audience is not expected to be well acquainted with risk analysis the technical elaboration and jargon must be replaced with simple, but effective, statements and graphics. If a technical elaboration cannot be avoided, a supplemental report or training session to discuss necessary ideas and concepts is appropriate.

2. Be concise.--The use of computers has made evaluations easier, but it is also easier to generate masses of detailed reports. Try not to use them in any report to management. Keep them handy and use them to answer specific questions which may arise later. Remember, if it takes too long to read an evaluation, it is likely never to be read completely.

3. Be innovative.--Try not to be boxed-in unnecessarily by past practices. If a new report, graph, chart, or whatever, appears as though it would communicate better or enhance the presentation of results, use it. Remember, a picture still is worth a thousand words.

3.7 Summary

A few final paragraphs regarding the evaluation process are in order. Technical professionals, especially engineers and geologists, are very comfortable when performing calculations with "hard" numbers. They are very uncomfortable when assessing how "soft" (uncertain) the numbers are. It is, therefore, difficult for many technical professionals to perform an investment evaluation realistically, i.e., as if it really is likely to happen. Consequently, they assume the economic parameters generated are fixed measures of a project's profitability.

This tendency is very common today. The usual excuses are (a) one feels he doesn't have the time to perform an in-depth analysis of input parameters, (b) the person has just been hired and doesn't know where to go for information or back-up data, (c) one rationalizes a lack of in-depth analysis on the basis that "it can't make that much difference," or (d) it is too uncertain to know anyway.

Another problem often encountered in the evaluation process is a result of the tendency of technical professionals to bias the evaluation in favor of their "pet" projects. Often this is accomplished by performing the analysis in reverse, i.e., starting with acceptable economic parameters and working backwards to obtain production or reserves to justify the project. The potential problems with this method should be obvious. One should always begin with "independent" and unbiased production and cost estimates and calculate the parameters based on these estimates.

A third example of improper evaluations results from the tendency of some to take overly conservative approaches, especially with regard to cost estimates. The prime objective of good analysis is to project as accurately as possible--neither over nor under what actually will happen if the project is approved.

DEVELOPING A CASH FLOW MODEL

4.1 Reason for Developing Cash Flows

To determine whether or not an investment will provide satisfactory returns, one must develop and analyze individual cash flows--revenues minus costs, etc. Positive cash flow is a must, of course, but large initial investments mean that cumulative cash flow may be negative for many years before becoming positive. Thus, many years of projections are required, and the accuracy of these projections far into the future is vital to overall project economics. Remember--the accuracy of these estimates ultimately determine the investment capital, and your salary in the future.

4.2 Elements in Cash Flow Analysis

A cash flow or investment model is a representation of period-by-period cash receipts and expenditures which are expected to result from an investment. Typical models contain many individual items of cash flow which, when totaled, result in a full life cash stream called net cash flow. It is

this cash stream which is analyzed to determine investment worth. Cash flow projection is the process of developing estimates of future period-by-period cash receipts and expenditures. Projection extends over an investment's economic life.

A cash flow model is developed in the following general sequence:

1. Identify the items of cash receipt and expenditures for the venture.
2. Determine which items are to be displayed and projected.
3. Project cash flows period-by-period over the investment's economic life.
4. Total each period's cash flows to derive a cash surplus stream.

Basically, the goal in developing a cash flow model is to account for all important cash inflows and outflows without having the model become overly complicated. Therefore, cash items should be selected for individual display and subsequent projection on the basis of significance. For example, if a particular item is expected to produce cash flows which contribute one thousand dollars annually to a project having average annual net cash production in millions of dollars, the item hardly can be considered significant. Note that the comparison for significance is with net cash flow (NCF), which is itself a much smaller number than items such as revenue.

When several nonsignificant cash items are encountered, they may be combined for display and projection as a single unit. When only a few nonsignificant items are found, these may be omitted from the model in the interest of practicality. However, be cautious about omitting items that often do make a difference, such as overhead and working capital. As a general rule, contributions of approximately 3% or more of net cash flow by individual cash items

should be considered significant. Significance, however, is a judgmental choice which is made based upon experience and available evaluation resources.

Cash flows are projected by a variety of approaches. The particular approach to be taken is a function of the characteristics of the cash item, available data, experience with similar projections, time constraints, and many other variables. Some characteristics are listed in Exhibit 4.1.

The bottom line of a cash flow analysis on an after tax basis is termed "Net Cash Flow" or NCF. NCF has a technical difference from book income, a "book" number, because capital expenditures are deducted when they occur on a direct cash basis. In the determination of book income, only an annual depreciation of the capital expenditures is deducted each year. This spreads out the impact of the capital expenditures with the objective of making annual numbers more representative of a longer term view.

Cash flows must be projected over the full economic life of an investment. Economic life (or full life) is the shortest period between investment start-up and one of the following:

1. Time when current operating cash expenditures exceed current operating cash receipts (i.e., "economic limit").
2. Time when residual or salvage value exceeds present worth of future benefits.
3. Time when all benefits or operations must cease as established by contractual obligation (e.g., lease expiration date).

Cash flows occur relative to time. Cash flow timing refers to the time cash flows from one period to another or the time cash flows occur within a single period. Timing is a major consideration affecting investment worth.

Cash flows within a single period are generally considered, for modeling purposes, to occur at a point in time or uniformly throughout the period.

In a typical evaluation model, cash flows are assumed to occur uniformly throughout the year. When a major cash flow does not occur uniformly (such as an initial purchase price), "point in time" timing should be considered.

One particularly important aspect of cash flow analysis is that cash flow information must be generated on an incremental basis so that only the difference between cash flows of the firm with and without the project are analyzed. For example, when evaluating the installation of a gas processing plant, the net cash production from the sale of the resulting NGL and other products must be computed by subtracting their alternative value in the sales gas. This represents the incremental value to the NGL since the gas could be sold whether or not it is processed.

In the above example, <u>if</u> the gas could not be sold unless it was processed (due to contractual quality requirements) then the analysis would no longer be incremental and the gross value of the NGL could be used in the cash flow analysis. There will be no revenue if the investment is not made.

Cash flow projections require one to make an estimate of general financial conditions in order to estimate future prices, expenses, etc. To meaningfully compare evaluation results, approved and consistent data must be used for all investment analyses. For example, it would be meaningless to compare two similar investments of different projects if one is based on forecasts of product prices increasing 10% per year while the other is based on forecasts of the same product prices increasing at 2% per year.

Exhibit 4.1--Characteristics of Typical Items of Cash Flow

Revenue.--Usually the product of price and volume projections. Many projects produce a rather constant revenue on a real basis. However, others, such as typical oil producing properties, gradually decline over the years to an economic limit, where expenses exceed revenues.

Direct Operating Expense.--Includes both variable expenses (production of unit cost and volume projections) and fixed expenses (expense generally unrelated to volume). The point when volume generates enough revenues to equal or exceed expenses is called the break-even point. Discussion of this break-even point may be desirable in some evaluations.

Overhead or General and Administrative Expenses.--Fixed administrative expenses, such as accounting, management, and other services, which are not directly related to variable revenue or cost. Generally, any incremental overhead expense resulting from an investment project should be included in the evaluation.

Capital Expenditures.--Initial expenditures required to develop expected future benefits. Includes outlays for buildings, equipment, and land. Investment outlays are usually heaviest in the beginning years of the investment's life, but additional investment outlays may be made in later years to accelerate or maintain benefits. Investment tax credit effects should also be included.

Working Capital.--The amount of capital required to carry the ongoing business of the venture--for items such as inventories and receivables versus payables.

Capital Recovery.--For many investments, there is a possibility that part of the investment outlay will be recovered at the end of the project's life. Most assets have some residual salvage value at that time, and a few assets (e.g., real estate working capital) even may have appreciated in value.

Noncash Expense.--Depreciation, depletion and amortization must be computed in order to accurately calculate the income tax, and for projection of "book" income. Depreciation for tax purposes usually is different from that for "book" purposes.

Taxes.--Many types of taxes must be included, such as: excise taxes (sales and windfall taxes), production taxes (severance tax), property taxes, and foreign and domestic income taxes. To project taxes, applicable regulations must be determined and the proper computations performed. Tax Department assistance is often required.

4.3 Calculation of Net Cash Flow (NCF)

NCF is determined by subtracting a number of costs and expenses from net revenue, as shown below:

Net Cash Flow (NCF) = Net Revenue
- Operating Costs
- Overhead
- Investments
- Working Capital Additions
- Taxes

Net revenue represents that portion of the yearly revenue stream remaining after payment of royalties, severance taxes, and excise taxes (such as windfall profits tax). In some situations it is advisable also to deduct those costs which are directly related to the price and volume of the products. For example, if the fuel used in steam generators is crude, then the fuel cost is dependent on both the price and production of crude, much like a royalty or severance tax payment. This procedure simplifies the calculation, especially in the analysis of risk and uncertainty. This specific aspect of the NCF calculation will be discussed in more detail later. The first deduction from net revenue, operating costs, refers to those costs which may be directly attributed to the operations resulting from the investment. Examples are operating labor, expendable supplies, maintenance, etc. In contrast, overhead represents costs which cannot be directly allocated (indirect costs). An example of these indirect costs is increased accounting or personnel department employee requirements due to investment and increased time commitments by management and staff, etc. Overhead costs which should be included in the analysis are those considered to be incremental, though indirect, costs associated with the investment. Identification of these costs is normally quite difficult; therefore, it is common practice to allocate overhead to the project based on a percentage of the investment cost or direct operating cost.

Investments refer to major cash expenditures which are required over the life of the investment project and which are classified as capital expenditures. Examples of investments would be an addition of a pumping unit, the capitalized cost of drilling an "in-fill" well, or major overhaul of a compressor which extends the life of the unit. Working capital must be added to carry inventories and to provide the cash to handle an excess of receivables over payables. Working capital is returned at the end of the project.

The determination of taxes is more complicated. Taxable income must first be calculated in order to determine the federal and state income taxes to be paid. Taxable income is defined as follows:

Taxable Income	=	Net Revenue	- Operating Costs
			- Overhead
			- Expensed Capital (Intangible)
		Investments	
			- Capital (Tangible as Amortized)
			- Other Taxes

For the calculation of taxable income the net revenue, operating costs and overhead are determined as before. However, the method of handling investments varies, according to whether the costs are expensed (intangible), capitalized, or are a combination of both. Expensed items are deducted directly from revenue in the year they are recognized. Capitalized costs, however, are written off over a longer period of time via various amortization methods.

One hundred percent of the intangible investment used to be deducted from income taxes in the year that the money was spent. Tax legislation in August of 1982 changed this. Now, 85% of the intangible costs is deducted from income, and 15% is capitalized and depreciated over a three year period. As an example, suppose $500,000 of IDC's was spent on a well. The entire

$500,000 would have been written off in the year that it was spent, under the old legislation. The new legislation stipulates that only .85 x $500,000 = $425,000 is deducted from income. The remaining $75,000 is capitalized, hence, the often used phrase "capitalized IDC's "

The capitalized IDC's are amortized over three years, using a straight-line schedule. The straight-line schedule is determined by dividing n, the number of years, into 1 and then multiplying 1/n = 1/3 = 0.33 by the capitalized IDC amount. Using the above example, the amortization in each of the three years is

Year	Factor	Capitalized IDC	Amortization
1	.333	75,000	25,000
2	.333	75,000	25,000
3	.333	75,000	25,000
Total	1.0		75,000

Follow this schedule for all capitalized IDC calculations.

Capital write-offs occur because of the accounting orientation where transactions are viewed on the basis of matching revenues and costs. Investment costs are recognized over the project life by the use of capital write-offs. Three principal forms of capital write-offs are: (1) depreciation, which is associated typically with such tangible (physical) assets as a plant facility, or well and lease equipment, which are shown on AFE's; (2) depletion, which is associated specifically with bonuses and other costs incurred in the acquisition of lease; and (3) amortization, which is associated with the acquisition of nonproducing properties, and capitalized IDC's as explained above. These three deductions are frequently termed noncash, or "book" charges since they do not constitute an actual change in cash flow in the year they are deducted. They represent, instead, the method of accounting for capitalized costs.

1. Depreciation.--The calculation of depreciation must follow the procedures outlined in the Economic Recovery Act of 1981, as amended in August, 1982. Every company and individual is required by law to use the schedules in Exhibit 4.2. The Capital Recovery Factors are determined by the year in which the asset is placed in service and the life of the asset. Asset life is specified by law. Autos, trucks, and research equipment exemplify three-year life assets. Examples of five-year life assets are producing wells, compressors, separators, pipelines, and other tangible property in E & P, refining, mining and the chemical sectors. Regulated gas pipelines and railroad tank cars are in the ten-year category, while office buildings, service stations and other real estate fall into the fifteen-year category.

Depreciation is based on 1-0.5 (ITC), where ITC is the investment tax credit which is discussed in more detail later. Oil and gas tangible investments have a 10% ITC, so the depreciation base is 1-0.5 (.10) = .95, or 95% of the tangible investment. An amount of $2 MM has been spent on tangible oil and gas equipment. The depreciation, or noncash charge is:

Year	Factor	Depreciable Base	Depreciation
1	.15	.95 x $2 MM	285,000
2	.22	.95 x $2 MM	418,000
3	.21	.95 x $2 MM	399,000
4	.21	.95 x $2 MM	399,000
5	.21	.95 x $2 MM	399,000
Total	1.0		$1.9 MM

The factors are taken from the 5-year column in TABLE 4.2 and are multiplied by the depreciable base to yield depreciation in each year.

Exhibit 4.2--Capital Recovery Factors

Class and Recovery Percentage for Property Placed in Service During Period Indicated

Year	3-Year	5-Year	10-Year	15-Year Public Utility
1	25%	15%	8%	5%
2	38	22	14	10
3	37	21	12	9
4		21	10	8
5		21	10	7
6			10	7
7			9	6
8			9	6
9			9	6
10			9	6
11				6
12				6
13				6
14				6
15				6
	100%	100%	100%	100%

NOTE: Tables for 15-year real property are to be prescribed by IRS based on month in which building is placed in service.

2. Depletion.--Depletion is the process of amortizing a wasting asset (such as oil and natural gas) through "write-offs." Depletion exists in two forms--percentage (or statutory) depletion and cost depletion. Percentage depletion no longer applies to major oil and gas companies, but it does apply to other minerals. Cost depletion is based on the Units of Production method and is used for lease bonuses and capitalized geological and geophysical (G & G) costs. A simplified calculation of annual cost depletion,

or amortization, on a Units of Production basis can be made as follows:

Depletion = (Production in the Year/Estimated Ultimate Production in All Years) x Bonus Cost

In the production of most other minerals, the IRS allows the use of statutory (or percentage) depletion. Under statutory depletion a stated percentage of gross income may be taken as the depletion deduction for tax calculation purposes. This percentage varies from about 5% to 22% and depends on the mineral produced. Percentage depletion also applies to enhanced oil recovery (EOR) projects.

3. Amortization (Tangible/Intangible Splits).--Many of the investments encountered in the energy business result in the formation of both tangible and intangible assets. Categorizing these assets and the associated development costs can have a large effect on taxable income. Tangible and intangible assets are defined as follows:

Tangible Assets.--Tangible assets are the dollar value of assets which may be appraised by inspection. This includes buildings, machinery and equipment of all types which depreciate in value with age and usage.

Intangible Assets.--In the broad sense, intangible assets are those properties without physical substance, which are useful to an entity because of the special rights their ownership confers. In the oil and gas industry a good example of an intangible asset is the "hole." A great deal of

funds were expended to acquire the "hole" but the "hole" in itself has no worth.

The exact differentiation between a tangible (capital) asset and an intangible asset is somewhat arbitrary. From a practical standpoint, such differentiation depends on the current applicable tax provisions governing a specific type of property. Evaluations should not rely solely on past evaluations since the laws regarding intangible assets change constantly.

Accounting principles require that intangible assets be "written off" on a Units of Production basis for calculation of book income. However, federal tax laws allow some intangible assets to be "expensed" (written off in one year). A common example of an intangible write-off is "intangible drilling costs." In an accounting sense, these costs are a portion of the investment in an intangible asset (the hole) and should be amortized over the life of the asset. However, federal tax laws allow these costs to be expensed in the year incurred, resulting in a lower taxable income. Exhibit 4.3 summarizes the tax treatment of several common energy investment expenditures.

4.4 Taxes and Investment Tax Credit

Once taxable income has been determined, the income taxes can be computed from the formula:

Income Taxes = (Taxable Income x Tax Rate) - Investment Tax Credit

Taxes other than income taxes, such as windfall profits tax, property taxes, severance taxes, etc., should be deducted earlier to arrive at taxable

income. The tax rate is usually a combination of federal and state income tax rates, recognizing that the state income tax is a deductible expense for federal income tax.

Exhibit 4.3--Tax Treatment of Common Energy Investment Expenditures

Expenditure	Taxable Income Treatment
Bonus	Depleted (UOP)
Capitalized Portion of G&G on Producing Properties	Depleted(UOP)
Producer Well Expenditures Including 15% of Intangible Drilling Costs	Depreciated According to IRS Guidelines
Intangible Drilling Costs	Expensed at 85%
Equipment, Platforms	Depreciated According to IRS Guidelines
Development Dry Hole	Expensed
Exploratory Dry Hole	Expensed

The investment tax credit (ITC) reduces federal taxes directly. This direct reduction is the reason for calling it a tax credit, as opposed to tax savings like depreciation. Any investment with a life of five years or longer has a 10% ITC. Three year projects possess a 6% ITC. In the $2 MM tangible investment by the company earlier, they would get a .10 x 2 = $.2 MM ITC.

4.5 Financial "Book" Income

Calculation of taxable income is required for calculation of income tax, which is, in turn, necessary for determination of NCF. However, Financial Book Income (the information presented in the financial statement) is not required for determination of NCF. Nonetheless, it may be desired as an information item. It is typically reported to provide insight into an investment's effect upon future division and company income reports. It is not reported as another financial criterion for the investment decision. Financial Book Income is calculated in the same manner as Taxable Income, except the capital write-off schedules are different. A summary of the capital write-off procedures for determination of Financial Book Income is shown in Exhibit 4.4.

Exhibit 4.4--Capital Write-off Procedures for Financial Book Income

Expenditure	Financial Book Income Treatment
Bonus	Depleted (UOP)
Capitalized Portion of G&G on Producing Properties	Expensed
Producer Well Expenditures Excluding Intangible Drilling Costs	Depreciated (UOP)
Intangible Drilling Costs	Amortized (UOP)
Equipment, Platforms	Depreciated (UOP)
Development Dry Hole	Amortized (UOP)
Exploratory Dry Hole	Expensed

Book income is generally developed and reported when an investment is expected to have a discernible impact upon future division income. Plans generate book income values automatically.

Note that if income taxes were calculated based on Financial Book Income they would be different than those calculated on taxable income. The difference between these two tax amounts is called deferred taxes and the difference arises because of different depreciation methods in the write-off of assets. Over the life of a project, the total taxes paid will be the same in either case. Calculation of taxes using taxable income allows the firm to defer tax payments to the later years of the project life. Exhibit 4.5 is an example of the difference between NCF, Taxable Income, and Financial Book Income.

Exhibit 4.5--Simplified Example of NCF, Book Income, and Taxable Income

	Year						
	1	2	3	4	5	6	Total
NCF View							
Drilling Cost	2000	-	-	-	-	-	
Bonus + G & G	100	-	-	-	-	-	
Net Revenue	-	900	825	725	600	440	
Operating Costs	-	50	50	50	50	50	
Income Taxes	(630)	332.25	277.3	267.6	207.6	130.1	584
Net Cash Flow	(1470)	517.75	491.7	407.4	342.4	259.9	549
Financial Book View							
Net Revenue	-	900	825	725	600	440	
Operating Cost	-	50	50	50	50	50	
Depreciation[2]	-	600	500	400	300	200	
Depletion	-	30	25	20	15	10	
Book Income (BFIT)	-	220	250	255	235	180	
Book Income Taxes	-	110	125	128	118	90	571
Book Income (AFIT)	-	110	125	127	117	90	570
Tax Calculation							
Net Revenue	-	900	825	725	600	440	
Operating Costs[1]	1190	50	50	50	50	50	
Depreciation[3]	70	155.5	195.4	119.7	119.7	119.7	
Depletion	-	30	25	20	15	10	
Taxable Income	(1260)	664.5	554.6	535.3	415.3	260.3	
Income Taxes[4]	(630)	332.25	277.3	267.6	207.6	130.1	584
Deferred Income Taxes	630	408	255	115	26	0	

1 70% of drilling cost is intangible x .85
2 Units of production schedule
3 .95 x ACRS 5 year depreciation facators + 1/3 capitalized IDCs
4 50%

SECTION 5

INVESTMENT EVALUATION MEASURES

5.1 Introduction

In SECTION 2 an investment project was determined to be unacceptable unless it provided a rate of return greater than the firm's cost of capital. In this section we will discuss investment evaluation measures which use this concept to establish the worth of a cash flow stream (NCF) in order that management can make rational decisions about that investment's value to the firm as a whole. In other words, will this investment meet the earnings growth and wealth maximization objectives?

5.2 Time Value of Money or Discounted Cash Flow (DCF)

Most individuals and companies prefer receiving money today rather than in the future, and conversely, prefer paying debts in the future rather than today. Such preferences demonstrate the relationship between money value and its time of receipt or expenditure. Generally it is agreed that this occurs for the following reasons:

1. Money received today may be put to use today (e.g., to earn income, to pay current debts or simply to buy things now).
2. Money received in the future is subject to the uncertainties of the future (e.g., inflation or risk of loss).

When determining an investment's worth, this time value of money cannot be overlooked. Therefore, an evaluation should consider both cash flow magnitude and time of cash flow occurrence.

The discounted cash flow (DCF) approach to investment evaluation considers time of cash flow occurrence as well as cash flow magnitude. This is accomplished through the technique of discounting. Basically, discounting restates a future cash flow to an equivalently valued cash flow occurring today. Discounting may be conceptualized as the calculation of compound interest in reverse. Instead of compounding a present amount into the future, a future amount is discounted (or reduced in value) back to the present. In both procedures, an interest rate is used for either compounding or discounting. An interest rate used for discounting is called a discount rate, and its percentage value may be thought of as a quantitative reflection of the importance of time in valuing future money.

Future cash flows are typically discounted by multiplying them by a discount factor defined as follows:

$$DF_t = 1/(1 + i)^t$$

Here, DF_t is the discount factor for any specific time period, t, (e.g., t = 1, 2, 3, . . .) discounted at rate i. When continuous discounting is used (t 0) the discount factor becomes:

$$DF_t = 1/e^{it}$$

The above factor is for point in time discounting. Many times cash is paid out or received uniformly over a time period. If the cash flow is uniform over the time period and continuous discounting is used, the discount factor is further modified as follows:

$$DF_t = \frac{e^{i(1 - t)} (1 - e^{-i})}{i}$$

Use continuous discounting and uniform cash flow in investment evaluation. Discount factors for various time periods and discount rates can be found in the Tables section.

Exhibit 5.1 plots the present value (i.e., today's value) of $1, discounted from various future time periods at discount rates of 5%, 15% and 25%. Notice that as a dollar is received farther and farther into the future, its value today decreases. Further, this decrease in value is directly dependent on the discount rate. In any given time period, as the discount rate is increased, the value of a future dollar decreases.

Four primary financial return criteria measure investment worth. They are net present value (NPV), net present value to investment ratio (NPV/I), net present value to exposure ratio (NPV/E) and discounted cash flow rate of return (DCF ROR). Each is derived using a discounted cash flow approach. When the NPV, NPV/I, and NPV/E criteria are calculated, a specific discount rate is required.

5.3 Net Present Value (NPV)

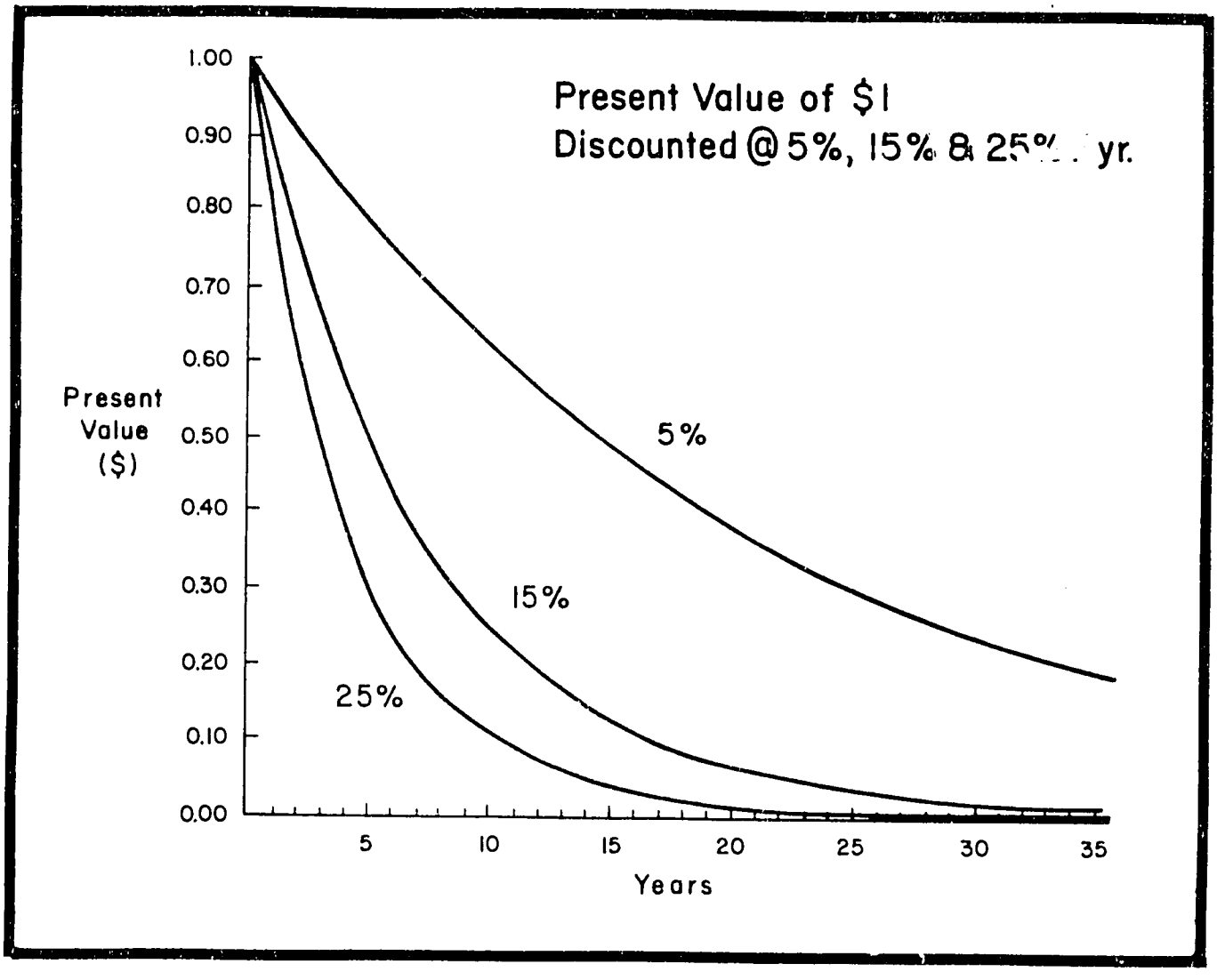
The net present value (NPV) criterion for valuing an investment is a direct application of discounting. NPV is developed by discounting an investment's cash surplus stream to the present at the corporate minimum return. NPV is calculated as follows:

NPV

$$NPV = \sum_{t=1}^{t=n} NCF_t \left[\frac{e^{i(1-t)}(1-e^{-i})}{i}\right] \qquad \text{Eq. (5.1)}$$

Where:
- NPV = net present value
- NCF = net cash flow
- i = discount rate
- t = time period
- n = economic life

Exhibit 5.1--Effects of Time and Discount Rate on Present Value of Future $1



If the NPV of an investment proposal is greater than zero, the project meets the minimum standard and is acceptable. However, the decision as to whether the project actually will be accepted depends on several additional factors, including:

1. Is the project strategically compatible with business and long term goals?
2. Is capital available for investment? In a capital constrained environment, the minimum NPV required may be greater than zero.
3. Does the risk of loss require the NPV to be substantially greater than zero before the proposal is acceptable?
4. Is management convinced the projections are sound? Have all the risks been fully included in the analysis or should further discounting be superimposed for factors not included (such as foreign risk).

NPV can be quite sensitive to the discount rate (minimum return standard). For example, the NCF streams for three separate projects are shown in Exhibit 5.2. Note that, at a given discount rate, one project may appear the most attractive while at a different rate another project may be the most attractive. These anomalies arise because of differences in the magnitude and timing of the NCF streams.

Exhibit 5.2--Example Calculation of NPV

	NCF					
	0	0-1	1-2	2-3	3-4	4-5
Project A	(10,000)	6000	5000	4000	3000	2000
Project B	(10,000)	0	8000	0	7000	7000
Project C	(10,000)	0	0	11,000	0	11,500

	PW of Project			
Discount Rate	A	B	C	Most Attractive Project
0%	10,000	12,000	12,000	C
4%	8,409	9,468	9,560	C
8%	7,141	7,274	7,034	B
12%	5,936	5,370	4,860	A
16%	4,856	3,713	2,985	A
20%	3,885	2,269	1,366	A
24%	3,011	1,007	(333)	A

5.4 Net Present Value to Investment Ratio (NPV/I)

The Net Present Value to Investment Ratio (NPV/I) criterion for valuing an investment is an extension of the present worth calculation. NPV/I is developed by comparing the present worth of a net cash flow stream with the present worth of investment outlays. NPV/I is calculated as follows:

$$NPV/I = \frac{\sum_{t=1}^{t=n} NCF_t \left[\frac{e^{i(1-t)}(1-e^{-i})}{i}\right]}{\sum_{t=1}^{t=n} INVT_t \left[\frac{e^{i(1-t)}(1-e^{-i})}{i}\right]} \qquad \text{Eq. (5.2)}$$

Where:
- NPV/I = net present value to investment ratio
- NCF = net cash flow
- INVT = investment outlays
- i = discount rate
- t = time period
- n = economic life

Use of NPV/I allows ranking of projects on the basis of their relative profitability without regard for the size of the investment. If the NPV/I of a project is greater than 0, the project is acceptable.

5.5 Net Present Value to Exposure Ratio (NPV/E)

The present worth of net cash flow divided by the present worth of before-tax exploration expense (NPV/E) measures the return per dollar of exploration expense. The NPV/E is typically larger than NPV/I because NPV/I includes exploration expenditures as well as development and production facility costs. The difference between the NPV/I and NPV/E is a measure of the return per dollar of producing investment dollar spent. NPV/E is calculated as follows:

$$\sum_{t=1}^{t=n} NCF_t \left[\frac{e^{i(1-t)}(1-e^{-i})}{i}\right] \qquad \text{Eq. (5.3)}$$

$$NPV/E = \sum_{t=1}^{t=n} E_t \left[\frac{e^{i(1-t)}(1-e^{-i})}{i}\right]$$

Where: NPV/E = net present value to exposure ratio
NCF = net cash flow
E_t = exploration investment
i = discount rate
t = time period
n = economic life

NPV/E is a measure of exposure in an exploration prospect. While an NPV/E greater than zero indicates the project is acceptable, it is not a final measure of profitability because it does not include development costs.

5.6 Discounted Cash Flow Rate of Return (DCF ROR)

The Discounted Cash Flow Rate of Return (DCF ROR) (or internal rate of return) criterion for valuing an investment is a time-weighted comparison of cash outflows and inflows. DCF ROR is developed by finding the discount rate which equates the present worth of a cash surplus stream to zero. DCF ROR is calculated as follows:

$$\text{Find } i^* \text{ for } \sum_{t=1}^{t=n} NCF_t \left[\frac{e^{i^*(1-t)}(1-e^{-i^*})}{i^*}\right] \qquad \text{Eq. (5.4)}$$

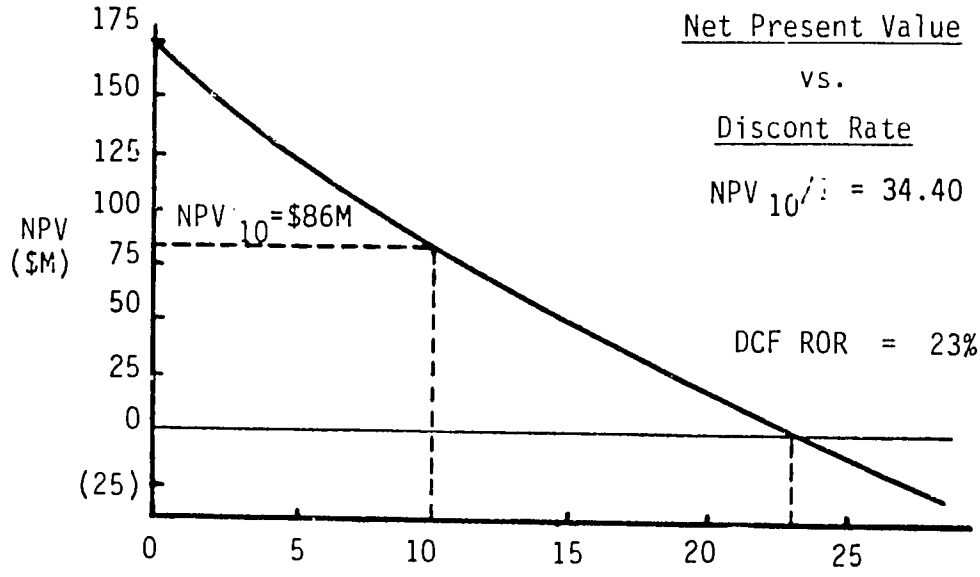
Where:
- i^* = discounted cash flow rate of return (DCF ROR)
- NCF = net cash flow
- t = time period
- n = economic life

The appropriate discount rate, i^*, is found by trial and error

Exhibit 5.3 illustrates the graphical solution of DCF ROR for a short four year project. At a 21% discount rate, the discounted cash surplus stream for this particular project is zero.

The acceptance criterion generally employed for the DCF ROR method is to compare DCF ROR with the minimum return standard. If the DCF ROR exceeds the standard, the project is acceptable. If not, it is rejected. Again, final acceptance of the project is contingent on the factors mentioned earlier.

Exhibit 5.3--Graphical Solution of Discounted Cash Flow Rate of Return (DCF ROR)



Net Present Value

vs.

Discont Rate

NPV 10% = 34.40

DCF ROR = 23%

Year	NCF $M
0	-250
0-1	0
1-2	150
2-3	175
3-4	100
Total	175

Present Worth Profile

Discount Rate	0%	5%	10%	15%	20%	25%	30%
NPV , $M	175	128	86	49	17	-11	-36

5.7 Differences in DCF ROR, NPV, NPV/I and NPV/E as Investment Valuation Measures

Often the NPV (or NPV/I) and DCF ROR methods lead to the same acceptance or rejection decision; however, not always. Important differences exist between the methods.

1. Reinvestment Rate.--One important difference is the reinvestment rate on the cash outflow from the investment. The DCF ROR method implies that funds are reinvested at the internal rate of return of the investment over the remaining life of the project. The NPV method implies reinvestment at the minimum return rate. Because of these differences, these two methods can result in different accept/reject decisions on a given proposal. Exhibit 5.4 gives an example of this apparent paradox.

   In this example, the DCF ROR and NPV methods give different results as to which project is the most attractive. The difference arises because of differing assumptions about reinvestment rate.

Exhibit 5.4--Reinvestment Rate Returns

Year	NCF (MS) Project A	NCF (MS) Project B
0	-100	-100
0-1	200	0
1-2	0	350
NPV	90	201
DCF ROR	159%	85%
NPV/I	0.90	2.01

Minimum Return Standard 10%

2. Multiple Rates of Return.--Another characteristic of the DCF ROR method is that it can result in multiple solutions. Note that Equation 5.3, used for solving for DCF ROR, is an n-th degree polynomial and therefore has n solutions. For most investment projects, there is only one real DCF ROR and all but one of the solutions are imaginary. However, in projects where cash flow reversals occur, (i.e., from plus to minus and back to plus again) multiple real roots can result. This may occur in capital acceleration projects and delayed infill drilling projects. Exhibit 5.5 is an example of an investment proposal with multiple DCF ROR's.

Exhibit 5.5--Example of Project with Multiple Rates of Return

Year	NCF (MS)
0	- 50
1-0	300
1-2	-550
2-3	300

In this example, Equation 5.3 results in three DCF ROR's--0%, 32% and 596%. Which one represents a realistic DCF ROR for the purpose of decision making? Since the NPV of this project at a 10% discount rate is -$4.4M, DCF ROR should not be used.

Which method (NPV or DCF ROR) is best for accept/reject decisions? The NPV method is both theoretically superior and easier to use. The primary

justification for the NPV method is based on reinvestment rate. The reinvestment rate implied by the NPV method may be conservative, but it has the virtue of being applied consistently to all investment proposals. To the extent that we can regard the minimum return standard as an approximate measure of the opportunity rate for reinvestment, the NPV is preferred over DCF ROR.

For project ranking, however, NPV/I ratio is preferred. Since it is a ratio relative to investment, it measures a project's return independent of size. With NPV/I, large marginally profitable projects cannot dominate small highly profitable projects.

5.8 Other Evaluation Tools

Although many financial return criteria exist, most (if not all) investment opportunities may be successfully evaluated using NPV, NPV/I or DCF ROR along with some measure of uncertainty. In some situations, usually at the specific request of management, some other return criterion may be used to supplement those required.

1. Payout Percent.--Payout percent (using either before-tax or after-tax dollar values) is used to measure cash production coverage of the investment outlays. Payout percent is generally viewed only as an indicator of investment funds exposure (i.e., risk). It should not be confused with the payout (in years) which is a parameter used by several companies. Overall, payout percent is not a very good measure of investment worth, since undiscounted values are used in its calculation. Exhibit 5.6 shows an example of a payout percent calculation.

Exhibit 5.6--Example of Payout Percent Calculation

Payout Percent Calculation

End of Year	NCF(M$)	Investment
0	-100	-100
1	60	
2	50	
3	40	
4	30	
	80	

$$\text{Payout percent (AFIT)} = \frac{\text{NCF + Investment}}{\text{Investment}} \times 100 = \frac{80 + 100}{100} \times 100 = 180\%$$

To calculate payout percent on a before tax basis (BFIT), use erating earnings (cash basis) rather than net cash flow (NCF).

Payout percent is a crude measure of risk. It gives management an indication of how much coverage of investment funds the project generates. Higher values infer less risky projects. Payout percent is calculated on both an AFIT and BFIT basis.

2. Book Return on Assets Employed (ROI).--This is an accounting method frequently noted in stock market type of evaluation. It is based on the ratio of average annual book profits to the book investment in the project. The book investment may be calculated by deducting accrued depreciation and depletion from the original investment. An example of book return on assets employed is shown in Exhibit 5.7.

Exhibit 5.7--Book Return on Assets Employed

Year	Book Net Income	Assets Employed	Book Return on Assets Employed (Pct)
1	60	100	60
2	40	67	60
3	30	33	91
	130	200	65

Investment = 100 (depreciated over 3 years on a straight line basis)

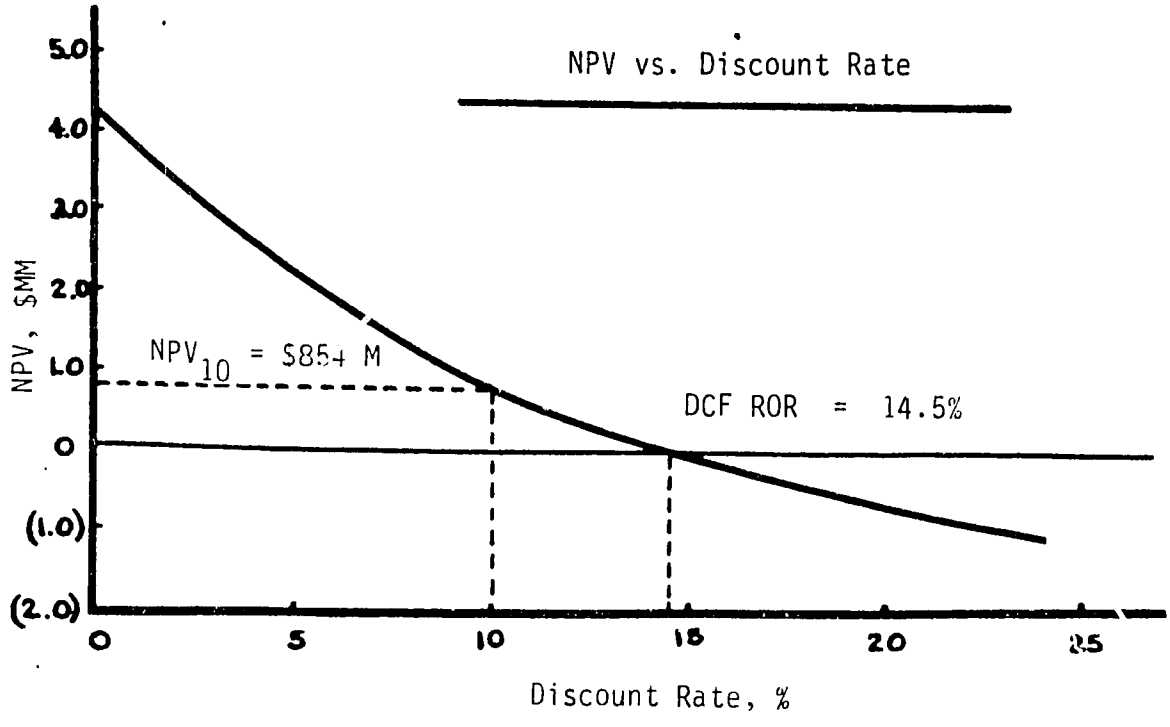
This is an extremely crude method of evaluating a project's profitability. It is not generally used in investment evaluation and its only advantage is that it is relatively simple and can be quickly determined.

Exhibit 5.8--An Example Calculation of Investment Measures

Year	NCF ($M)	Factor	Discount @ 10%
0-1	(2085)	0.9516	(1984)
1-2	(1150)	0.8611	(990)
2-3	(850)	0.7791	(662)
3-4	1510	0.7050	1065
4-5	1435	0.6379	915
5-6	1265	0.5772	730
6-7	1030	0.5223	538
7-8	875	0.4726	413
8-9	600	0.4276	257
9-10	525	0.3869	203
10-11	300	0.3501	105
11-12	835	0.3168	265
	4290	NPV @ 10%	= 854

Year	Investment ($M)	Factor	Discount @ 10
0-1	(2085)	0.9516	1984
1-2	(1150)	0.8611	(990)
2-3	(1025)	0.7791	(662)
		Discounted Investment	=(3637)

$$NPV/I = \frac{854}{3637} \times 100 = 23.48$$



5.9 Investment Decisions: Accept/Reject; Best Alternatives; Best Combinations

The desired end product of good business analysis of good decisions for meeting corporate objectives. Thus, the analysis must provide the best information possible to the decision maker by focusing on the decision alternatives. To help analyze the alternatives, it is useful to categorize investment decisions into three types:

Accept/Reject	Does the proposed project meet the minimum return standard on its own merit?
Best Alternative	Out of several alternatives, what is the one best course of action?
Best Combination	While working within limited resources, what combination of proposed projects best fulfills the corporate objective?

A simple accept-reject decision is required to test whether or not a project is profitable in its own right. Best alternative, or mutually exclusive, analysis is required when the one best project must be selected from several possible alternatives. Best combination analysis is used when the decision is to choose the combination of projects with the highest total NPV from a pool of candidates, while remaining within a budget.

Categorizing investments in this way is only one of many possible techniques for sorting through and organizing an assignment. It also often helps develop an appropriate format to present results. Obviously, all investment situations are not going to be as clear-cut as these categories may tend to indicate. In fact, all investments, to some extent, involve accept-reject choices between mutually exclusive alternatives and resource restrictions.

5.10 Accept-Reject Investment Decision

Some investment situations require a decision primarily for or against funds expenditure (i.e., is the project to be accepted or rejected?). Typical examples of this occur when a prospective property may be acquired at a fixed price, or a "wildcat" well may be drilled.

Often the accept-reject decision is a quick test to determine profitability. If the analysis shows that the project has a negative NPV and the project is not required for legal or environmental considerations, it may be dropped from further review. When a project has a positive NPV this may be only a first test before being included in a Best Alternative or a Best Combination analysis.

Sometimes investment situations arise which appear to require simple accept-reject decisions, but, in fact, involve choices among alternatives of a choice over investment level. A common example is a decision to participate in a joint venture. On the surface, this is a simple accept-reject choice: either participate in the joint venture or don't participate. However, those involved with putting joint ventures together know that they are typically derived through negotiations involving many contractual and participation options and levels of commitment. Nevertheless, viewing a joint venture as a simple accept-reject situation can be useful, particularly as a starting point for analysis. If the accept alternative appears attractive, then further consideration of various contract terms and participation levels is warranted.

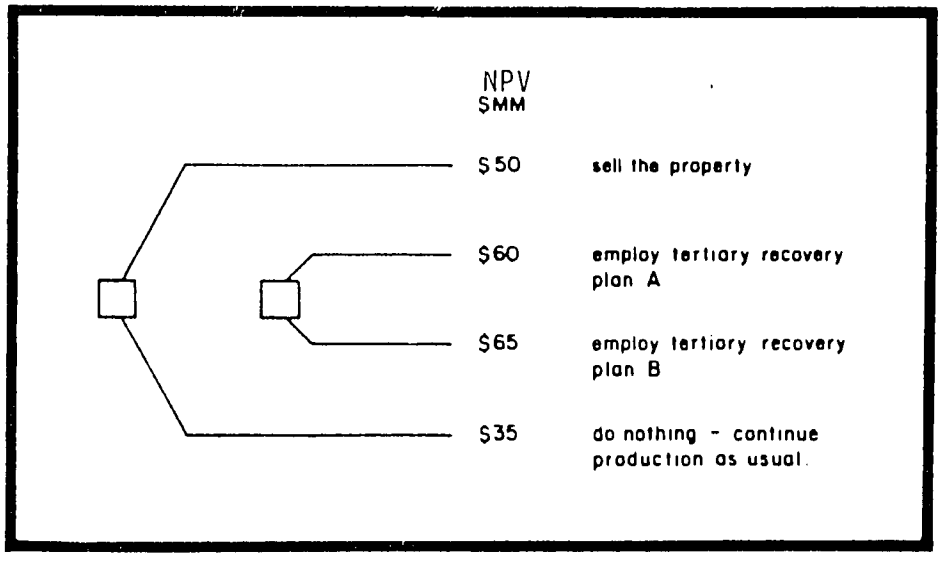
5.11 Best Alternative Investment Decision

Some investment situations clearly require selection of a single investment from among two or more investment alternatives where, once selection

is made, the remaining alternatives can no longer be undertaken. Making a decision of this kind involves mutually exclusive alternatives. Typical situations which require such decisions are those concerned with alternative ways to exploit a resource or provide a service. For example, selection of a specific secondary recovery method for an oil reservoir requires a Best Alternative decision. So does a choice on a production rate acceleration project. Other mutually exclusive alternative decisions are made almost any time equipment is purchased or replaced.

The critical concern in any Best Alternative analysis is that all effects of its decisions must be accounted for with each alternative. If you choose to sell a producing lease, you stand to gain from the sale of property, but you will lose the production revenue. One way to insure that no "side effects" of a decision are left out is to construct a decision tree.

Exhibit 5.9--Decision Tree Method of Comparing Alternative Investments



A decision tree is a simple diagram showing at what point decisions must be made and all of the options to consider. The decision is represented by a square. The alternatives are represented by "branches" extending from the decision square. The result of each alternative is shown at the end of each branch by the data labeled NPV.

In Exhibit 5.9 a simple decision tree has been built showing possible future alternatives for a producing property. These are mutually exclusive alternatives. If you sell the property, you forego any tertiary recovery. If you choose tertiary recovery, you must choose between Plan A or Plan B. If you prefer the status quo, you forego the sell and tertiary benefits. Each alternative has been labeled with a positive NPV. Even the "do nothing" option has an NPV of $35MM. Which decision should be made? Provided each alternative has been evaluated correctly and the riskiness of each alternative is identical, the decision with the greatest NPV would be the correct one.

The choice of "employ tertiary recovery Plan B" has an NPV of $65 million. But, in choosing this course of action, you forego an NPV of $50 million by selling the property. Incrementally, this decision increased the NPV of the company by only $15 million. The $50 million NPV of the alternative "sell the property" is commonly called an "opportunity cost" of the decision. It is the NPV you are willing to forfeit for the opportunity of achieving a greater NPV.

In the following example (Exhibit 5.10), it is assumed that the development well may be completed and equipped by one of three methods--A, B, or C. Selection of any one method eliminates the others from consideration; therefore, the alternatives are mutually exclusive. Completion by Method A gives the base case results. Completion by Method B costs the same as A but leads

Exhibit 5.10--Mutually Exclusive Alternatives Decision Selection of Well Completion Method

Analysis of the economic data for each alternative well completion method gives the following results:

ABSOLUTE

Year	Net Cash Flow Method A	Method B	Method C
0	-200	-200	-250
0-1	90	110	123
1-2	67	77	93
2-3	45	45	61
3-4	36	36	42
4-5	18	18	21
Total	56	86	90
NPV , $M	15	43	38
DCF ROR, %	14.5	23.3	19.2
NPV/I	7.63	21.45	15.20

RELATIVE

Year	Net Cash Flow of Each Method Minus Net Cash Flow of Next Best Alternative, $M: A Minus B	B Minus C	C Minus B
0	0	50	-50
0-1	-20	-13	13
1-2	-10	-16	16
2-3	0	-16	16
3-4	0	-6	6
4-5	0	-3	3
Total	-30	-4	4
NPV, $M	-28	5	-5

to reduced maintenance expense in the first two years. Method C requires an additional $50MM initial investment but leads to operating cost improvements over other Methods A and B.

The analysis is first performed on an "absolute" basis to show the evaluation parameters which result from each completion method. An "Absolute" analysis is the common form of analysis used. However, to clearly demonstrate the opportunity cost impact of mutually exclusive alternatives on this investment decision, analysis is also performed on an "incremental" or "relative" basis. A relative analysis shows the financial return of each completion method less the opportunity cost of foregoing net cash flow from the next best completion method. These results are also shown in Exhibit 5.10. In the relative analysis, NPV is calculated using the difference between net cash flow streams, and the investment alternative selection is based on the case (or difference) yielding the highest value.

Both an absolute and relative analysis should always yield the same decision, providing at least one alternative has positive economics. Examination of both the absolute and relative analyses shows completion Method B to be better than Methods A or C. Notice that the absolute analysis shows all three completion methods to be potentially acceptable, while the relative analysis, which considers opportunity cost, shows only Method B as being acceptable. Completion Method B requires the same investment as Method A but generates more net cash flow through cost savings. In Method C, the extra $50M investment does not generate sufficient cost reductions to offset this additional investment on a present value basis. All of this is clearly highlighted in the relative analysis.

A special case of mutually exclusive analysis is the selection of an optimum investment scale. Making a choice of this kind is an investment decision which asks: What is the size of the investment that will maximize the present worth of the project? For example, a production facility can be built with a capacity of 10 MB/D, 15 MB/D or 30 MB/D. Which capacity is best? The greater the capacity, the greater the potential revenues. But, each increase in the size of the plant will require more investment.

The accepted practice is to determine the revenues, costs, and investment of each size of plant. The net cash flow stream is produced and a present worth is calculated for each proposed plant size. The plan that produces the greatest present worth would be the optimum design.

In many investment situations, it is quite obvious that an investment sizing decision is required. Some examples: (1) Any decision to bid on an oil lease always requires a decision about the level of the offer and (2) an oil field may be developed using any legal well density desired. On the other hand, many mutually exclusive alternative decisions also involve incremental decisions which sometimes are not easily recognized. The well completion example in Exhibit 5.11 is such a case. Completion Method C involves a decision regarding benefits versus costs for an additional or incremental investment of $50M.

Exhibit 5.11 is an example analysis of a situation involving an incremental investment decision. A number of development wells may be drilled on a property. Well spacing is unrestricted by state law. Consequently, the property may be developed using the most economically attractive number of wells. Previous studies indicate that through faster or additional recovery, added benefits arise by drilling up to four wells. No further benefits result from

Exhibit 5.11--Incremental Investment Decision Optimum Number of Development Wells

Analysis of both economic and reservoir data for each development choice gives the following results:

	Net Cash Flow			
Year	1 Well	2 Wells	3 Wells	4 Wells
0	-200	-390	-580	-760
0-1	110	201	318	465
1-2	77	145	189	224
2-3	45	100	140	147
3-4	36	76	100	102
4-5	18	51	69	69
Total	86	183	235	253
NPV ,$M	43	90	108	106
DCF ROR, %	23.3	23.3	21.3	19.6
NPV/I	21.45	23.08	18.78	13.93

The added benefits of each increment of investment are:

	Incremental Net Cash Flow			
Year	1 Well	Over 1 Well	Over 2 Wells	Over 3 Wells
0	-200	-190	-190	-180
0-1	110	91	117	147
1-2	77	68	44	35
2-3	45	55	40	7
3-4	36	40	24	2
4-5	18	33	17	1
Total	86	97	52	18
NPV, $M	43	47	18	-2
DCF ROR, %	23.3	23.3	16.5	8.2
NPV/I	21.45	24.87	9.56	-1.37

drilling additional wells. Also, completion Method B is used, since it has been shown, from the analysis in the previous section, to give the best investment return. And, in the opinion of the field's engineers, the superiority of this completion method will continue in the multiple well situation. Therefore, the incremental investment decision focuses upon using completion Method B to drill 1, 2, 3 or 4 development wells.

Particular care is taken in examining the well data to be certain that appropriate costs are used for each level of investment. Average costs are not used. Further, the uncertainty in the project is carefully scrutinized, since a change in revenues or expenses may shift the optimum level of investment. If revenues turn out lower than expected, the return from the last increment of investment may fall and not meet the corporate minimum return. In uncertain situations of this type, a lower investment level may be best.

The results of the analysis are summarized in Exhibit 5.11 and show that development with three wells gives the highest NPV. Notice that full life net cash flow increases for each new well, indicating that each well brings in additional reserves. The biggest addition comes with the second well. The third and fourth wells also accelerate production, but each adds a smaller increment of reserves. Unfortunately, the fourth well, in spite of both production acceleration and reserve additions, does not return enough to justify its additional cost.

Although not shown here, additional considerations such as sensitivity analyses may be employed to influence final investment decisions. In this example, a sensitivity analysis is performed which indicates that, if revenues are 10% less than expected, development with two wells is the best choice.

Whether this justifies a two or three well program depends entirely on the decision maker's (and the company's) attitude toward risk. Some decision makers may be willing to accept the risk associated with a three well program, while others, in order to "play it safe," may be willing to use only a two well program.

As the previous sections have emphasized, alternatives are an important part of every investment situation because benefits from foregone alternatives contribute to an investment's cost as an opportunity cost. Failure to consider opportunity costs can distort evaluation results and may lead to wrong decisions.

Another twist of mutually exclusive investment analysis involves identifying "sunk costs," i.e., costs which have been incurred previously and are no longer relevant to the analysis. For example, in the development well problem in Exhibit 5.11, assume that money has been budgeted for the three well program and that two wells have been drilled and completed. Any analysis of the third well must ignore the costs incurred to date, as these costs are not relevant to the accept-reject decision on well #3. Costs to be ignored include leasehold rental, bonus costs, drilling and completion costs, as well as operating expenses of the two previous wells, etc. Any costs which have been incurred or will be incurred in the future, regardless of the accept-reject decision, are irrelevant to the analysis.

Be aware that tax effects of an expenditure may linger on years after the costs may have been sunk. As an example, an exploration property that has already been bought for $10 million is evaluated for drilling a wildcat well. In the evaluation of whether to drill the property, sell it, or let the lease expire, the $10 million cost of the lease is a sunk cost and should be

ignored. That $10 million is on the depletion account, however. Walking away from the lease means that the $10 million cost of the lease may be written off against other income, producing a tax savings of $4.6 million.

Many times management may require summary economics for the entire investment program but these parameters are for information purposes only and should not affect the accept-reject decision.

5.12 Best Combination Investment Decision

The third type of analysis occurs when many independent proposed projects compete for limited investment funds. This is a Best Combination analysis, where the goal is to select the combination of projects that yield the greatest total Present Worth. The total capital requirement for the investments selected, however, must not exceed the available funds in the budget.

Generally, the funds available are the limiting factor in project selection. Usually there are more projects that exceed the minimum return standard than there is cash to fund them. Management is, therefore, faced with the task of ranking the projects in an order of profitability which meets the acceptance criteria.[1]

Which ranking method works best? It is generally accepted that the NPV or NPV/I parameters result in optimal project ranking. DCF ROR is neither sensitive to the size nor to the start timing of the investment and, as was pointed out earlier, can result in a "Best Alternative" decision which is

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[1] Sometimes project rationing may be unrelated to available funds. Limited management or engineering talent or perhaps other strategic reasons may require some sort of project rationing.

inconsistent with the NPV method. Exhibit 5.12 is an example of project ranking in a capital constrained environment.

A division manager would like to do all of the projects submitted to him. Each project is profitable in its own right. The problem is that it requires $27 million to do all of the projects and he has only $20 million in his budget. Clearly, some of these projects must go. By ranking the projects in decreasing order of NPV/I, the manager sees that Project B has the lowest NPV/I. In other words, Project B is the least efficient generator of NPV for its investment dollar. If the manager drops this project, the remaining projects fit within his investment budget and the combined NPV's are as high as they can be.

In Exhibit 5.12, Project B would be rejected even though it meets the minimum economic parameters and would result in earnings growth. This results in a less than optimal investment strategy. Theoretically, a company should accept all projects yielding more than the real cost of capital. In a capital constrained environment this would require that additional funds be raised, either by issuing stock or by debt financing. Most large firms choose not to change their capital structure from year to year in order to supply a level of funds which exactly matches the investment requirements. However, over longer time periods firms do change their capital structure in order to finance new projects for strategic reasons.

Exhibit 5.12--Project Ranking in a Capital Constrained Environment

The following projects are nonmutually exclusive and have been submitted to the division manager for approval. The negotiated investment budget is $20MM. The division manager's task is to select the combination of projects that has the greatest combined NPV while remaining within his investment budget.

Project	Investment ($MM)	NPV ($MM)	NPV/I
A	5.8	2.8	0.56
B	7.0	1.9	0.27
C	3.0	1.7	0.57
D	2.5	0.9	0.36
E	5.0	1.5	0.3
F	4.5	1.7	0.38

Project Ranking	NPV/I	Investment $MM)
C	0.57	3.0
A	0.56	5.0
F	0.38	4.5
D	0.36	2.5
E	0.30	5.0
		$20MM

Project B would not be accepted

SECTION 6

GLOSSARY OF KEY FINANCIAL TERMS

The definitions in this Glossary
correspond primarily with
common usage

GLOSSARY

Accelerated Depreciation

The process, as permitted by tax codes, of rapidly writing-off of the cost of an asset. Compared to normal (straight-line) depreciation, this technique reduces early life income tax payments by deferring tax payment until later periods.

Acceleration Investment

An investment which increases present worth by causing investment benefits to be received earlier. Total benefits on an undiscounted basis, however, may increase, decrease or remain unchanged.

Amortization

An accounting term referring to the process of writing-off the cost or value of an asset over its expected service life. Intangible assets such as acquisition costs for nonproducing properties, lease bonuses, title clearing expenditures, geological and geophysical cost are "written-off" or "amortized" in amortization accounts. Tangible assets such as physical equipment or in-place reserves are written off through depreciation or depletion accounts.

Appropriation

An investments budget term for funds approved for investment.

Asset

An accounting term for an item owned by a company. An asset is typically classified as a fixed or tangible asset (e.g., petroleum reserves, real estate, equipment), an intangible asset (e.g., lease bonuses, patents, license agreements, trade marks) or a current asset (e.g., cash securities, notes, inventories, accounts receivable).

Assignment

An assignment is that legal document whereby one party transfers all or a portion of his interest to another, subject to specific considerations.

Assignee (Grantee)

The assignee is the party to whom an assignment is made.

Assignor (Grantor)

The assignor is the party who makes the assignment.

Base Case

A reference case to be compared with alternative investment choices or outcomes.

Base Projection

A forecast of financial and operating flows related to existing assets including investments required for maintenance and completion of current commitments.

Book Income

An accounting term for income values computed in accordance with a company's established accounting policies. Book income is used for both internal and external financial reporting, but it is not used as a basis for computing investment return criteria. See "net income."

Break-Even Analysis

An analysis of the relationship between revenues and costs to determine the sales volume (called break-even point) required to offset costs.

Capital Expenditure

An accounting term for funds expended for the long-term (greater than one year) addition, replacement or improvement of fixed assets.

Capital Recovery

The method under which capital expenditures, such as bonus and tangible investments are reported in calculating taxes.

Carried Interest

A carried interest is an agreement between two or more partners in the working interest whereby one party (carried party) does not share in the working interest revenue until a certain amount of money has been recovered by the other party (carrying party). This type of arrangement may result when the carrying party advances all or part of the development costs of the carried party, or where land brokers use the device for a portion of their profits. It is also a provision in some

farm-out agreements. Carried interest may apply to a single well or an entire lease.

Cash

Currency, undeposited receipts and demand deposits (checking accounts) in banks.

Cash Flow

Cash received or expended.

Cash Flow from Operations

Cash revenues less cash operating expenses before deduction of taxes. In accounting terms, net income plus book write-offs.

Cash Flow Projection

The process of calculating and developing period-by-period estimates of future cash receipts and expenditures.

Cash Flow Timing

Either the time cash flows occur from one period to another (e.g., 1978, 1979, 1980), or the time cash flows occur within a single period (e.g., beginning, middle or end of year).

Consumer Price Index (CPI)

Published monthly by the Bureau of Labor Statistics, this index is comprised of the retail prices of approximately four hundred goods and services statistically selected to typify the prices of all final goods and services purchased by urban residents. The CPI is used for representing changes in the average level of all prices. Hence, percent changes in the CPI are indicative of general inflation.

Controllable Expense

An operating expense over which managers and supervisors are deemed to have a degree of control. For example, salaries, repairs, maintenance, materials supplies, rentals, contract services, freight, transportation and utility expenses.

Corporate Objectives

The goals toward which the operating and investment plans of a company are directed.

Debt Equivalent

A term for the discounted value of a predetermined schedule of payments, after tax, required for investments tied to financing.

Debt Financing

Funds obtained through borrowing, typically from the sale of bonds or commercial paper, or by directly borrowing from a bank or other creditor.

Decision Tree

A schematic technique for studying the joint impact that various uncertainties have upon investment return for alternate decision choices.

Deferred Expense

An accounting term for an expense paid out for a benefit which may not be received for one year or more. For example, an advance payment on a contract such as a premium on an insurance policy, or development costs for a new product. Also called a "deferred charge."

Deferred Investment

An investments budget term for a contractually binding agreement requiring fixed payments for more than one year in exchange for the use of an asset. For example, a long-term lease.

Deferred Taxes

Computed tax liability and book charges based on the timing difference in write-offs for book and tax purposes.

Dependent Investment

An investment whose cash flows are affected in some way by the acceptance or rejection of other investments.

Depletion

An accounting and tax term for the value or cost assigned to an amount of natural resource removed or produced in a time period. The process of amortizing the value of a wasting asset through "write-offs".

Depreciation

An accounting and tax term for allocating a portion of tangible asset cost to a time period. Property, plant and equipment are depreciated, as well as all the costs of developing producing wells and related facilities.

Development Well

A development well is one drilled on property that is considered proved.

Discount Factor Tables

See "TABLE OF DISCOUNT FACTORS."

Discount Rate

An interest rate used for finding the current value of future cash flows.

Discounting

A procedure which restates (reduces) a future cash flow to an equivalently valued cash flow occurring today.

Division Order

A division order is the instructions, signed by all interests, to the oil or gas purchaser showing how the purchase price is to be divided. Normally, all money due the working interest is paid to the operating interest who, in turn, apportions it in accordance with the interests held. All royalty is normally paid directly by the purchaser, although this is not always the case.

Economic Limit

Generally refers to that production rate of an operating oil or gas well (or total property) at which current cash expenditures start to exceed current cash receipts before income taxes. Thus, continued production at a rate below the economic limit would be expected to result in a net cash loss.

Economics or Economic Returns

As used in this Manual, the value of an investment established by performing a financial analysis incorporating a company's financial return objectives.

Environmental Investment

An investment required to comply with government regulations designed to provide ecological benefits.

Equity Financing

Funds obtained from retained earnings (internal financing) or from selling stock (external financing).

Expansion Investment

An investment which adds benefits by increasing the extent or the scope of a project. One type of incremental investment.

Expenditure

A cash disbursement. In an investments budget, a cash disbursement of funds designated for investment.

Expense

A disbursement of outlay which is subtracted from current revenue. In book or taxable income computations, this may be either a cash (e.g., salaries and wages) or a noncash (e.g., current year depreciation) disbursement.

Farm-In Agreement

This most often occurs after commercial production is found. The finder needs more capital to develop the property than is available. One or more partners are found to develop the mineral property. An assignment of interest is made in consideration of specific services provided.

Farm-Out Agreement

This is the name applied to a specific form of assignment wherein the lessee grants a conditional interest to a third party in consideration for the development of a prospect within a specified length of time on a given acreage. It is usually undertaken where the lessee has leases on a relatively large block of acreage and does not wish to undertake the sole cost of developing it. In most instances this form of agreement is between a major company and the independent operator who cannot afford to acquire large acreages.

Fixed Expense

An operating expense which does not change in relation to the volume of production or sales of merchandise or services. For example, rent, mortgage, insurance, property tax and equipment lease payments.

Forecast

The formulation of possible future events of economic conditions (e.g., evaluation premises) through a comprehensive study and analysis of available pertinent information.

General and Administrative (G & A) Expense

A component of controllable expense for management or service departments involved in administration and not directly identified with a specific operating function. Also called "overhead."

Gross National Product (GNP)

The market value of domestic current final output (goods and services) in the economy.

Income

An imprecise term for the gain or benefit derived from capital or labor over a given time period. In financial statements, this is an accounting computation broadly defined as revenues minus expenses.

Income Tax

A monetary assessment levied upon a company by a federal, state, or local government, based upon taxable income.

Incremental Investment

An investment which increases project benefits by enlarging its scale or reducing its costs. This includes expansion and maintenance investments.

Independent Investment

An investment which may be undertaken or rejected with no effect on other investments.

Inflation

The rise in general level of all prices. This results in a corresponding general decrease in the purchasing power of a dollar.

Intangible Drilling and Development Cost

A portion of the cost incurred in drilling a well which is expensed for tax purposes by capital and depreciated for book purposes. For example, well labor, fuel, hauling and supply expense.

Interest

A charge of a sum paid for the use of borrowed money or credit. Usually it is calculated as an annual percentage on outstanding principal.

Internal Rate of Return

See PI.

Investment

An expenditure of funds to acquire physical or financial assets from which benefits are expected to occur for more than one year.

Investments Budget

A tabulation for a calendar year of an approved investment plan. It is linked to the long-range investment plan and consolidates program

appropriations for capital expenditures, programmed expenses, deferred investment and stock purchases.

Lease Bonus

A Lease Bonus is cash payment to the potential lessor by a potential lessee and an inducement to give a lease on a property. Where the bonus is large, it is sometimes paid over a period of years, in which case it is known as a deferred bonus. This payment is normally amortized over the life of the lease. This amortization is referred to as cost depletion.

Lease Financing

Obtaining the use of an asset (without obtaining title to it) by entering into a contractually binding agreement to make certain minimum payments over a fixed period of time exceeding one year.

Leaseback

The practice of selling an asset such as a plant, machine, computer, or ship to an outside investor and then renting it back under a long-term lease.

Lease Rental

This is annual rental paid to the lessor by the lessee in lieu of production during the life of the lease. In some cases, such rentals are paid even after production is obtained.

Leverage, Financial

The use of funds obtained at a fixed cost in the hope of earning more on assets purchased with the funds than the fixed cost of their use, or equivalently, the act of controlling a certain amount of investment worth with a smaller amount of money. For example, the purchase of land with a 10 or 20% down payment in anticipation of price appreciation can be considered a use of financial leverage.

Liability

An accounting term for a claim against a company. A liability is typically classified as a fixed or long-term liability (e.g., mortgage bond, debenture, bank loan) or a current liability (e.g., account payable, accrued interest payable, accrued taxes payable).

Maintenance Investment

An investment which sustains benefits (i.e., by preventing revenue losses or losses of cost increases) or postpones asset replacement. One type of incremental investment.

Margin

A term with multiple meanings. "Margin" or "operating margin" generally refers to the result of operating revenues less operating expenses. "Margin" may also refer to a percentage value representing net income as a percent of revenues.

Marginal Tax Rate

The corporate tax rate that is applicable to any change (increase or decrease) in taxable income. The tax rate used for investment evaluation should be a marginal tax rate.

Maximum Efficient Rate (MER)

An MER is a theoretical number that presumably will optimize ultimate recovery and/or economics. It is normally expressed as volume of production per day, per well or per lease (or field) unit. Such numbers possess some value for general guidance purposes. They are sometimes used (erroneously) as a standard by which the efficiency of a given operation is judged.

Mean Value

A statistical measure reflecting an arithmetic average or a probability weighted average of values.

Mineral Lease

A mineral lease is in reality not a lease in the general sense of the term. It is rather the delegation of exclusive rights to "capture" such minerals from the mineral owner (lessor) to a lessee (oil or minerals company). In return the lessee gets to keep and sell the greater part of these minerals as compensation for his efforts. The remainder, or royalty, belongs to the mineral owner and is that portion that is to be recovered for him at no cost, by the lessees.

Mineral Rights

Mineral ownership legally may be separate from surface ownership except where otherwise provided. The mineral owner therefore has the right to recover said minerals from the premises.

Minimum Return

The currently approved discount rate to be used in the present worth and present worth to investment ratio computation. The minimum return establishes a threshold for investment acceptance based upon the cost of investment funds.

Monte Carlo Simulation

A technique for generating probability distributions of investment return when the probability distribution for each investment uncertainty is known or can be approximated.

Most Likely Outcome or Value (MODE)

That outcome or value with the highest probability of occurrence.

Mutually Exclusive Investment

An investment which, if accepted, eliminates other comparable investments from consideration.

Net Income

An accounting term for revenues less cash and noncash or book expenses which may be expressed before or after tax.

NonCash

An accounting amount which directly affects the computation of book income and net income but does not generate or require a cash outlay during the period. Book charges such as a depreciation, depletion and amortization are examples.

Noncontrollable Expense

An expense item over which managers and supervisors are deemed to have no direct control. For example, federal, state, local taxes, property taxes, license fees, insurance and depreciation expenses.

Obligation Investment

An investment which is undertaken to satisfy contractual commitments or other legal liabilities.

Operating Expense

Generally, a cost of conducting business activities or, specifically, cost directly involved with production or services.

Operating Statement

A tabulation of data generally of a financial nature, such as revenues and expenses for a specific period, e.g., week, month, or year.

Opportunity Cost

The highest valued opportunity necessarily foregone. This indirect cost is equal to the cash value of benefits from the best alternative not chosen.

Overhead

A component of controllable expense for management or service departments involved in administration and not directly identifiable with a specific operating function. Also called "general and administrative expense."

Overriding Royalty

This is an additional royalty created out of the working interest and having the same term as this interest. It is said to be "carved out" if such royalty is assigned free of all operating and development expenses. It is said to be "reserved" if the lessee assigns the working interest and retains only a fractional share. The latter is the more common and usually results from the activities of a land broker who obtains leases for the sole purpose of ultimately assigning them to a third party for development purposes. This form of royalty may also become a part of a Farm-Out Agreement.

Parameter Method

A shortcut technique for generating a probability distribution of present worth which does not require detailed specification of each investment uncertainty.

Payable

An accounting term for a cash payment to be made for goods or services received.

Payout

The length of time required to recover investment outlays from the cash surplus stream computed using either discounted or undiscounted values. Should not be used as an investment return criterion. Also called "payback."

PI

The discount rate that yields a zero net cash production.

Prepaid Expense

An accounting term for an expense paid out for goods or services not yet received, but which are to be received in less than one year.

Present Worth

The value of a discrete or continuous cash flow discounted at some discount rate. The corporate minimum return rate is always one rate that is computed and presented. "Present Worth (PW)," also called "present value." Net Present Worth = PW (Cash Inflows) - PW (Cash Outflows).

Present Worth to Investment Ratio

A ratio derived by dividing an investment's present worth by the present worth of its investment outlays.

Probabilistic Analysis

An analytic procedure that identifies which items of cash flow are uncertain and determines how this uncertainty affects the probability of achieving various levels of investment return. Includes a variety of techniques.

Probability

The ratio of the outcomes that would produce a given event to the total number of possible outcomes. Usually expressed either as a decimal value between 0.0 and 1.0 or as a percentage between 0 and 100%.

Probability Distribution

The definition of the mathematical behavior of a random variable by specifying its possible values together with their respective probabilities.

Probability Tree

A visual display showing combinations of uncertainties, their probability of occurrence, and the probability of each combination.

Production (Oil) Payment

A production payment entitles the owner of the payment to a specified portion of the production for a limited time, or until a specified amount of money has been received. It is almost like a royalty, except that it expires when a given amount of money has been received.

Profit

An imprecise term generally perceived to reflect the financial return from an investment. Profit is commonly defined as the excess of revenues over all costs and is also considered to be equivalent to income.

Project View

Investment results computed using most likely projections of cash flow items. Returns developed in this way, however, do not necessarily represent most likely investment results.

Proration

This refers to the artificial control of producing rate imposed by regulatory bodies in an attempt to enforce good conservation practices

and to hold production within the limits of the current market. The methods used vary, none of them being entirely satisfactory to all parties.

Proved Property

A proved property is one probably containing commercial quantities of oil. Normally, a property is considered proved if all geological and geophysical information is positive, nearby wells are commercial and apparently on the same structure, and there are no negative values to be considered, except the usual error in the interpretations above. In general, a property must be at least partially developed before it is considered proved.

Rate of Return

An imprecise term which is used to refer to either PI, accounting ROR or return on investment (ROI).

Receivable

An accounting term for an amount of money to be received for goods shipped or services performed.

Replacement Investment

An investment in an asset which replaces an existing asset. One type of mutually exclusive investment.

Reserves

Reserves are that quantity of oil or gas that should be produced by the methods outlined in the report under the conditions specified. For oil, the standard unit is either cubic meters or the API barrel (42 U.S. gallons) measured at atmospheric temperature and pressure. For gas the unit is either standard cubic feet or standard cubic meters, as measured at a given base temperature and pressure.

Reserve for Depreciation

An accounting term for the accumulated total of all depreciation recorded for a tangible asset from the time depreciation is first taken.

Return on Investment (ROI)

This is an accounting term reflecting average annual net income as a percent of original or average investment outlay.

Revenue

The amount received for the sale of production of manufactured products. Usually, the mathematical product of unit price and volume. The chief source of cash inflow in most investment evaluation.

Reversionary Interest

This is similar to a carried interest, differing only in the sense that the type of interest held by each party changes after a specified set of conditions have been met. A typical example might be found in a farm-out agreement. Lessee A retains a 1/16 or 7/8 overriding royalty until B recovers $300,000 from drilling a successful farm-out. After this recovery, the override reverts to a one-half working interest, the override becoming null and void. Therefore, A is said to have a reversionary one-half interest in the property.

Risk

Denotes the possibility of a monetary loss or an unachieved objective. Sometimes, a formal distinction is made between risk and uncertainty. Risk is associated with an objective probability distribution and uncertainty with no probability distribution (or a subjective probability distribution).

Royalty

Royalty is the interest of a party owning minerals in the ground where another party (the working interest) has gained the right to capture such minerals under a lease agreement. Such royalty interest is normally free of all costs of capture except for special treating costs that might be specified in the lease or assignment. This term is often used as an abbreviation for the term land-owner's royalty. There are many specific forms of royalty.

Salvage

The amount expected or actually received from the sale of property, plant or equipment, before or after tax.

Sensitivity Analysis

An analytic procedure which quantifies the impact various items of cash flow have upon investment return.

Standard Deviation

A statistical measure of deviation from a mean value. It is the square root of the variance.

Taxable Income

The computation of income in accordance with tax codes so as to serve as the basis for computing income taxes. Generally differs from book income (as reported in financial statements) because of different depreciation and depletion accounting procedures.

Uncertainty

Refers to a lack of definite knowledge about an event or outcome. Also, an uncertain event or outcome.

Unitization

Unitization is the process whereby the owners of adjoining properties pool their reserves and form a single unit for the operation of the properties. The revenue from operation of this unit is then divided in accordance with the basis established in the unit agreement.

Unproved Property

Unproved property is possibly productive but, as the name implies, not considered proved. Since there are usually no nearby wells, the only indications of possible oil or gas are taken from regional geological studies and/or general geophysical surveys.

Variable Expense

An expense which varies with business or production volume.

Variance

A statistical measure of dispersion around a mean value. It is the probability weighted average of the square of differences between all values and the mean value.

Wildcat Well

A wildcat well is one drilled on unproved property. A well is sometimes designated a semi-wildcat for those in-between cases where property classification is uncertain.

Working Capital

The funds required for project startup or to support continued operations. In accounting terms, current assets less current liabilities.

Working Interest

The working interest is the total interest minus the royalty. For all practical purposes it is an interest in the oil and gas in place that is liable for the cost of developing and operating a property. It is formed by the granting of a lease by the owner of the mineral rights.

Write-Off

An accounting term for a noncash or book expense. It is the cost of a long-term asset allocated, period-by-period, over its deemed life. Also called an "Extinguishment." For example, depreciation, depletion and amortization expenses.

PRESENT WORTH DISCOUNT FACTORS

R x T = Profitability Index x Number of Years in Time Period Involved

Table A

Factors for Cash Effects Which Occur at a Point in Time After the Reference Point.

R x T	0	1	2	3	4	5	6	7	8	9
0	1.0000	.9901	.9802	.9704	.9608	.9512	.9418	.9324	.9231	.9139
10	.9048	.8958	.8869	.8781	.8694	.8607	.8521	.8437	.8353	.8270
20	.8187	.8106	.8025	.7945	.7866	.7788	.7711	.7634	.7558	.7483
30	.7408	.7334	.7261	.7189	.7118	.7047	.6977	.6907	.6839	.6771
40	.6703	.6637	.6570	.6505	.6440	.6376	.6313	.6250	.6188	.6126
50	.6065	.6005	.5945	.5886	.5827	.5770	.5712	.5655	.5599	.5543
60	.5488	.5434	.5379	.5326	.5273	.5220	.5169	.5117	.5066	.5016
70	.4966	.4916	.4868	.4819	.4771	.4724	.4677	.4630	.4584	.4538
80	.4493	.4449	.4404	.4360	.4317	.4274	.4232	.4190	.4148	.4107
90	.4066	.4025	.3985	.3946	.3906	.3867	.3829	.3791	.3753	.3716
100	.3679	.3642	.3606	.3570	.3535	.3499	.3465	.3430	.3396	.3362
110	.3329	.3296	.3263	.3230	.3198	.3166	.3135	.3104	.3073	.3042
120	.3012	.2982	.2952	.2923	.2894	.2865	.2837	.2808	.2780	.2753
130	.2725	.2698	.2671	.2645	.2618	.2592	.2567	.2541	.2516	.2491
140	.2466	.2441	.2417	.2393	.2369	.2346	.2322	.2299	.2276	.2254
150	.2231	.2209	.2187	.2165	.2144	.2122	.2101	.2080	.2060	.2039
160	.2019	.1999	.1979	.1959	.1940	.1921	.1901	.1882	.1864	.1845
170	.1827	.1809	.1791	.1773	.1755	.1738	.1720	.1703	.1686	.1670
180	.1653	.1637	.1620	.1604	.1588	.1572	.1557	.1541	.1526	.1511
190	.1496	.1481	.1466	.1451	.1437	.1423	.1409	.1395	.1381	.1367
200	.1353	.1340	.1327	.1313	.1300	.1287	.1275	.1262	.1249	.1237
210	.1225	.1212	.1200	.1188	.1177	.1165	.1153	.1142	.1130	.1119
220	.1108	.1097	.1086	.1075	.1065	.1054	.1044	.1033	.1023	.1013
230	.1003	.0993	.0983	.0973	.0963	.0954	.0944	.0935	.0926	.0916
240	.0907	.0898	.0889	.0880	.0872	.0863	.0854	.0846	.0837	.0829
250	.0821	.0813	.0805	.0797	.0789	.0781	.0773	.0765	.0758	.0750
260	.0743	.0735	.0728	.0721	.0714	.0707	.0699	.0693	.0686	.0679
270	.0672	.0665	.0659	.0652	.0646	.0639	.0633	.0627	.0620	.0614
280	.0608	.0602	.0596	.0590	.0584	.0578	.0573	.0567	.0561	.0556
290	.0550	.0545	.0539	.0534	.0529	.0523	.0518	.0513	.0508	.0503
300	.0498	.0493	.0488	.0483	.0478	.0474	.0469	.0464	.0460	.0455
310	.0450	.0446	.0442	.0437	.0433	.0429	.0424	.0420	.0416	.0412
320	.0408	.0404	.0400	.0396	.0392	.0388	.0384	.0380	.0376	.0373
330	.0369	.0365	.0362	.0358	.0354	.0351	.0347	.0344	.0340	.0337
340	.0334	.0330	.0327	.0324	.0321	.0317	.0314	.0311	.0308	.0305
350	.0302	.0299	.0296	.0293	.0290	.0287	.0284	.0282	.0279	.0276
360	.0273	.0271	.0268	.0265	.0263	.0260	.0257	.0255	.0252	.0250
370	.0247	.0245	.0242	.0240	.0238	.0235	.0233	.0231	.0228	.0226
380	.0224	.0221	.0219	.0217	.0215	.0213	.0211	.0209	.0207	.0204
390	.0202	.0200	.0198	.0196	.0194	.0193	.0191	.0189	.0187	.0185
400	.0183	.0181	.0180	.0178	.0176	.0174	.0172	.0171	.0169	.0167
410	.0166	.0164	.0162	.0161	.0159	.0158	.0156	.0155	.0153	.0151
420	.0150	.0148	.0147	.0146	.0144	.0143	.0141	.0140	.0138	.0137
430	.0136	.0134	.0133	.0132	.0130	.0129	.0128	.0127	.0125	.0124
440	.0123	.0122	.0120	.0119	.0118	.0117	.0116	.0114	.0113	.0112
450	.0111	.0110	.0109	.0108	.0107	.0106	.0105	.0104	.0103	.0102
460	.0101	.0100	.0099	.0098	.0097	.0096	.0095	.0094	.0093	.0092
470	.0091	.0090	.0089	.0088	.0087	.0087	.0086	.0085	.0084	.0083
480	.0082	.0081	.0081	.0080	.0079	.0078	.0078	.0077	.0076	.0075
490	.0074	.0074	.0073	.0072	.0072	.0071	.0070	.0069	.0069	.0068

R x T	0	10	20	30	40	50	60	70	80	90
500	.0067	.0061	.0055	.0050	.0045	.0041	.0037	.0033	.0030	.0027
600	.0025	.0022	.0020	.0018	.0017	.0015	.0014	.0012	.0011	.0010
700	.0009	.0008	.0007	.0007	.0006	.0006	.0005	.0005	.0004	.0004
800	.0003	.0003	.0003	.0002	.0002	.0002	.0002	.0002	.0002	.0001
900	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001
1000	.0000									

PRESENT WORTH DISCOUNT FACTORS

Factors for Cash Effects Which Occur
Uniformly Over One-Year Periods After
the Reference Points

Year	1%	2%	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%	13%
0-1	.9950	.9901	.9851	.9803	.9754	.9706	.9658	.9610	.9563	.9516	.9470	.9423	.9377
1-2	.9851	.9705	.9560	.9418	.9278	.9141	.9005	.8872	.8740	.8611	.8483	.8358	.8234
2-3	.9753	.9512	.9278	.9049	.8826	.8608	.8396	.8189	.7983	.7791	.7600	.7413	.7230
3-4	.9656	.9324	.9004	.8694	.8395	.8107	.7829	.7560	.7300	.7050	.6808	.6574	.6349
4-5	.9560	.9140	.8737	.8353	.7986	.7635	.7299	.6979	.6672	.6379	.6099	.5831	.5575
5-6	.9465	.8959	.8479	.8026	.7596	.7190	.6806	.6442	.6098	.5772	.5463	.5172	.4895
6-7	.9371	.8781	.8229	.7711	.7226	.6772	.6346	.5947	.5573	.5223	.4894	.4588	.4299
7-8	.9278	.8607	.7985	.7409	.6874	.6377	.5917	.5490	.5093	.4726	.4385	.4069	.3775
8-9	.9185	.8437	.7749	.7118	.6538	.6006	.5517	.5068	.4655	.4276	.3928	.3609	.3314
9-10	.9094	.8270	.7520	.6839	.6219	.5656	.5144	.4678	.4254	.3869	.3519	.3201	.2910
10-11	.9003	.8106	.7298	.6571	.5916	.5327	.4796	.4318	.3888	.3501	.3152	.2839	.2556
11-12	.8914	.7946	.7082	.6312	.5628	.5016	.4472	.3986	.3553	.3168	.2824	.2518	.2244
12-13	.8825	.7788	.6873	.6065	.5353	.4724	.4169	.3680	.3248	.2866	.2530	.2233	.1970
13-14	.8737	.7634	.6670	.5827	.5092	.4449	.3888	.3397	.2968	.2593	.2266	.1981	.1730
14-15	.8650	.7483	.6473	.5599	.4844	.4190	.3625	.3136	.2713	.2347	.2030	.1757	.1519
15-16	.8564	.7335	.6282	.5380	.4608	.3946	.3380	.2895	.2479	.2123	.1819	.1558	.1334
16-17	.8479	.7189	.6096	.5169	.4333	.3716	.3151	.2672	.2266	.1921	.1629	.1382	.1172
17-18	.8395	.7047	.5916	.4966	.4169	.3500	.2938	.2467	.2071	.1739	.1460	.1225	.1029
18-19	.8311	.6908	.5741	.4772	.3966	.3296	.2740	.2277	.1893	.1573	.1308	.1087	.0903
19-20	.8228	.6771	.5571	.4584	.3772	.3104	.2554	.2102	.1730	.1423	.1171	.0964	.0793
20-21	.8147	.6637	.5407	.4405	.3588	.2923	.2382	.1940	.1581	.1288	.1049	.0855	.0697
21-22	.8065	.6505	.5247	.4232	.3413	.2753	.2221	.1791	.1445	.1165	.0940	.0758	.0612
22-23	.7985	.6376	.5092	.4066	.3247	.2593	.2071	.1653	.1320	.1054	.0842	.0673	.0537
23-24	.7906	.6250	.4941	.3907	.3089	.2442	.1931	.1526	.1207	.0954	.0754	.0596	.0472
24-25	.7827	.6126	.4795	.3753	.2938	.2300	.1800	.1409	.1103	.0863	.0676	.0529	.0414
25-30	.7596	.5772	.4386	.3334	.2535	.1928	.1466	.1115	.0849	.0646	.0492	.0374	.0285
30-35	.7226	.5223	.3775	.2730	.1974	.1428	.1033	.0748	.0541	.0392	.0284	.0205	.0149
35-40	.6874	.4726	.3250	.2235	.1538	.1058	.0728	.0501	.0345	.0238	.0164	.0113	.0078
40-45	.6538	.4276	.2797	.1830	.1197	.0784	.0513	.0336	.0220	.0144	.0094	.0062	.0041
45-50	.6219	.3869	.2407	.1498	.0933	.0581	.0362	.0225	.0140	.0087	.0054	.0034	.0021

Year	14%	15%	16%	17%	18%	19%	20%	21%	22%	23%	24%	25%	26%
0-1	.9332	.9286	.9241	.9196	.9152	.9107	.9063	.9020	.8976	.8933	.8990	.8848	.8806
1-2	.8112	.7993	.7875	.7759	.7644	.7531	.7421	.7311	.7204	.7098	.6993	.6891	.6790
2-3	.7053	.6879	.6710	.6546	.6385	.6228	.6075	.5926	.5781	.5639	.5501	.5367	.5235
3-4	.6131	.5921	.5718	.5522	.5333	.5150	.4974	.4804	.4639	.4481	.4327	.4179	.4037
4-5	.5330	.5096	.4873	.4659	.4455	.4259	.4072	.3894	.3723	.3560	.3404	.3255	.3112
5-6	.4634	.4386	.4152	.3931	.3721	.3522	.3334	.3156	.2988	.2829	.2678	.2535	.2400
6-7	.4029	.3775	.3538	.3316	.3108	.2913	.2730	.2558	.2398	.2247	.2106	.1974	.1850
7-8	.3502	.3250	.3015	.2798	.2596	.2409	.2235	.2074	.1924	.1786	.1657	.1538	.1427
8-9	.3045	.2797	.2569	.2360	.2168	.1992	.1830	.1681	.1544	.1419	.1303	.1197	.1100
9-10	.2647	.2407	.2189	.1991	.1811	.1647	.1498	.1363	.1239	.1127	.1025	.0933	.0848
10-11	.2301	.2072	.1866	.1680	.1513	.1362	.1227	.1105	.0995	.0896	.0807	.0726	.0654
11-12	.2000	.1783	.1590	.1417	.1264	.1126	.1004	.0895	.0798	.0711	.0634	.0566	.0504
12-13	.1739	.1535	.1355	.1196	.1055	.0932	.0822	.0726	.0641	.0565	.0499	.0441	.0389
13-14	.1512	.1321	.1154	.1009	.0882	.0770	.0673	.0588	.0514	.0449	.0393	.0343	.0300
14-15	.1314	.1137	.0984	.0851	.0736	.0637	.0551	.0477	.0413	.0357	.0309	.0267	.0231
15-16	.1143	.0979	.0838	.0718	.0615	.0527	.0451	.0387	.0331	.0284	.0243	.0208	.0178
16-17	.0993	.0842	.0714	.0606	.0514	.0436	.0369	.0313	.0266	.0225	.0191	.0162	.0137
17-18	.0864	.0725	.0609	.0511	.0429	.0360	.0303	.0254	.0213	.0179	.0150	.0126	.0106
18-19	.0751	.0624	.0519	.0431	.0358	.0298	.0248	.0206	.0171	.0142	.0118	.0098	.0082
19-20	.0653	.0537	.0442	.0364	.0299	.0246	.0203	.0167	.0137	.0113	.0093	.0077	.0063
20-21	.0568	.0462	.0377	.0307	.0250	.0204	.0166	.0135	.0110	.0090	.0073	.0060	.0049
21-22	.0493	.0398	.0321	.0259	.0209	.0169	.0136	.0110	.0088	.0071	.0058	.0046	.0038
22-23	.0429	.0343	.0274	.0218	.0175	.0139	.0111	.0089	.0071	.0057	.0045	.0036	.0029
23-24	.0373	.0295	.0233	.0184	.0146	.0115	.0091	.0072	.0057	.0045	.0036	.0028	.0022
24-25	.0324	.0254	.0199	.0156	.0122	.0095	.0075	.0058	.0046	.0036	.0028	.0022	.0017
25-30	.0217	.0165	.0126	.0096	.0073	.0056	.0043	.0032	.0025	.0019	.0014	.0011	.0008
30-35	.0108	.0078	.0057	.0041	.0030	.0022	.0016	.0011	.0008	.0006	.0004	.0003	.0002
35-40	.0054	.0037	.0025	.0018	.0012	.0008	.0006	.0004	.0003	.0002	.0001	.0001	.0001
40-45	.0027	.0017	.0011	.0008	.0005	.0003	.0002	.0001	.0001	.0001	-	-	-
45-50	.0013	.0008	.0005	.0003	.0002	.0001	.0001	-	-	-	-	-	-

Year	27%	28%	29%	30%	31%	32%	33%	34%	35%	36%	37%	38%	39%	40%
0-1	.8764	.8722	.8681	.8640	.8598	.8558	.8517	.8477	.8438	.8398	.8359	.8319	.8281	.8242
1-2	.6690	.6592	.6495	.6400	.6307	.6214	.6123	.6034	.5946	.5859	.5774	.5689	.5606	.5525
2-3	.5107	.4982	.4860	.4741	.4626	.4512	.4402	.4295	.4190	.4088	.3988	.3891	.3796	.3703
3-4	.3899	.3765	.3637	.3513	.3393	[illegible]	.3165	.3057	.2953	.2852	.2755	.2661	.2570	.2482
4-5	.2976	.2846	.2721	.2602	.2488	.2379	.2275	.2176	.2081	.1990	.1903	.1820	.1740	.1664
5-6	.2272	.2151	.2036	.1928	.1825	.1728	.1636	.1549	.1466	.1388	.1314	.1244	.1178	.1115
6-7	.1734	.1626	.1524	.1428	.1339	.1255	.1176	.1102	.1033	.0968	.0908	.0851	.0798	.0748
7-8	.1324	.1229	.1140	.1058	.0982	.0911	.0845	.0785	.0728	.0676	.0627	.0582	.0540	.0501
8-9	.1011	.0929	.0853	.0784	.0720	.0662	.0608	.0558	.0513	.0471	.0433	.0398	.0366	.0336
9-10	.0772	.0702	.0638	.0581	.0528	.0480	.0437	.0397	.0362	.0329	.0299	.0272	.0248	.0225
10-11	.0589	.0530	.0478	.0430	.0387	.0349	.0314	.0283	.0255	.0229	.0207	.0186	.0168	.0151
11-12	.0450	.0401	.0357	.0319	.0284	.0253	.0226	.0201	.0180	.0160	.0143	.0127	.0113	.0101
12-13	.0343	.0303	.0267	.0236	.0208	.0184	.0162	.0143	.0127	.0112	.0099	.0087	.0077	.0068
13-14	.0262	.0229	.0200	.0175	.0153	.0134	.0117	.0102	.0089	.0078	.0068	.0060	.0052	.0045
14-15	.0200	.0173	.0150	.0130	.0112	.0097	.0084	.0073	.0063	.0054	.0047	.0041	.0035	.0030
15-16	.0153	.0131	.0112	.0096	.0082	.0071	.0060	.0052	.0044	.0038	.0033	.0028	.0024	.0020
16-17	.0117	.0099	.0084	.0071	.0060	.0051	.0043	.0037	.0031	.0027	.0022	.0019	.0016	.0014
17-18	.0089	.0075	.0063	.0053	.0044	.0037	.0031	.0026	.0022	.0018	.0015	.0013	.0011	.0009
18-19	.0068	.0057	.0047	.0039	.0032	.0027	.0023	.0019	.0016	.0013	.0011	.0009	.0007	.0006
19-20	.0052	.0043	.0035	.0029	.0024	.0020	.0016	.0013	.0011	.0009	.0007	.0006	.0005	.0004
20-21	.0040	.0032	.0026	.0021	.0017	.0014	.0012	.0009	.0008	.0006	.0005	.0004	.0003	.0003
21-22	.0030	.0024	.0020	.0016	.0013	.0010	.0008	.0007	.0005	.0004	.0004	.0003	.0002	.0002
22-23	.0023	.0018	.0015	.0012	.0009	.0007	.0006	.0005	.0004	.0003	.0002	.0002	.0002	.0001
23-24	.0018	.0014	.0011	.0009	.0007	.0005	.0004	.0003	.0003	.0002	.0002	.0001	.0001	.0001
24-25	.0013	.0011	.0009	.0007	.0005	.0004	.0003	.0002	.0002	.0002	.0001	.0001	.0001	.0001
25-30	.0006	.0005	.0004	.0003	.0002	.0002	.0001	.0001	.0001	.0001	-	-	-	-
30-35	.0002	.0001	.0001	.0001										
35-40	-	-	-	-										
40-45	-	-	-	-										
45-50														

1. You are developing a cash flow analysis for the following projects. For each project explain the basis for the net revenue, operating expense, and capital costs you develop.

   a) Waterflood Project

   b) Infill Drilling Project

   c) Offshore development Project

      1) Lease bid (bonus) will be made next month

      2) Bonus was paid 18 months ago, and geological and geophysical expenses have been previously incurred.

2. Your company is considering setting a drilling platform in the Gulf of Mexico this year. If the platform will be 60% tangible and 40% intangible, evaluate the NCF impact of this investment if the platform costs $60 million and will be depreciated in 5 years using the process outlined in the Economic Recovery Act. Don't forget the investment tax credit. The $60 million includes only purchase and installation costs. What other costs should be considered?

3. A prospective well in the Overthrust Belt has the following investment schedule, production profile, and revenue stream. Assuming that operating costs will be $2.50/Bbl., and a 1/6 royalty exists, calculate taxable income, federal taxes, and net cash flow after tax. The investment should be treated as 70% IDC and 30% tangible. The tangible portion should be treated as having a 5 year life, beginning in year 0-1.

Year	Investment (MM$)	Production (MMB/YR)	Revenue (MM$) (After Windf Profit Tax)
0 - 1	49	3.0	60
1 - 2	0	6.0	132
2 - 3	0	10.0	250
3 - 4	0	5.0	137.5
4 - 5	0	3.0	90
	49.0	27.0	669.50

How would your answer change if your company had to pay a $150 MM bonus to the property owner?

Should any other costs be included in the analysis?

4. Calculate the financial book income for each project year in problem #3. Assume the $150 MM bonus was paid. What are the deferred income taxes?

5. If the cost of money is 12% which is worth more: $1,000 today or $2,000 after 6 years? Assume continuous discounting.

6. A friend points out that the price of gold has doubled over the last five years, and suggests that you buy a $10,000 gold bar immediately and sell it for $20,000 at the end of year 5. Assume continuous compounding.

   a) If your friend is right, would you be better off buying the gold or putting your $10,000 in a savings account paying 10% a year?

   b) What if your savings account paid 20% per year?

   c) At what interest rate would you be indifferent to the gold or the savings account?

7. If you had to choose among the following investments, which one would you select if your reinvestment rate was 10%? 15%?

Time	A	B	C
0	(1000)	(1000)	(1000)
1	300	0	0
2	300	500	0
3	300	400	0
4	300	300	800
5	400	300	1100

8. A friend asks you to loan him $10,000 which he will repay in 3 equal installments of $4,100. While you would like to loan him the money, you are temporarily out of cash and will have to borrow the money at 10% from the bank. The bank loan is a balloon note. You will pay the accrued interest annually and repay the $10,000 in year 3. Savings accounts currently pay 9%/year, compounded continuously.

   a) What is the incremental cash flow pattern?

   b) What discount rate did you use?

   c) Would you loan the money?

   d) Would any of the above answers change if you found a savings account paying 11%/year?

9. We are considering an energy investment for which the data below have been developed.

Year	Investment, $M	Cash Flow from Operations, $M
0-1	$6,000	
1-2		1,500
2-3		2,000
3-4		2,000
4-5		2,000
5-6	1,600	1,200
6-7		2,200
7-8		1,100

a) Calculate Discounted NCF @ 10%

b) Calculate Discounted NCF/Disc. Investment

c) DCFROR

10. For problem #3 calculate:

a) Discounted NCF @ 10%

b) Discounted NCF/Discounted Investment

c) Discounted NCF/Discounted Exposure

d) DCFROR

Assume the $150 MM Bonus is paid in year 0-1 and that $6MM of the $49MM invested is for an exploratory test well.

11. A stockbroker guarantees that you'll double your money at the end of 10 years if you invest in Langiappe Oil. What DCFROR is he guaranteeing?

12. The following two projects have been submitted to you for approval. Budget constraints will allow the acceptance of only one project. Which one would you select if the discount rate is 15%?

Year	A	B
0	(10,000)	(10,000)
0-1	5,000	7,000
1-2	5,000	6,000
2-3	5,000	3,000
3-4	5,000	2,000

DCFROR = 40% DCFROR = 46%

13. You are currently making $20,000 (take home salary), but you figure that by returning to school for two years and picking up a Master's degree in business you can boost that to $40,000 a year. If the tuition is $4,000 per year paid out uniformly, what is the DCFROR of your investment versus keeping your current job? (Assume you will work three more years after school and then retire to the good life).

14. Your company is considering an infill drilling project. You have developed the following NCF for the project:

Year	Base Case	Infill Case	Incremental
0-1	-200	-350	-150
1-2	100	200	100
2-3	100	200	100
3-4	100	200	100
4-5	100	200	100
5-6	100	200	100
6-7	100		-100
7-8	100		-100
8-9	100		-100
9-10	100		-100
10-11	100		-100
TOTAL	800	650	-150

Find and graph the DCFROR for this project.

Is this an acceptable project by corporate standards?

15. You have calculated the DCFROR and discounted NCF for all the investment opportunities recommended for the upcoming year. Your budget for the next year is 10MM$ for capital expenditures. Which projects should be selected?

Project	DCFROR	Discounted NCF @ 15%	Expenditure this Year
A	21	7 MM$	6 MM$
B	17	2 MM$	1 MM$
C	19	3 MM$	3 MM$
D	24	4 MM$	2 MM$
E	16	3 MM$	1 MM$
F	14	-2 MM$	4 MM$

If investment F is obligatory which of the remaining investments would you select?

16. If you develop a particular property yourself, the cash flows are as follows:

Year	Net Cash Flow
0	-20,000
0-1	+10,000
1-2	+10,000
2-3	+10,000

Alternatively, an independent oil company has offered to farm-in on the property you are considering developing. The independent will get a 100% working-interest (100% of the net cash flows) until payout, and a 50% working-interest after payout. Assume the projects cash flows will be the same whether you or the independent develops the property. Assume continuous discounting and uniform cash flows through the years.

What is the discounted NCF (@10%) and the DCFROR of each alternative and which one would you accept?

17. Last year your company spent $22,000 in seismic testing and $385,000 for an exploratory well. The company is currently preparing to develop the property.

The cash flows look like this:

	Year	Net Cash Flow
(Last year)	-1	-407,000
(Right now)	0	0
	0-1	-803,000
	1-2	500,000
	2-3	600,000

An insurance company is offering to pay your company $40,000 right now (at time 0) for a 10% WI. What would you recommend, knowing that your company uses 10% discount rates with continuous discounting in project evaluations.

18. Two years ago your company paid an $85 MM Bonus plus $3 MM G & G expenses for a property.

Last year an exploratory well was drilled at a cost of $7 MM. Based on the test well information the following NCF's are projected for the development of the property:

Year	Invest $ MM	Prod MBPY	NCF, $MM
0-1	63	2000	-39
1-2	13	4000	35
2-3		4000	48
3-4		2000	24
4-5		1000	12
5-6		500	6

Development only Discounted NCF @ 10% = $58.5 MM
Full life Discounted NCF @ 10% =-$56.7 MM

If development does not take place your company can immediately write off the Bonus, G & G expense and the tangible portion of the exploratory well (3 MM). Should this property be developed?

19. What bonus could we afford to pay in problem #3 and still have an economically viable project?

20. Consider Problem #3

a) What is the impact on the discounted NCF if oil price increases by 10%?

b) What is the impact on the discounted NCF if operating costs increase by 20%?

c) What is the impact on the discounted NCF if the capital costs increase by 15%

d) What is the impact on the discounted NCF if the bonus costs increase by 33%?

e) What implicit assumptions have you made in the above analysis?

21. Your drilling program in the Gopher Broke oil play has the following expected results and associated probabilities.

Result	NPV, $M	Probability
Dry Holes	-200	.50
Poor Producers	-50	.30
Excellent Producers	+1800	.20

What is the expected NPV of the drilling program? Excluding the poor producing category, what must be the minimum likelihood of finding excellent producers to make the project acceptable?

22. The exploration staff has made an analysis of a given drilling prospect and come up with the following.

Drilling Result	NPV	Probability of Occurrence
Dry Hole	(2,000)	0.4
100,000 Bbl Reserves	(1,000)	0.2
200,000 Bbl Reserves	500	0.16
500,000 Bbl Reserves	5,000	0.14
1,000,000 Bbl. Reserves	12,500	0.10

a) What is the Expected Value of this investment?

b) You have proposed alternatives to drilling the above well with a 100% working interest. The alternatives and their outcomes are detailed below.

Drilling Result		NPV of Alternative, $M			
	Don't Drill	Drill w/100% interest	Drill w/50% interest w/partner	Farm Out w/15% Override	Farm Out w/45 Back in W.I. after payout
Dry Hole	0	(2000)	(1000)	0	0
100,000 Bbl Reserves	0	(1000)	(500)	225	0
200,000 Bbl Reserves	0	500	250	450	225
500,000 Bbl Reserves	0	5000	2500	1125	2850
1000,000 Bbl Reserves	0	12,500	6250	2250	5625

What is the expected value of each alternative?

Which alternative would you select?

What other factors would you consider?

23. Your company is evaluating the acquisition of a potential producting property. Based on the following information calculate the expected value of the NPV for this investment.

Lease Acquisition Cost (Bonus)	$5,000 M
Probability of Acquiring lease	0.85
Probability of Test Well Success	0.43
Dry Hole Cost	$3,800 M
Completion Cost	$1,100 M
Development Cost (Wells & Prod. Facility)	$12,300 M

Production Outcomes and Probabilities -

	NPV*, $M	Probability
Excellent	43,000	0.4
Good	28,000	0.4
Poor	10,200	0.2

* Does not include investment, but does include depletion and depreciation.

24. Based on Problem #22 assume the relative probabilities of the "success" cases remain the same. (Success is defined as "not a dry hole"). At what dry hole probability would you be indifferent between drilling yourself and farming out the well with a back-in W.I? Farming out w/15% overriding royalty?

APPENDIX

(SLIDES)

ELEMENTS OF PROJECT EVALUATION

Minimum Return Standard - embodies most important corporate objectives

Cash Flows - estimates of the monetary impacts of the project each period in the future

Decision Techniques - combine the time value of money, minimum return standard, and cash flows in a rational decision making process

PROJECT EVALUATION MODEL

$$P.V. = \frac{Cf_1}{(1 + r)^1} + \frac{Cf_2}{(1 + r)^2} \cdots + \frac{Cf_N}{(1 + r)^N}$$

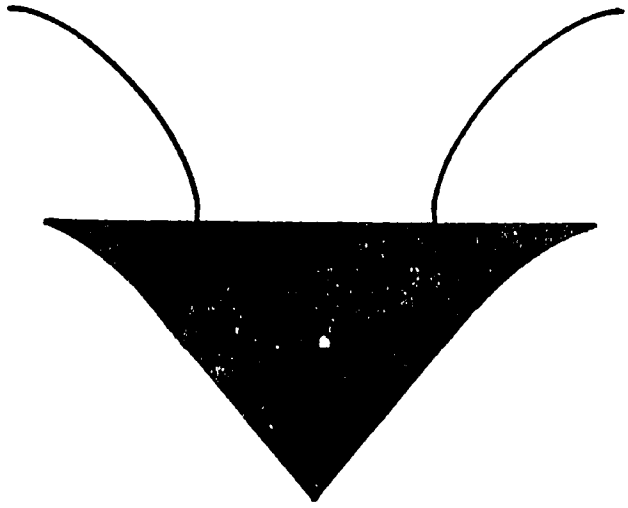
CORPORATE OBJECTIVES

1) PROFITABILITY

2) STABILITY

3) EARNINGS GROWTH

4) SOCIAL RESPONSIBILITY



MAXIMUM SHAREHOLDER WEALTH

GOAL OF PRIVATE COMPANIES

The primary objective of private companies is to maximize the wealth of their shareholders. Shareholder wealth is maximized when companies show reasonable profits and stable growth in assets and equity, now and in the future.

Companies achieve objectives by investing in projects that are profitable after-tax and adjusted for inflation, while maintaining liquidity.

GOALS OF PUBLIC AGENCIES

Public agencies face more complex objectives.

These include:

1) Develop resources in an efficient manner
2) Allocate proceeds of resources to all members of society fairly
3) Plan so that resources will be available for future members of society
4) Reinvest proceeds in social overhead capital for the immediate benefit of society – roads, schools, hospitals, etc.

CAUSES OF CONFLICTS

1) Public agencies do not possess a single, accurate measure of their objectives

2) Allocation of proceeds is often a political process

3) Fair division of proceeds from sale of resources

4) Changes in basic rules of resource development

FINANCIAL STATEMENTS

BALANCE SHEET - SNAPSHOT

ASSETS	2,000	LIABILITIES	1,000
		EQUITY	1,000

INCOME STATEMENT

1,000		REVENUES
800	-	ALLOWED EXPENSES
200	=	TAXABLE INCOME
100	-	TAXES
100	=	NET INCOME

NOTE : TAXES = TAXABLE INCOME x TAX RATE

Consolidated Balance Sheet

Dollars in Millions

ASSETS	As of December 31 1981	1980
Current Assets		
Cash	$ 162	$ 253
Marketable securities and cash investments	1,328	2,789
Accounts and notes receivable, less reserves (includes amounts due from affiliated companies of $1,040 in 1981 and $1,073 in 1980)	4,904	5,162
Inventories		
Crude oil and products	1,445	1,499
Other merchandise	212	233
Materials and supplies	440	320
Prepaid taxes and other expenses	411	451
Total current assets	8,902	10,707
Long-Term Receivables, Less Reserves	399	214
Investments and Advances		
Affiliated companies accounted for by the equity method		
Operating in foreign countries	1,715	1,608
Operating in the United States	668	664
Other, at or below cost	49	34
Properties, Plant and Equipment, at Cost		
Producing	10,750	8,317
Manufacturing	4,028	3,307
Marketing	1,695	1,663
Marine	1,383	1,357
Pipeline	537	485
Motor transport	118	106
Other	916	594
	19,427	15,829
Less Depreciation, depletion and amortization reserves	7,689	7,049
	11,738	8,780
Deferred Charges	209	155
Total Assets	$23,680	$22,162

The "successful efforts" method is used to account for oil and gas exploration and producing activities.

See accompanying notes to consolidated financial statements

Dollars in Millions

LIABILITIES, DEFERRED CREDITS AND STOCKHOLDERS' EQUITY	As of December 31 1981	1980
Current Liabilities		
Accounts and notes payable (includes amounts due to affiliated companies of $2,122 in 1981 and $2,385 in 1980)	$ 4,628	$ 4,994
Current maturities of long-term debt	64	211
Current maturities of obligations under capital leases	36	35
Federal and other taxes on income	1,163	1,308
Other taxes payable	370	437
Total current liabilities	6,261	6,985
Long-Term Debt, Less Current Maturities	1,164	1,109
Obligations Under Capital Leases, Less Current Maturities	871	739
Deferred Income Taxes	1,775	1,325
Deferred Credits and Other Noncurrent Obligations	838	852
Reserves–Employee Annuity Plans	68	75
Total Liabilities and Deferred Credits	10,977	11,085
Stockholders' Equity		
Common Stock–$3.00 Par Value Authorized–500,000,000 shares Issued–342,109,258 shares	1,026	1,026
Capital In Excess of Par Value	877	881
Retained Earnings	10,800	9,170
Total Stockholders' Equity	12,703	11,077
Total Liabilities, Deferred Credits and Stockholders' Equity	$23,680	$22,162

See accompanying notes to consolidated financial statements

Consolidated Statement of Income

Dollars in Millions Except Per Share Amounts	1981	1980	1979
Revenues			
Sales and other operating revenues(1)	$45,229	$41,553	$30,938
Equity in net income of certain affiliated companies	956	1,015	668
Other income	424	351	257
	46,609	42,919	31,863
Costs and Other Deductions			
Purchased crude oil and products(2)	32,823	30,451	22,364
Operating expenses	4,075	3,567	2,709
Selling, general and administrative expenses	1,011	954	804
Depreciation, depletion and amortization	909	767	707
Taxes other than on income	3,628	2,724	2,188
Interest and debt expense	167	158	156
	42,613	38,621	28,928
Income Before Taxes on Income	3,996	4,298	2,935
Provision for taxes on income	1,616	1,897	1,150
Net Income	$ 2,380	$ 2,401	$ 1,785
Net Income Per Share of Common Stock	$6.96	$7.02	$5.22
(1) Includes - Consumer excise taxes	$ 1,005	$ 1,074	$ 991
- Sales to affiliated companies	$ 9,211	$10,008	$ 7,434
(2) Includes purchases from affiliated companies	$24,341	$23,316	$16,210

Consolidated Statement of Retained Earnings

Dollars in Millions Except Per Share Amounts	1981	1980	1979
Balance at Beginning of Year	$ 9,170	$7,384	$6,094
Net Income for Year	2,380	2,401	1,785
Cash Dividends			
$2.20 per share in 1981, $1.80 in 1980 and $1.45 in 1979	(750)	(615)	(495)
Balance at End of Year	$10,800	$9,170	$7,384

See accompanying notes to consolidated financial statements

CORPORATE PROFITS

NET INCOME (100)

- DIVIDENDS (50)
- RETAINED EARNINGS (50)

EQUITY	PAID IN CAPITAL	300
	RETAINED EARNINGS	700
		1,000

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$$\% \text{ Return OR } \% \text{ Yield} = \frac{\text{Number of Dollars of Profit}}{\text{Number of Dollars Invested}} \times 100$$

MEASURES OF SHAREHOLDER RETURN

$$\text{Dividend Yield} = \frac{\text{Dividend Per Share}}{\text{Initial Price Per Share}} = \frac{D_{t+1}}{P_t}$$

$$\text{Capital Gains Yield} = \frac{\text{Price Change}}{\text{Initial Price}} = \frac{P_{t+1} - P_t}{P_t}$$

$$\text{Holding Period Yield} = \frac{\text{Price Change}}{\text{Initial Price}} = \frac{P_{t+1} - P_t + D_{t+1}}{P_t}$$

IN THE LONG RUN

$$\frac{P_{t+1} - P_t}{P_t} \approx g$$

Where g = growth in earnings

CORPORATE MEASURES OF PERFORMANCE

FINANCIAL BOOK EARNINGS

OPERATING MARGIN

NET PROFIT MARGIN

RETURN ON TOTAL CAPITAL

RETURN ON NET WORTH

EARNINGS PER SHARE

GROWTH IN EARNINGS

Minimum Return Standard

1) Must be greater than cost of capital to achieve corporate objective (maximize shareholder's wealth)

2) Any investment proposal accepted which does not return at least the minimum rate of return will detract from achieving the corporate objective.

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$$\text{Cost of Equity Capital} = \frac{D}{P} + g$$

$$\text{Cost of Debt Capital} = i(1-t)$$

where i is the before tax cost of debt

Minimum Return Standard (Cost of Capital) -

That minimum rate of return that will cause the price of stock to remain unchanged.

1)

k = cost of capital

E = equity capital

D = debt capital

K_c = cost of equity = $\frac{D}{P} + g$

K_d = cost of debt = $i(1 - tx)$

$$K = \left(\frac{E}{E + D}\right) K_e + \left(\frac{D}{E + D}\right) K_d + \text{Risk Factor}$$

2) Real Growth:

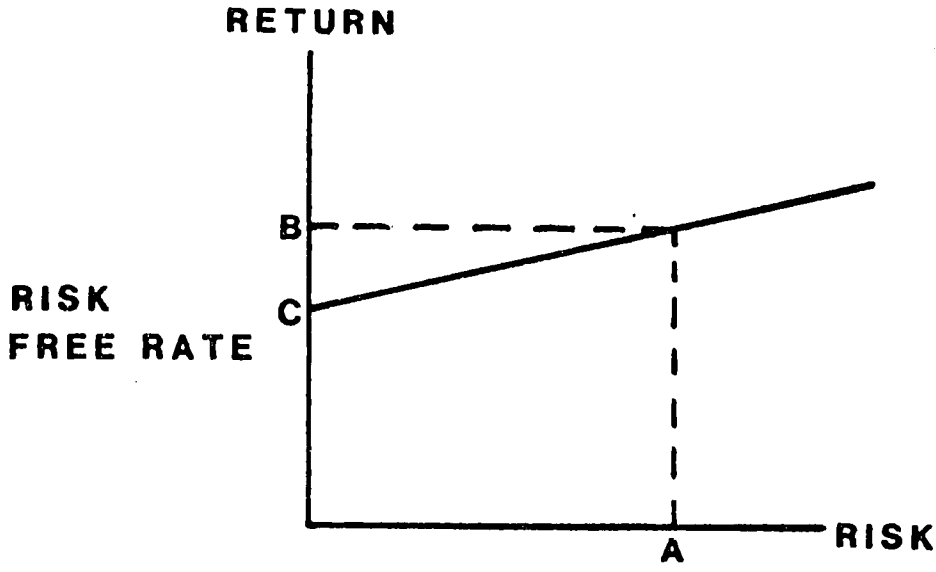
DR = (1 + Expected average inflation rate)
X (1 + desired real growth rate)

If average inflation rate is expected to be 10% and the desired real growth rate is 6%, then

DR = (1.10)(1.06) = 1.166 or 16.6%

Real growth rates currently vary from 5% to 11%

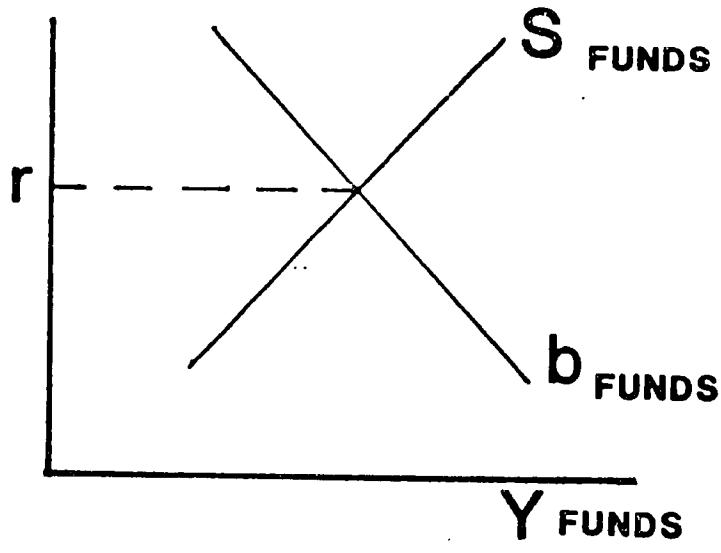
3) Risk Adjusted Opportunity Cost



Companies investing in assets with risk A will choose DR = B. National agencies typically set DR = C.

MARKET RATE OF INTEREST

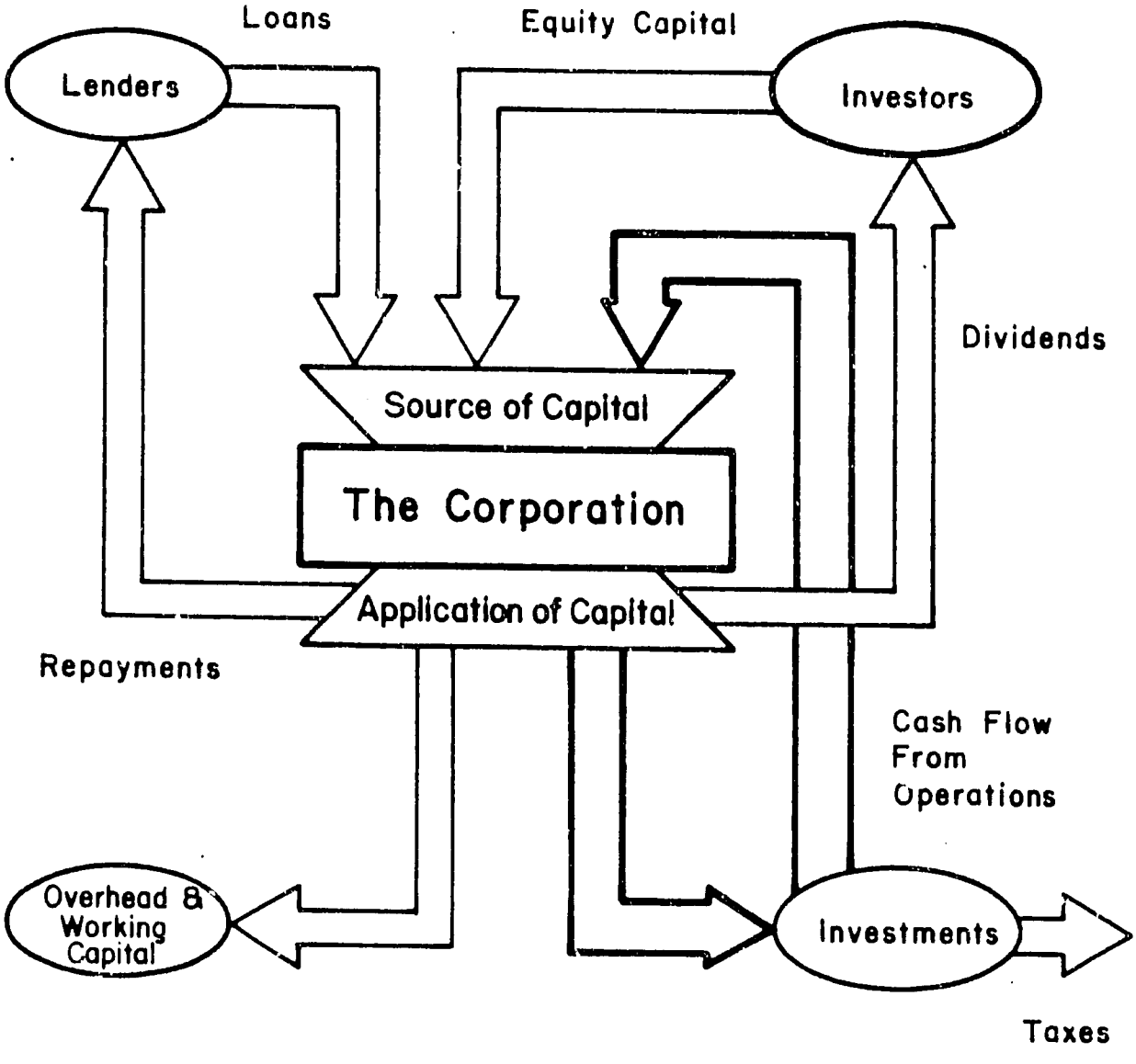
Interest Rate – an annual percentage necessary to induce people who have money to forego current consumption.



Market Interest Rate =

Real Rate + Expected Rate of Return

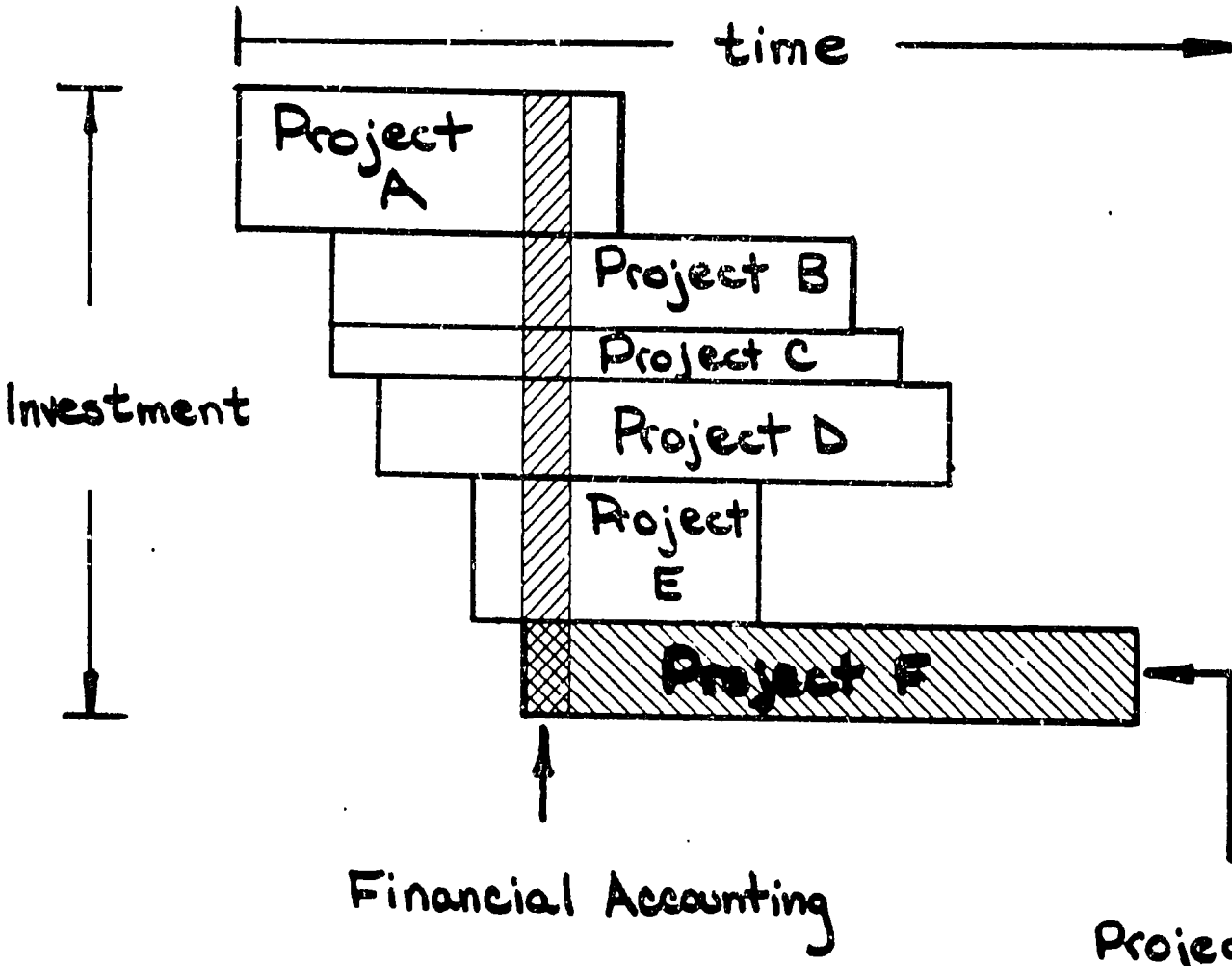
CORPORATE CASH FLOWS



FINANCIAL BOOK MEASURES

vs.

PROJECT MEASURES



Project Evaluation Measures

PW

PW/I

DCF-ROR

CAPITAL BUDGETING SCENARIOS

1) INSUFFICIENT FUNDS ARE AVAILABLE TO FINANCE ALL PROPOSED PROJECTS WHICH MEET OR EXCEED MINIMUM RETURN STANDARD

OPTIONS: A) Forego Projects

B) Raise Additional Capital

2) AVAILABLE FUNDS EXCEED PROPOSED PROJECTS MEETING MINIMUM RETURN STANDARD

OPTIONS: A) Pay out surplus funds as dividends

B) Accept projects below minimum return standard

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Planning Responsibilities

Corporate -

Long Range Planning

Development of Corporate Strategy

Specification of Corporate Objectives

Operating Units -

Short Range Planning

Develop tactics for Following Strategy

Insure Consistency w/ Objectives

The Role of the Technical Professional

1) Generates the majority of the investment recommendations

2) Performs the project evaluation

3) Makes the presentation to district/division management

4) Performs engineering or other technical tasks regarding the project

5) Acts as project implementor.

6) Provides progress reports & cash flow projections

7) Performs the investment follow-up

Objectives of Investment Evaluation

1) Determine investment's worth

2) Identify & quantify the risk associated w/ the investment

3) Explore all alternatives

4) Insure that data & premises are reasonable

5) Inform management of the investment opportunity

EVALUATION PROCESS

1) Formulate Problem

   Key: Identify alternatives

2) Plan Analysis

   Key: Identify req'd information & sources
   Make a quantitative assessment of project uncertainty

3) Examine Data & Premises

   Key: Check other sources — BE CYNICAL!

4) Perform Analysis

   Key: Understand cash flow development & investment evaluation models

5) Report Results

   Key: Be informed & concise

CASH FLOW ANALYSIS

Evaluations must be based on an analysis of Net Cash Flows (NCF) generated.

WHY?

1) Cash is used to pay expenses
2) Cash is used to pay interest & repay debt
3) Cash is used to pay dividends
4) Cash is reinvested in the company
5) Timing

CALCULATION OF NCF

Net Revenue$_t$
- Direct Operating Costs$_t$
- Indirect Operating Costs (Overhead)$_t$
- Investments$_t$
- Taxes$_t$

= Net Cash Flow (NCF)$_t$

Works In All Countries

COMPONENTS OF NCF

NET REVENUE- GROSS REVENUE Less Royalties, Severance Taxes, Excise Taxes, etc.

DIRECT OPERATING COSTS- Costs Directly Attributable to the Operation of the Investment; Operating Labor, Maintenance, etc.

INDIRECT OPERATING COSTS- Costs Which Cannot be Directly Allocated to the Investment; Staff Personnel, Accounting, Management, etc.

INVESTMENT- Capital Expenditures Required over the Life of the Investment; Equipment Additions, Development Drilling, Major Overhauls., etc.

NET REVENUE

1) Production Profile

2) Price

   a) Projections

   b) Adjustments: Location, Quality, Quantity, etc.

3) Deal Structure , (Working Interest, Override, etc.)

4) Timing : Construction Delays, Hook-up Delays, etc.

OPERATING COSTS

1) From Historical Data Adjusted for Inflation, Technology Changes, Productivity

2) Governmental Impacts: Enviromental, Safety

3) Type of Installation: Plant vs. Field, Type of Equipment, Offshore vs. Onshore, etc.

4) Deal Structure: Funded vs. Unfunded

ESCALATION OF DRILLING AND OPERATING COSTS

A major mistake recurring worldwide during the 70's is the understanding of drilling and operating costs.

Types of Escalation Factors

1) Consumer Price Index
2) Implicit GNP Deflator
3) Individual Component Forecasts, usually a multiple of 1 or 2

Example: Drilling cost escalation is estimated to be 20%, 15%, and 13% in the next three years. What will be the cost per well in the next three years if a well currently costs $10 MM Nairas?

$t + 1 = 10MM \times 1.20 = 12MM$

$t + 2 = 12M \times 1.15 = 13.8MM$

$t + 3 = 13.8 \times 1.13 = 15.6MM$

OVERHEAD & G & A EXPENSE

1) MANAGEMENT

2) PROFESSIONAL & SUPPORT PERSONNEL: ENGINEERS, STAFF, ACCOUNTING, LEGAL, CLERICAL, etc.

3) OFFICE SPACE & SUPPLIES

4) BENEFIT PLANS

These are **REAL** Costs & **SHOULD BE INCLUDED** in the Calculation.

May be Calculated Directly or Allocated on a % Basis, e.g. % of Capital Cost.

CAPITAL COSTS (INVESTMENT)

1) Based on Historical Costs Factored for Size & Inflation

2) From 3rd Party Estimates: Contractors

3) Direct Calculation: Man Hours + Equip. + Engineering, etc.

What major factors affect capital costs?

a) Timing; e.g., deliveries, construction, permits, etc.

b) Technological Assumptions

c) Governmental Obligations; e.g., Enviromental, Safety, etc.

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Capital Costs (Investment) continued

d) Cost Estimation Factors; Escalation Labor Efficiency, Over-time, Field Corrections

e) Recurring Capital Costs ; Major Maintenance (overhauls), Re-placements, De-bottlenecking, etc.

WORKING CAPITAL ADDITIONS

1) Holding Inventories e.g. Product, Feedstock, &Supply

2) Pipeline Line Fill

3) Cash for Payments (e.g. Payroll) Before Receipts

OIL VOLUMETRIC RESERVE ESTIMATION

Recoverable Reserves (STB) =

$$\frac{(C)\,(Ah)\,(\phi)\,(1 - Sw)}{\beta_{oi}}\,(RF)$$

where

C = 7758 barrels per acre-ft. (U.S.)
= 1233.4 m^3 per acre-ft. (SI)

Ah = extent of producing formation in acre-ft.

ϕ = porosity

Sw = % of voids filled with interstitial water

β_{oi} = formation volume factor , reservoir barrels divided by stock tank barrels

RF = % of oil in place recovered in stock tanks

STB = stock tank barrels

SOLUTION GAS DRIVE RESERVE ESTIMATION

$$\text{Reserves} = (C)(Ah)(O)\left[\frac{1 - Sw}{\beta_{oi}} - \frac{1 - Sw - Sgr}{\beta_{oa}}\right]$$

β_{oi} = formation volume factor at initial conditions at or below bubble point

β_{oa} = formation factor at abandonment

Sgr = % of pores containing gas at abandonment

All other values as defined before

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EXPONENTIAL

DECLINE CURVES

Basic Equation: $a = q_i/e^{at}$ (19.5) or $\ln q_i/q = at$ (19.6)

Where: a = rate of decline

$\ln$ = log base e

q_i = oil production at point in time

q = oil production t units later

Other Equations: $d = \dfrac{q_i - q}{q_i}$ (19.7)

$a = -\ln (1 - d)$

$r = 1 - d$

$t = 1/365$ (prod. factor) $\ln q_i/q_a$ (19.10)

Table 19.1 Convenient Decline Curve Factors

(1) Decline rate (d) per cent	(2) Production factor	(3) (First year's production) / (First day's production)	(4) (Last year's production) / (Last day's production)
1.0	36,684	363	367
2.0	18,434	361	369
2.9	12,348	360	370
3.8	9,307	358	372
4.8	7,481	356	374
5.7	6,264	355	376
6.5	5,395	353	378
7.4	4,743	351	379
8.3	4,236	350	381
9.1	3,830	348	383
9.9	3,498	347	385
10.7	3,221	345	386
11.5	2,986	344	388
12.3	2,786	342	390
13.0	2,612	341	392
13.8	2,459	339	393
14.5	2,325	338	395
15.3	2,205	337	397
16.0	2,098	335	399
16.7	2,002	334	400
17.4	1,915	333	402
18.0	1,836	331	404
18.7	1,763	330	406
19.4	1,697	329	407
20.0	1,636	327	409
20.6	1,579	325	411
21.3	1,527	325	412
21.9	1,479	324	414
22.5	1,433	322	416
23.0	1,391	321	417
23.7	1,353	320	419
24.2	1,315	319	421
24.8	1,280	318	422
25.4	1,247	317	424
25.9	1,216	316	426
26.5	1,187	314	427
27.0	1,159	313	429
27.5	1,133	312	431
28.1	1,108	311	432
28.6	1,085	310	434
30.0	1,023	307	438
35.0	847	296	456
40.0	715	286	477
45.0	611	275	500
50.0	527	264	527

Column (1) - The value of d defined by Equation 19.7.

Column (2) - Reserves on the decline in API barrels [m^3] ($q_i - q_a$), where q values are in m^3/day or bbls/day.

Columns (3) and (4) - Values for converting daily rate to annual rate for first and last years on the decline.

The first and last year's production may be used to calculate a from Equation 19.5 or 19.6. Knowing d, r may be calculated from Equation 19.8.

Time on decline. Table 19.1 may also be used to calculate the time on the decline (in years) from the equation below.

$$t = \frac{1}{365} \text{ (Prod. Factor) } \ln \frac{q_i}{q_a}$$

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DECLINE CURVES

Steps:

1) Calculate Production Factor =

$$\frac{\text{Total Production on Decline}}{\text{Initial Decline Rate} - \text{Economic Limit Rate}}$$

2) Read d from Col. 1, Table 19.1

3) Multiply factor from Col. 3, Table 19.1 by initital decline rate to obtain 1st year's production.

4) Multiply factor from Col. 4, Table 19.1 by economic limit to get last year's production.

5) Use 19.10 to obtain years on decline.

EXAMPLE DECLINE CURVE CALCULATION

Reservoir engineering analysis estimates that a well will produce 100 MM bbl on decline, initial decline is 398 M bbls/day, and the economic limit is 15 M bbls/day. Calculate the production profile and the time it will take to reach the economic limit.

1) Production factor $= \frac{100 \text{ MM}}{398 \text{ M} - 15 \text{ M}} = 2{,}612$

2) d = 13% (Col. 1, 19.1)

3) (341) (398M) = 13.57 MM

4) (392) (15M) = 5.88 MM

5) t = (1/365) (2,612) ln (398/15) = 23.5 years

6) Plot on graph

How would the decline curve change if 10 MM bbls. of the 100 MM bbls were produced uniformly over a 3 year period?

HYDROCARBON PRICES

Sources:

1) Company Forecasts

2) Forecasting Services

3) Adjustments of 1 & 2 for local market conditions

4) Personal or group forecasts – discussed in risk and uncertainty section.

Most important source of forecast error in the 1970's.

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Taxes - Federal, State & Local Income taxes

Taxes = Taxable Income x Tax rate

Federal Income tax rate = 46%
For calculation purposes tax rate is assumed to be 50%. This includes state & local income tax effects.

	Net Revenue	
-	Direct Operating Costs	
-	Indirect Operating Costs	
-	Capital Recovery	Investments
-	Expensed Costs	Investments
-	Other Taxes	
=	Taxable Income	

Taxable Income Determination

Capital Write-offs -

A) Depreciation (Tangible $)

B) Depletion (Bonus)

C) Amortization
(Non-producing property
and .15 x IDC)

Expensed Investment Costs -

A) Intangible Drilling Costs (8

B) Dry Hole Costs

C) Other

CASH FLOW MODELS

Firms attempt to generate early cash flows and to minimize and postphone tax payments.

Public Agencies must balance the desire for early tax revenues with the desire to attract capital investment by providing incentives for private firms to develop energy resources.

IMPORTANT VARIABLES IN DESIGNING INCENTIVES

TAX RATES

ALLOWED EXPENSES

CAPITAL RECOVERY SCHEDULES

OTHER INCENTIVES

Tax rates and timing of cash flows are crucial.

May be Calculated Directly or Allocated on a % Basis, e.g. % of Capital Cost.

4.7

DEPRECIATION EXAMPLE

A machine is purchased for 10mm and is depreciated on a straight line basis over a five year period (2mm per year). Associated revenues are 4mm per year.

Period 0	Cash outflow	10mm
	Book Value of Asset	10mm
	revenues	0
Period 1	Book Value	10 - 2 = 8mm
	Revenues	4mm
	Dep. exp	2mm
	Taxable Income	2mm
	Taxes (50%)	1mm
	Net Income	1mm
Period 2	Book Value	10 - 4 = 6mm
	Revenues	4mm
	Dep. exp	2mm
	Taxable Income	2mm
	Taxes	1mm
	Net income	1mm
	Cash Flow	3mm

Capitalized vs. Expensed Investment Costs -

	Expensed	Capitalized
Dry Holes	100%	0%
Producer Wells	I.D.C.	equip. + .15% of IDC's
Drilling Platforms		
Production Platforms	0%	100%
Production Equipment	0%	100%
Bonus & Leasehold Costs	0%	100%
Geological & Geophysical Costs		
Lease Rentals	100%	0%

Classification of Tangible Investments

3-Year (6% ITC)

Autos
Trucks
Research Equipment

5-Year (10% ITC

Producing Wells
Compressors
Separators
Pipelines
Other Tangible
Property in E/P
Refining, Marketin
Mining, + Chemical

10-Year

Regulated Gas Pipeline
Railroad Tank Cars
Buildings with Life < 12.5 YRs

15-Year

Office Bldgs.
Service Stations

Capital Recovery Schedule

Yr.	3-Year	5-Year
1	25%	15%
2	38	22%
3	37	21
4		21
5		21

	10-Year	15-Year
1	8%	7%
2	14	12
3	12	12
4	10	11
5	10	10
6	10	9
7	9	8
8	.	7
9	.	6
10	.	5
11-15		4,3,2,1

COST DEPLETION SCHEDULE

Year	Bonus	Production	Depletion
0	$ 50MM		
0-1		5MM Bbl.	$ 2.5 MM
1-2		15 MM Bbl.	$ 7.5 MM
2-3		10 MM Bbl.	$ 5.0 MM
⋮		⋮	⋮
9-10		10 MM Bbl.	$ 5.0 MM
Total	$ 50 MM	100 MM Bbl.	$ 50 MM

NCF ONE STEP FORMULA

Where tx is the tax rate and CR = Capital Recovery

(1 - tx) Revenue

- (1 - tx) Operating Costs

+ tx (CR)

- Investment

= Net Cash Flow

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It is estimated that a field will cost 100 million in investment to develop. Operating costs will be $3 per barrel and will increase at ten percent per year. The tax rate is 50%. The field will produce a total of 20 million barrels over a five year period with the following production schedule and price schedule.

Year	Production (mm/bbl)	Price ($/bbl)
1	5	$28
2	5	$28
3	4	$30
4	3	$31
5	3	$32
Total	20 mm/bbl	

Calculate NCF assuming

1. Investment is expensed the first year
2. Investment is written off using straight line depreciation

Assume Investment is Expensed

Year	Net Revenue	Taxable Income	Taxes	NCF
1.	125	25	12	12.5
2.	123.5	123.5	61.75	61.75
3.	104	104	52	52
4.	80	80	40	40
5.	79	79	39.5	39.5
Totals			205.75	205.75

Assume Investment is Depreciated on a Straight Line basis (20% per year)

Year	Net Revenue	Depreciation	Taxable Income	Taxes	NCF
1.	125	20	105	52.5	-27.5
2.	123.5	20	103.5	51.75	71.75
3.	104	20	84	42	62
4.	80	20	60	30	50
5.	79	20	59	29.5	49.5
Totals				205.75	205.75

Period	Net Income	Depreciation	Cash Flow
0	0	0	-10mm
1	1mm	2mm	3mm
2	1mm	2mm	3mm
3	1mm	2mm	3mm
4	1mm	2mm	3mm
5	1mm	2mm	3mm
Totals	5mm	10mm	5mm

NIGERIAN COMPONENTS OF AFTER - TAX NCF

$$
\begin{aligned}
NCF_t = \; & .15\ (\text{Gross Revenue})_t \\
& + .85\ (\text{Technical Cost Deduction})_t \\
& - .15\ (\text{O \& M})_t \\
& - .15\ (\text{Overhead})_t \\
& - .15\ (\text{Royalty})_t \\
& - .15\ (\text{Drilling Investment})_t \\
& - \text{Non-Drilling Investment}_t \\
& + .85\ (\text{Capital Allowance})_t \\
& + .85\ (\text{ITC})_t
\end{aligned}
$$

DEFINITION OF TERMS

Gross Revenue - posted price times production

Technical Cost Deduction - Deduction in current posted price from $35.50 to $33.90 . The $1.60 drop was adopted to sustain current production and stimulate new activity.

Operating and Maintenance Costs - costs attributable to operation of investing, management, etc.

Overhead - costs which can't be allocated to investment: staff, accounting, management, etc.

Drilling Investment - expenditures needed to spud and complete a well ($)

Other Investments - expenditures to move hydrocarbons from well to point of sale; basically all surface facilities.

Nigerian Taxes

Taxable Income = Gross Revenue
- Technical Cost Reduction
- O & M
- Overhead
- Royalties
- Drilling Investment
- Capital Allowance (Non-Drilling Inv.)
- Investment Tax Credit

Taxes = Taxable Income x Tax Rate

Petroleum Tax Rate = 85%

Non-Petroleum Tax Rate = 45%

TAXABLE INCOME

DETERMINATION

Capital Allowance for Petroleum Companies

Year	Rate %
1	20.0
2	20.0
3	20.0
4	20.0
5	19.
6 & after	19.

CAPITAL ALLOWANCE - EXAMPLE

Assume that a 1 MM non-drilling investment is made this year and the project has a ten year life.

Year	Beginning Book Value (M)	Rate	CA	Ending Book Value (M)
1	1,000	.2	200	800
2	800	.2	160	640
3	640	.2	128	512
4	512	.2	102	410
5	410	.19	78	332
6	332	.19	63	269
7	269	.19	51	218
8	218	.19	41	177
9	177	.19	33	144
10	144	.19	27	115

NCF EXAMPLE

Assumptions

1) Company is a Nigerian Co.
2) Production is from 2 wells costing 20 MM each
3) Onshore facilities cost 15 MM
4) Operating cost, including overhead is 5 MM
5) Royalty is 1 MM/year
6) Production Profile is

Year	Production (MM bbls)
1	4
2	4
3	3
4	1.5
5	.5

7) Posted Price equals market price and is currently $35.50. The posted price is forecast to escalate at 6%/year.
8) Operating Costs are expected to escalate at 11%/yr.

NCF - EXAMPLE

Year	Gross Revenue	Technical Cost	O & M	Royalty	Drilling	Non-Drilling	Capital Allowance	Tax Credit	Taxable Income	Tax	NCF
1	142	6.4	5	1	40	15	3	.75	85.85	72.97	8.03
2	150.52	6.4	8.88	1			2.4		131.84	112.06	28.57
3	119.66	4.8	9.85	1			1.92		102.09	86.77	22.03
4	63.42	2.4	10.93	1			1.53		47.56	40.42	11.06
5	22.40	.8	12.13	1			6.15		2.32	1.97	7.29
Total	498	20.8	46.79	5	40	15	15	.75	369.66	314.21	76.99

WINDFALL PROFITS TAX

WPT = Tax Rate *

(Selling Price -
- Tax Base Price
- Severance Tax)

Tax Base And Tax Rate Are Determined By Law And Inflatio

Selling Price is The Price The Crude Sells For.

CURRENT WPT RATES

Tier	Rate	
	Major	Independent
Newly Discovered (3)	25%	25%
Stripper (2)	60%	0%
Heavy, EOR (3)	30%	30%
New Market Level	70%	50%

WPT PRICES

	Tax Base	Escalation
Newly Discovered	$16.55	GNP + 2%
Stripper	15.20	GNP
Heavy, EOR	16.55	GNP + 2%
New Market Level	12.81	GNP

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TAXABLE INCOME vs. FINANCIAL BOOK INCOME

Taxable Income differs from Financial Book Income due to different treatment of investment costs.

Taxable Income

1) ERA Depreciation.
2) IDC is expensed
3) Development Dry holes are expense

Financial Book Income

1) UOP or SL Depreciation
2) IDC is capitalized
3) Development Dry holes are capitalized

Firms generally choose policies within the tax code & accounting standards which maximize financial book income & minimize taxable income.

NCF vs. Net Income (Financial)

NCF

Net Revenue
- Operating Costs
- Overhead
- Working Capital Additions
- Capital Costs
- Income Taxes*

= NCF

Net Income

Net Revenue
- Operating Costs
- Overhead
- Depreciation, Depletion & Amortization
- Income Taxes**

= Net Income

* Income Tax actually paid

** Income Tax actually paid + income tax deferred

DEFERRED TAXES

Deferred Taxes = Financial Taxes - Current Taxe

Current taxes = taxes due in any given year, calculated from <u>taxable</u> income

Financial taxes = taxes calculated from <u>financial book</u> income

Over the project life : $\sum$ current taxes = $\sum$ financial taxes

Deferred taxes arise because of different treatment of investment costs (expensed or capitalized), and different capital write-off schedules (accelarated vs. SL or UOP depreciation)

NCF vs. Net Income Example

Investment: Drill an exploratory well

Drilling Cost: $2,000 M 70% Intangible
30% Tangible

Bonus + G&G: $100 M

Net Revenue:	Year
$900 M	1
825	2
725	3
600	4
440	5

Production Profile:	Year
30 M Bbl.	1
25 "	2
20 "	3
15 "	4
10 "	5

Operating Expense: $50 M/year

Income Tax Rate: 50%

No Salvage Value

NCF VS. NET INCOME

NCF –

	1	2	3	4	5	6	Tota
Drilling Cost	2000	–	–	–	–	–	
Bonus + G & G	100	–	–	–	–	–	
Net Revenue	–	900	825	725	600	440	
Expenses	1190	50	50	50	50	50	
Depreciation	70	155.5	195.4	119.7	119.7	119.7	
Depletion	–	30	25	20	15	10	
Taxable Income	(1260)	664.5	554.6	535.3	415.3	260.3	
Taxes	(630)	332.25	277.3	267.6	207.6	130.1	584
NCF	(1470)	517.75	491.7	407.4	342.4	259.9	549

Net Income –

	1	2	3	4	5	6	Tota
Net Revenue	–	900	825	725	600	440	
Expenses	–	50	50	50	50	50	
Depreciation	–	600	500	400	300	200	
Depletion	–	30	25	20	15	10	
Taxable Income	–	220	250	255	235	180	
Taxes	–	110	125	128	118	90	571
Net Income	–	110	125	127	117	90	570

Year	Revenue	Operating Costs	Net Revenue	Investment
1	140	15	125	100
2	140	16.5	123.5	
3	120	16	104	
4	93	13	80	
5	93	14	79	

Compound Value, Point in Time Cash Flows, Annual Interest Payments

$$P_t = P_0(1 + r)^t$$

P_t = value of sum t periods in the future at compound interest

P_0 = amount invested today

r = annual rate of interest

t = number of periods at compound interest

Note

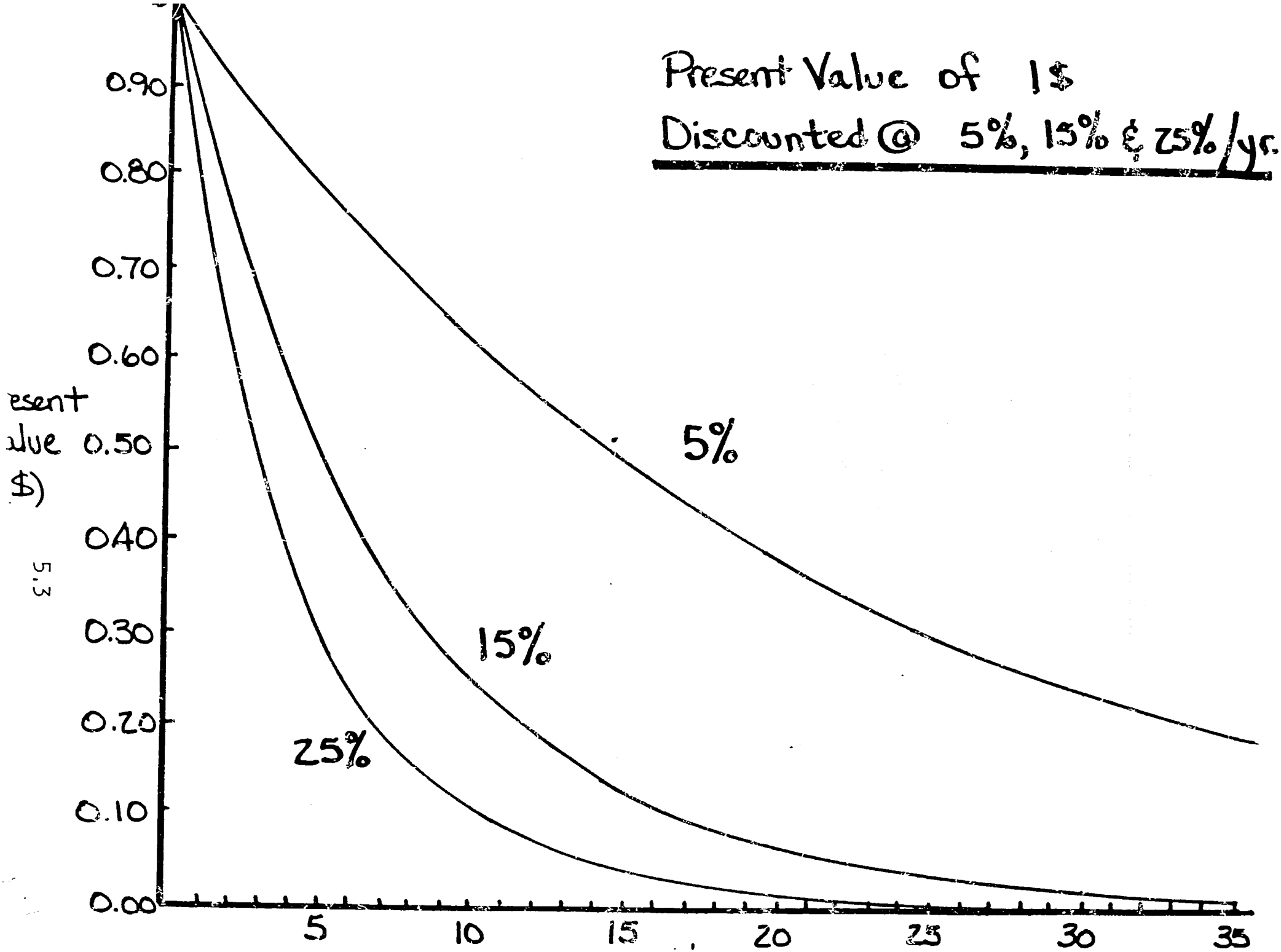
$$P_t = f(\overset{+}{P_0}, \overset{+}{r}, \overset{+}{t})$$

Present Value, Point in Time Cash Flows, Annual Interest Payments

$$P_0 = \frac{P_t}{(1 + r)^t}$$

Note

$$P_0 = f(\overset{+}{P_t}, \overset{-}{r}, \overset{--}{t})$$


Present Value of 1$
Discounted @ 5%, 15% & 25%/yr.
0.90
0.80
0.70
0.60
esent
alue
$)
0.50
0.40
0.30
0.20
0.10
0.00
5%
15%
25%
5
10
15
20
25
30
35

Rate of Return, Point in Time Cash Flows, Annual Interest Payments

$$(1 + r)^t = \frac{P_t}{P_0}$$

$$r = \sqrt[t]{\frac{P_t}{P_0}} - 1$$

Rule of 72

If money is invested at x% it will double in 72/x years.

If money takes x years to double, it is invested at 72/x percent.

Present Value, Point in Time Cash Flows

Continuous Discounting

$$P_0 = \frac{P_t}{e^{rt}}$$

$e = 2.71828$

Discounting
Point-in-Time
Uniform
Continuous
Annual
Continuous
Annual

5.6

CONTINUOUS DISCOUNTING UNIFORM

CASH FLOW

$$PV = \text{Cash Flow} \left[\frac{e^{i(1-t)} \; (1 - e^{-i})}{i} \right]$$

Many companies use continuous discounting and assume uniform cash flows

EFFECT of VARIOUS CASH FLOW and REINVESTMENT ASSUMPTIONS

A. Point-In-Time, Annual $DF_t = 1/(1+i)^t$

B. Point-In-Time, Continuous $DF_t = e^{-i\,t}$

C. Uniform, Annual $DF_t = 1/(1+i)^{t-0.5}$

D. Uniform, Continuous $DF_t = e^{-i(t-1)}\left[\frac{1-e^{-i}}{i}\right]$

Comparison of Discount Factors (17%)

	Year			
	1	5	10	20
A.	.854	.456	.208	.043
B.	.843	.427	.182	.033
C.	.924	.493	.225	.046
D.	.916	.466	.1991	.036

12 V

UNDISCOUNTED MEASURES OF VALUE

Payout (After-tax or Before-tax)

Definition - Point in time where cumulative NCF, or net revenue less costs and taxes equals zero is after-tax payment.

Before-tax payout does not include taxes in calculation. Before tax payouts are used to define back-in conditions, or participation percentages in joint ventures.

PO is about 12 years in previous slide

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UNDISCOUNTED MEASURES OF VALUE

Characteristics of Payout:

1) Does not recognize cash flows after payout
2) Ignores time value of money
3) Measures crudely risk exposure
4) Biased in favor of short life projects
5) Ignores magnitudes of cash flows

INVESTMENT EVALUATION

Net Present Value

$$NPV = \sum_{t=0}^{t=n} CF_t(DF_t)$$

Assuming Conventional Cash Flows

$$NPV = -I_0 + \sum_{t=1}^{t=n} CF_t(DF_t)$$

INVESTMENT EVALUATION CRITERIA NPV/I RATIO

$$\frac{NPV}{I} = \frac{\sum_{t=0}^{t=n} CF_t(DF_t)}{\sum_{t=0}^{n} INV_t(DF_t)}$$

INTERNAL RATE OF RETURN

$$\sum_{t=0}^{t=n} CF_t(DF_t) = 0$$

The discount factor which results in NPV = 0 is the Internal Rate of Return

Assuming Conventional Cash Flows

$$\sum_{t=1}^{t=n} CF_t(DF_t) - I_0 = 0$$

OR

$$\sum_{t=1}^{t=n} CF_t(DF_t) = I_0$$

INTERNAL RATE OF RETURN EXAMPLE

Solved by trial-and-error as follows

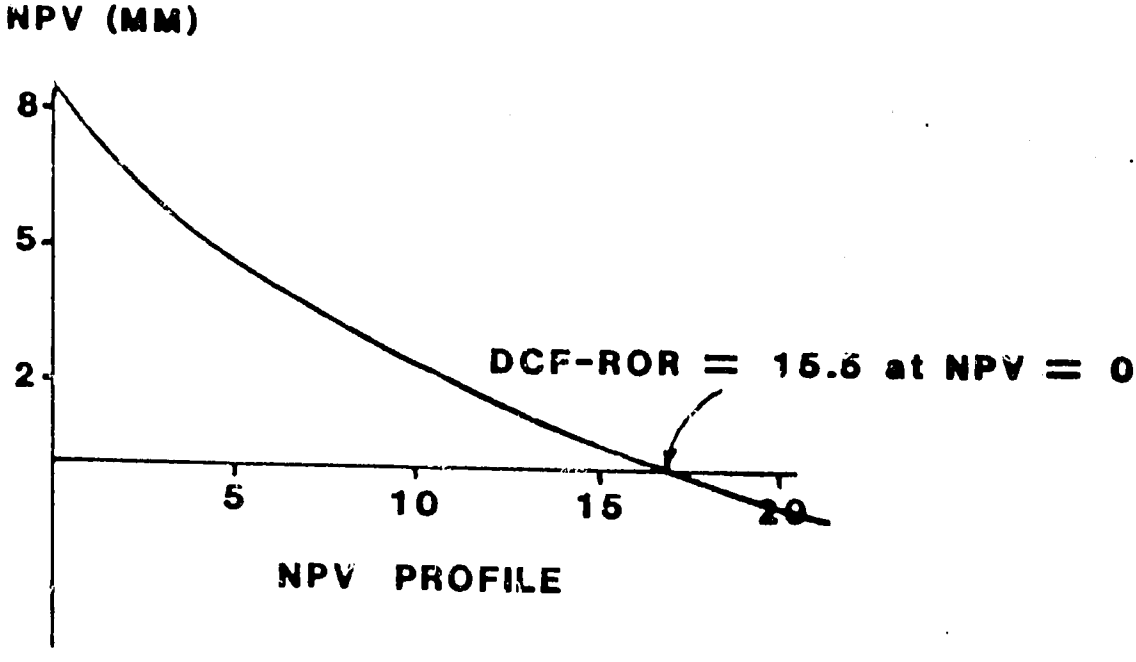
Year	(1) NCF	(2) DF_{15}	(3) 3 = 1 x 2	(4) DF_{50}	(5) 1 x 4
1	-30.2	.932	-28.1	.912	-27.5
2	18.1	.810	14.6	.760	13.7
3	11.8	.705	8.3	.633	7.4
4	8.6	.613	5.27	.528	4.5
Total	8.3		.10		-1.9

By interpolation

$$\text{DCF-ROR} = \left(\frac{.1}{.1 - (-1.9)}\right) \times 10\% + 15\%$$

$$= 15.5\%$$

INTERNAL RATE OF RETURN EXAMPLE



INTERNAL RATE OF RETURN EXAMPLE

1. Independent of investment size and beginning time.
2. Sensitive to errors in amount and timing of investments and cash returns in early years.
3. Can obtain meaningless negative results or multiple answers.
4. Absolute size of profit not indicated.
5. Assumes all project cash returns can be re-invested at project rate of return.
6. Not suitable generally for ranking alternatives with different lives cash flow patterns.
7. May give meaningless results in acceleration projects.
8. Biassed toward short live projects will with early cash returns.

INTERNAL RATE OF RETURN EXAMPLE

NPV method is considered superior because of:

1) Reinvestment Rate
2) Multiple Rates of Return

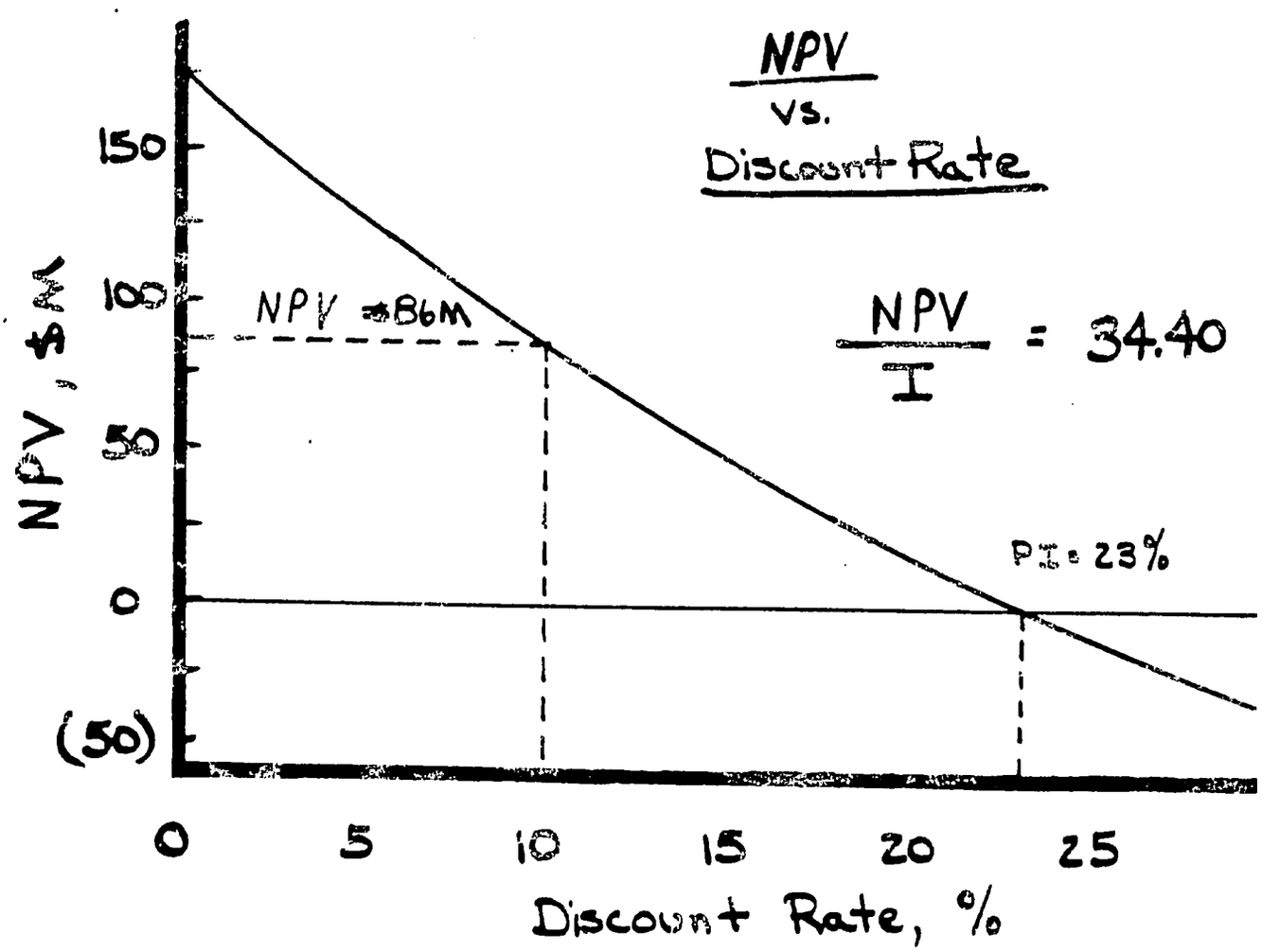
REINVESTMENT RATE - EXAMPLE (Exhibit 5.4)

End of Yr.	Proj. A CSAT	Proj. B CSAT
0	(100)	(100)
1	200	0
2	0	350
PW	71	156
DCF-ROR	100%	87%

Example of NPV, NPV/I, DCF-ROR

Exhibit 5.3

Year	NPV, $M
0	(250)
0-1	0
1-2	150
2-3	175
3-4	100
	175



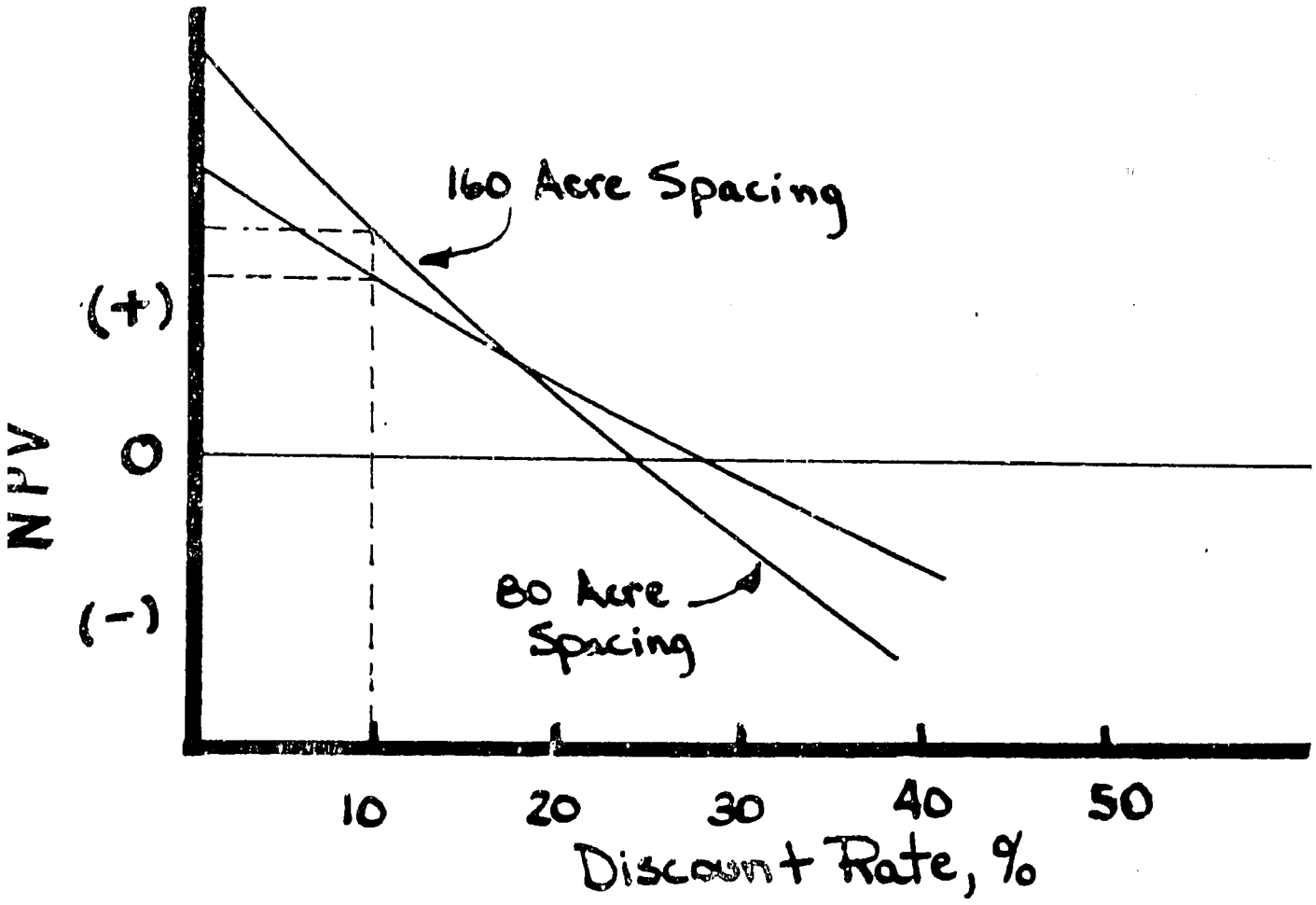
NPV vs. DCF-ROR as an Investment Evaluation Model

NPV is considered superior because

1) Reinvestment Rate
2) Multiple Rates of Return

Reinvestment Rate

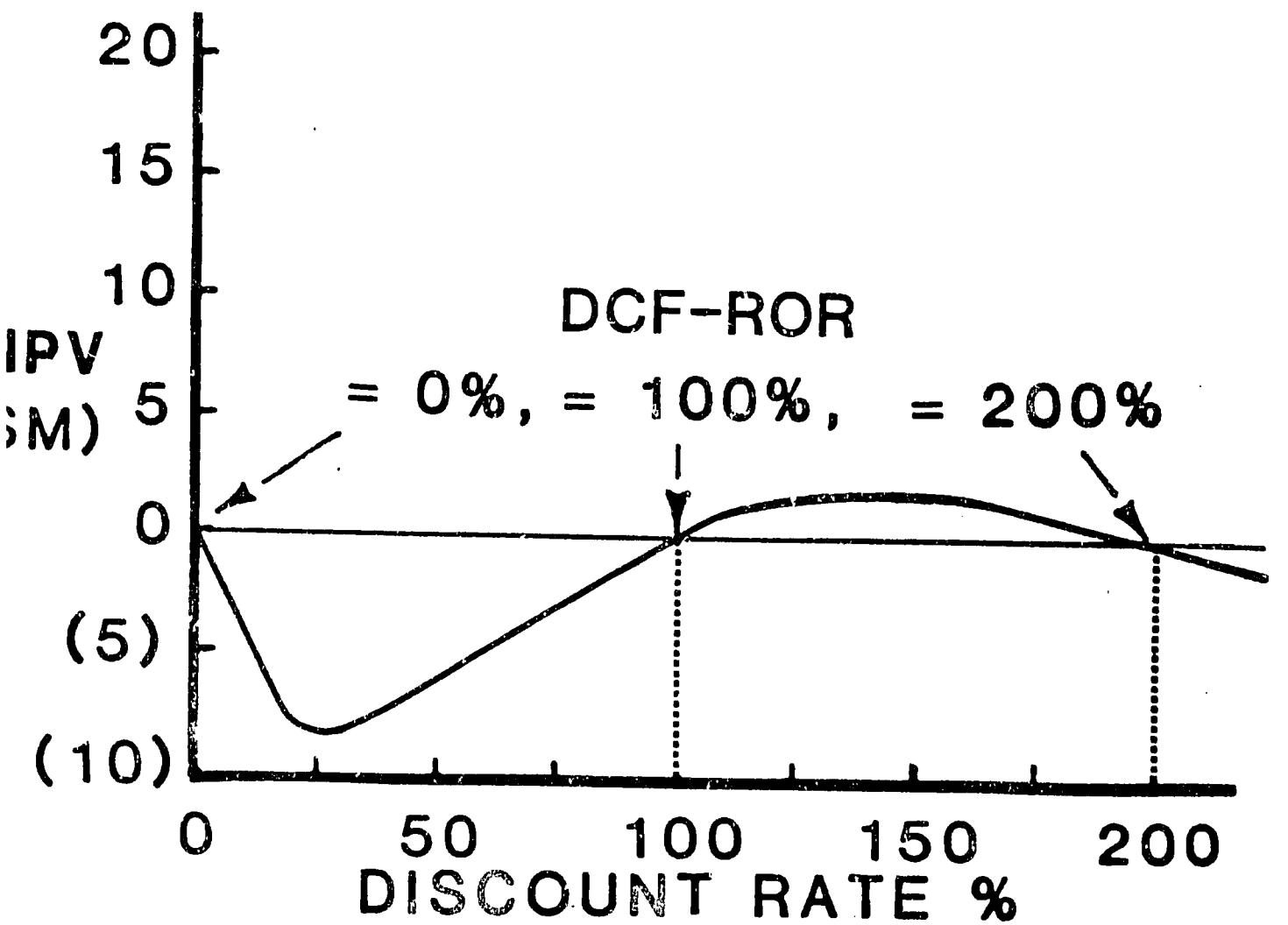
Well Spacing Example -



MULTIPLE RATES OF RETURN - EXAMPLE

END of YEAR	NCF ($MM)
0	(50)
1	300
2	(550)
3	300

NPV vs. DISCOUNT RATE



ANALYSIS OF PROJECTS

1) Accept/Reject Project – based on measures of value (already discussed)

2) Selection of Preferred Alternative

   a) Mutually Exclusive

   b) Incremental

   c) Yet - to - Spend

   d) Reliability

3) Ranking

Evaluation of Investment Alternatives -

Mutually Exclusive Investment Decisions:

1) Develop or Drop a Lease or Tract

2) Farmout vs. Drill

3) 160 Acre vs. 80 Acre well spacing in same field

4) Capital intensive low operating cost facility vs. less expensive higher operating cost facility

5) 10,000 BPD facility vs. a 15,000 BPD facility

Two special types of mutually exclusive investment decisions are:

1) Accept / Reject
2) Incremental

Accept/ Reject

Develop or Drop a lease is an accept/ reject decision: If we choose to develop we have several mutually exclusive alternatives

a) Drill or farmout
b) Well spacing
c) Number of development wells drilled

Incremental

Determing the optimum number of development wells is an example of an incremental decision

INCREMENTAL ANALYSIS
"YET TO SPEND" ECONOMICS

EXAMPLES OF "YET TO SPEND" DECISIONS

1) Development of a field after exploration & Discovery

2) Water flooding to increase or maintain production

3) Infill Drilling of a field

4) Installation of additional production equipment or facilities

SUNK Costs are Irrelevant to the ANALYSIS !

Example of Mutually Exclusive Alternatives Investment Decision

Exhibit 5.9 Completion Methods A, B, C

Absolute

	NCF $M		
Year	A	B	C
0	(200)	(200)	(250)
0-1	90	110	123
1-2	67	77	93
2-3	45	45	61
3-4	36	36	42
4-5	18	18	21
	56	86	90
NPV, $M	15	43	38
DCF-ROR	14.5	23.3	19.2
NPV/I	7.63	21.45	15.20

EXAMPLE OF INCREMENTAL INVESTMENT DECISION

Year	NCF, $M 1 well	2 wells	3 wells	4 wells
0	(200)	(390)	(580)	(760)
0-1	110	201	318	465
1-2	77	145	189	224
2-3	45	100	140	147
3-4	36	76	100	102
4-5	18	51	69	69
Total	86	183	235	253
NPV, $M	43	90	108	106
DCF-RoR%	23.3	23.3	21.3	19.6
NPV/I	21.45	23.08	18.78	13.93

Six Sample Projects

Year	A	B	C	D	E	F
0	-100	-200	-300	-200	-200	-200
1	60	180	0	180	- 50	60
2	40	100	0	120	- 50	50
3	30	40	-100	- 20	200	45
4	25		200	160	150	40
5	20		500	120	100	40
6	15		300	90	95	35
7	10		250	60	90	35
8	5		200	40	85	5
9			150	30	80	60
10			100		75	50
11			60		70	45
12			35		65	40
13			25		60	40
14			20		55	35
15			15		50	35

PRINCIPLE TYPES OF UNCERTAINTY

1. ECONOMIC

   A. Mineral Price
   B. Governmental Action
   C. Inflation

2. ENGINEERING

   A. Producing Rate
   B. Depletion Mechanism
   C. Investment

3. GEOLOGICAL

   A. Pay Thickness
   B. Rock and Fluid Properties
   C. Areal Extent

RISK AND UNCERTAINTY

TECHNIQUES

- Sensitivity Analysis
- Decision Trees
- Expected Values
- Monte Carlo Simulation
- Parameter Method
- Forecasting- Price, Supply, and Demand

SENSITIVITY ANALYSIS

Definition- measures impact of changes in input parameters by changing them individually and collectively.

Objective - answer what if questions

What if

- Costs are 10% higher
- Production is 20% lower
- Prices are 15% lower
- Construction is 6 months longer

SENSITIVITY ANALYSIS

ADVANTAGES:

1) IDENTIFIES CRITICAL UNCERTAINTIES
2) SIMPLE TO USE

DISADVANTAGES:

1) UNWIELDY WHEN SEVERAL UNCERTAINTIES ARE INVOLVED
2) PROVIDES NO INFORMATION ON LIKELIHOOD OF CHANGE
3) IGNORES DEPENDENT VARIABLES

SENSITIVITY ANALYSIS

Process:

1) Develop "base case" NCF and calculate desired parameters (NPV, DCF-ROR, etc.).

2) Form "What if" questions.

3) Reestimate profitability based on new assumptions.

4) Identify variables which influence projects outcome the most.

5) Plan project development to monitor changes in the critical input variables.

SENSITIVITY - EXAMPLE

Year	Gross Revenue	Technical Cost	O & M	Royalty	Drilling	Non-Drilling	Capital Allowance	Tax Credit	Taxable Income	Tax	NCF
1	142	6.4	5	1	40	15	3	.75	85.85	72.97	8.03
2	150.52	6.4	8.88	1			2.4		131.84	112.06	28.57
3	119.66	4.8	9.85	1			1.92		102.09	86.77	22.03
4	63.42	2.4	10.93	1			1.53		47.56	40.42	11.06
5	22.40	.8	12.13	1			6.15		2.32	1.97	7.29
Total	498	20.8	46.79	5	40	15	15	.75	369.66	314.21	76.99
PW_{15}	389.67	16.44	31.97	3.59	37.3	14.3	10.3	.71	289.3	245.9	56.8
PW_{10}	420.16	17.67	35.95	3.97	38.1	13.9	11.5	.70	312.1	265.3	62.4

SENSITIVITY

EXAMPLE - CONT'D

1) Compute the After-tax effect of each PW_{15}

	Before - Tax	After - Ta
Revenue	389.67	58.45
Technical Cost	16.44	13.97
O & M	31.97	4.79
Royalty	3.59	.53
Drilling	37.3	5.59
Non-Drilling	14.3	14.3
CA	10.3	-8.76
Tax Credit	.71	- .60
NCF*	56.8	56.57

* Does not add due to rounding

N = sample space of population

Event = subset of sample space

PROBABILITY TYPES

Classical or Apriori - probability determined by
Objective Logic flip of a coin
roll of a dice

Relative Probability - Obtained from Data

$$= \frac{\text{Total Number of Occurrences of the Event}}{\text{Total Number of Trials}}$$

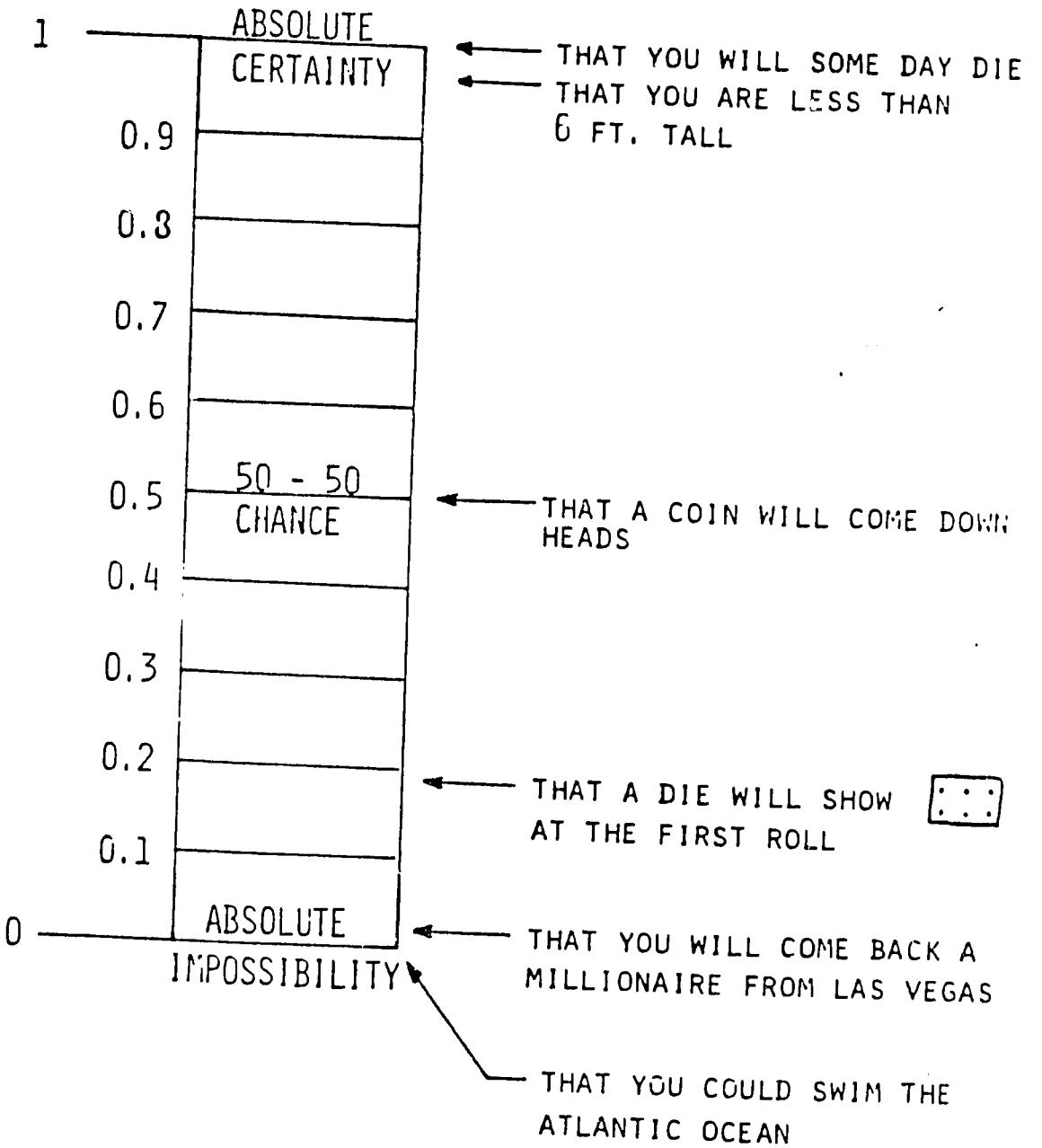
Subjective Probabilities - Personal opinion of likelihood
an event will occur

Mutually exclusive events - Event A precludes Event B - no points of the sample space in common

Independent events - Event A in no way affects or is affected by Event B

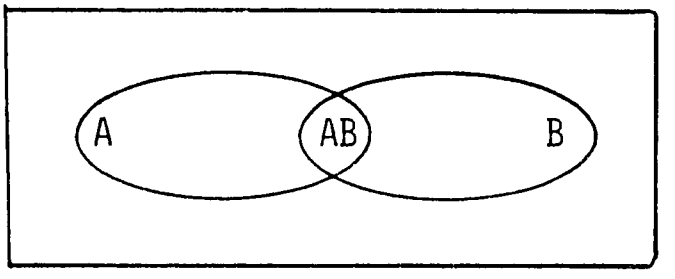
Conditional probability - probability of Event A given that Event B has occurred - dependent events

PROBABILITY IS THE LANGUAGE OF UNCERTAINTY



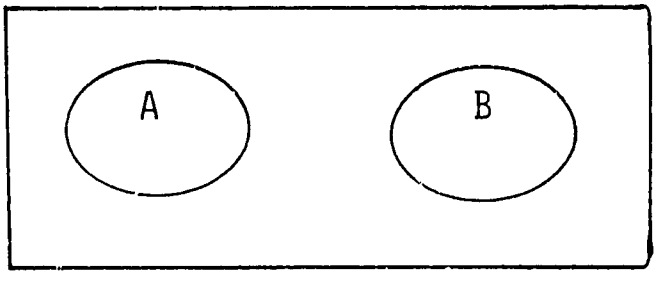
ADDITION THEOREM

$$P(A + B) = P(A) + P(B) - P(AB)$$



For Mutually Exclusive Events

$$P(A + B) = P(A) + P(B)$$



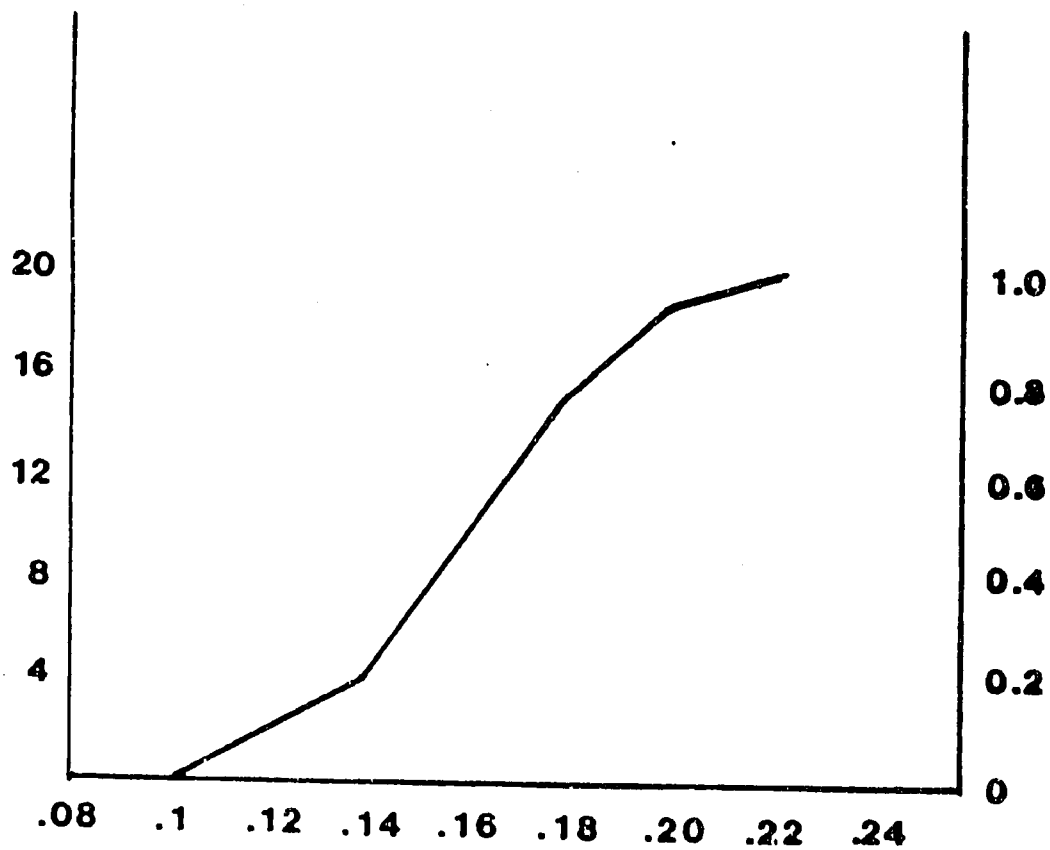
MULTIPLICATION THEOREM

$$P(AB) = P(B|A) \times P(A)$$

MULTIPLICATION THEOREM

$$P(AB) = P(B/A) \times P(A)$$

CUMULATIVE FREQUENCY



Probabilistic Approach

Assesses the likelihood of all possible outcomes of an investment.

The expected value of an investment is equal to the mean of the probability distribution.

$$E.V. = \sum_{i=1}^{N} V_i P_i$$

where V_i = value of the ith possibility

P_i = probability of the occurrence of V_i

N = the total number of possibilities

E.V. = the expected value of the investment

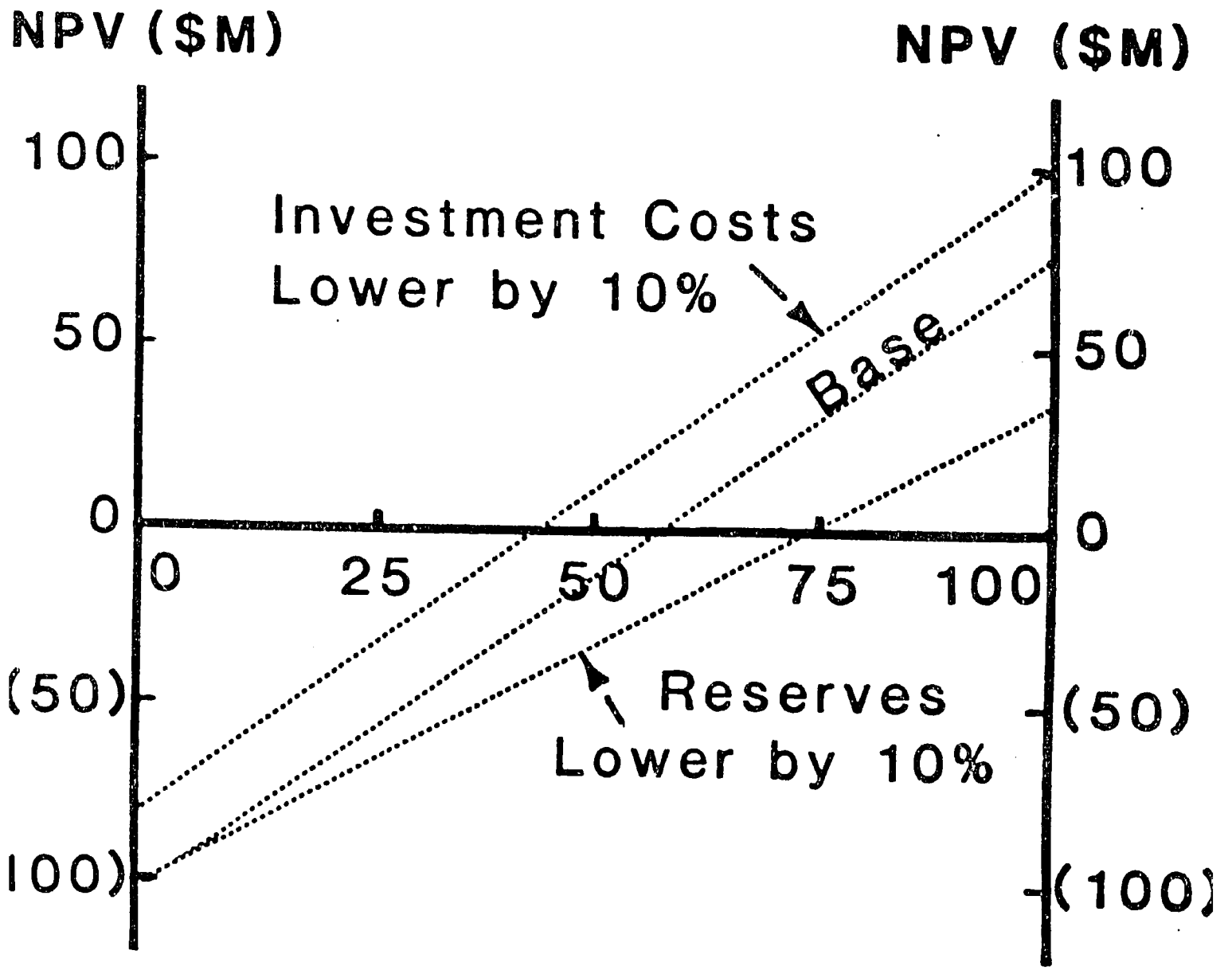
DECISION RULE

When choosing among several mutually exclusive decisions alternatives, select the alternative having the highest positive expected value.

Interpretation - the average monetary profit per decision that would be realized if the alternative is accepted over a series of repeated trials

REQUIRED PROBABILITY OF SUCCESS

Exhibit 6.9



BINOMIAL DISTRIBUTION

Equation

$$P(X) = (C_x^n)(P)^x(1-P)^{n-x}$$

$$= \frac{n!}{x!(n-x)!} P^x(1-P)^{n-Y}$$

or the nomial approximation

$$Z = (P-\pi)/\sigma_p$$

where

$$\sigma_p = \left[\frac{\pi(1-\pi)}{n}\right]^{0.5}$$

Assume sampling with replacement

TABLE 8.2

Cumulative Binomial Probability of At Least x Successes For Various Values of p When n=25.

x\p	01	02	03	04	05	06	07	08	09	10
1	2222	3965	.5330	6396	7226	7871	8370	8756	9054	9282
2	0258	0886	1720	2642	.3576	4473	5304	6053	6714	7288
3	0020	0132	0380	0765	1271	.1871	2534	.3232	3937	4629
4	0001	0014	0062	0165	0341	0598	0936	.1351	.1831	.2364
5		0001	0008	0028	0072	0150	.0274	0451	0686	0980
6			0001	0004	0012	0031	0065	0123	0210	0334
7					0002	0005	0013	0028	0054	0095
8						0001	0002	0005	.0011	0023
9								0001	.0002	0005
10										0001

x\p	11	12	13	14	.15	.16	.17	.18	19	20
1	9457	9591	9692	9770	9828	9872	.9905	.9930	9948	9962
2	7779	8195	8543	8832	9069	.9263	9420	9546	9646	9726
3	5291	5912	6483	7000	7463	7870	.8226	8533	8796	9018
4	2934	3525	4123	4714	5289	5837	.6352	6829	7266	7660
5	1331	1734	2183	2668	3179	3707	.4241	.4772	5292	.5793
6	0499	0709	0965	1268	.1615	2002	2425	2875	3347	.3833
7	0156	0253	0359	.0509	0695	0920	1185	1488	1827	2200
8	0041	0070	0113	0173	0255	0361	0495	.0661	0859	1091
9	0009	0017	0030	0050	0080	0121	0178	.0252	0348	0468
10	0002	0004	0007	0013	0021	.0035	0055	.0083	.0122	.0173
11		0001	0001	0003	0005	.0009	0015	.0024	0037	0056
12					0001	.0002	.0003	0006	0010	0015
13							0001	0001	.0002	0004
14										0001

x\p	21	22	23	24	25	.26	27	.28	.29	30
1	9972	9980	9985	9990	9992	9995	9996	9997	9998	9999
2	9789	9838	9877	9907	.9930	9947	.9961	9971	9979	9984
3	9204	9360	9488	9593	.9679	9748	9804	.9848	9883	9910
4	8013	8324	8597	8834	.9038	9211	9358	9481	9583	9668
5	6270	6718	7134	7516	7863	8174	8452	8696	8910	9095
6	4325	4816	5299	5767	6217	6644	7044	7415	7755	8065
7	2601	3027	3471	3927	4389	4851	5308	5753	6183	6593
8	1358	1658	1989	2349	.2735	3142	.3565	3999	4440	4882
9	0614	0788	0993	1228	.1494	1790	2115	2465	2838	3231
10	0240	0325	0431	0560	0713	0893	1101	1338	1602	1894
11	0082	0117	0163	0222	0297	0389	0502	0636	0795	0978
12	0024	0036	0053	0076	.0107	0148	0199	0264	0345	0442
13	0006	0010	.0015	0023	0034	.0049	0069	.0096	0130	.0175
14	0001	0002	.0004	0006	0009	.0014	0021	.0030	0043	0060
15			0001	.0001	.0002	.0003	0005	.0008	0012	0018
16						0001	0001	.0002	0003	0005
17									0001	.0001

x\p	31	32	33	34	35	36	37	38	39	.40
1	9999	9999	1 0000	1 0000	1 0000	1 0000	1 0000	1 0000	1 0000	1 0000
2	9989	9992	9994	9996	9997	9998	9998	9999	9999	9999
3	9932	9949	9961	9971	9979	9984	9989	9992	9994	9996
4	9737	9793	9838	9874	9903	9926	9944	9958	9968	9976
5	9254	9390	9504	9600	9680	9745	9799	9842	9877	.9905
6	8344	8593	8813	9006	9174	9318	9441	9546	9633	9706
7	6981	7343	7679	7987	8266	8517	8742	8940	9114	.9264
8	5319	5747	6163	6561	6939	7295	7626	7932	8211	8464
9	3639	4057	4482	4908	5332	5748	6152	6542	6914	7265
10	2213	2555	2919	3300	3697	4104	4517	4933	5347	.5754
11	1188	1424	1686	1975	2288	2624	2981	3355	3743	4142
12	0560	0698	0859	1044	1254	1490	1751	2036	2346	2677
13	0230	0299	0383	0485	0604	0745	0907	1093	1303	1538
14	0083	0112	0149	0196	0255	0326	0412	0515	0637	0778
15	0026	0036	0050	0069	0093	.0124	0163	0212	0271	0344
16	0007	0010	.0015	0021	0029	0041	0056	0075	0100	0132
17	0002	0002	0004	0005	0008	0011	0016	0023	0032	0043
18			0001	0001	0002	0003	0004	0006	0008	0012
19						0001	0001	0001	0002	0003
20										0001

x\p	41	42	43	44	45	46	47	48	49	50
1	1 0000	1 0000	1 0000	1 0000	1 0000	1 0000	1 0000	1 0000	1 0000	1 0000
2	1 0000	1 0000	1 0000	1 0000	1 0000	1 0000	1 0000	1 0000	1 0000	1 0000
3	9997	9998	9998	9999	9999	1 0000	1 0000	1 0000	1 0000	1 0000
4	9983	9987	9991	9993	9995	9997	9998	9998	9999	9999
5	9927	9945	9958	9969	9977	9983	9988	9991	9994	9995
6	9767	9816	9856	9888	9914	9934	9950	9963	9972	9980
7	9394	9505	9599	9677	9742	9796	9840	9876	9904	.9927
8	8692	8894	9071	9227	9361	9477	9575	9658	9727	9784
9	7593	7897	8177	8431	8660	8865	9046	9205	9343	9461
10	6151	6535	6902	7250	7576	7880	8160	8415	8646	8852
11	4548	4956	5363	5765	6157	6538	6902	7249	7574	7878
12	3029	3397	3780	4174	4574	4978	5382	5780	6171	6550
13	1797	2080	2387	2715	3063	3429	3808	4199	4598	5000
14	0941	1127	1336	1569	1827	2109	2413	2740	3086	.3450
15	0431	0535	0656	0797	.0960	1145	1353	1585	1841	2122
16	0171	0220	0280	0353	0440	0543	0663	0803	0964	1148
17	0058	0078.	0103	0134	0174	0222	0281	0352	0438	0539
18	0017	0023	0032	0044	0058	0077	0102	0132	0170	0216
19	0004	0006	0008	0012	0016	0023	0031	0041	0055	0073
20	0001	0001	0002	0003	0004	0005	0008	0011	0015	0020
21					0001	0001	0002	0002	0003	0005
22									0001	0001

INDIVIDUAL TERMS, BINOMIAL DISTRIBUTION (Continued)

n	x	p = .05	.10	.15	.20	.25	.30	.35	.40	.45	.50
1	0	.9500	.9000	.8500	.8000	.7500	.7000	.6500	.6000	.5500	.5000
	1	.0500	.1000	.1500	.2000	.2500	.3000	.3500	.4000	.4500	.5000
2	0	.9025	.8100	.7225	.6400	.5625	.4900	.4225	.3600	.3025	.2500
	1	.0950	.1800	.2550	.3200	.3750	.4200	.4550	.4800	.4950	.5000
	2	.0025	.0100	.0225	.0400	.0625	.0900	.1225	.1600	.2025	.2500
3	0	.8574	.7290	.6141	.5120	.4219	.3430	.2746	.2160	.1664	.1250
	1	.1354	.2430	.3251	.3840	.4219	.4410	.4436	.4320	.4084	.3750
	2	.0071	.0270	.0574	.0960	.1406	.1890	.2389	.2880	.3341	.3750
	3	.0001	.0010	.0034	.0080	.0156	.0270	.0429	.0640	.0911	.1250
4	0	.8145	.6561	.5220	.4096	.3164	.2401	.1785	.1296	.0915	.0625
	1	.1715	.2916	.3685	.4096	.4219	.4116	.3845	.3456	.2995	.2500
	2	.0135	.0486	.0975	.1536	.2109	.2646	.3105	.3456	.3675	.3750
	3	.0005	.0036	.0115	.0256	.0469	.0756	.1115	.1536	.2005	.2500
	4	.0000	.0001	.0005	.0016	.0039	.0081	.0150	.0256	.0410	.0625
5	0	.7738	.5905	.4437	.3277	.2373	.1681	.1160	.0778	.0503	.0312
	1	.2036	.3280	.3915	.4096	.3955	.3602	.3124	.2592	.2059	.1562
	2	.0214	.0729	.1382	.2048	.2637	.3087	.3364	.3456	.3369	.3125
	3	.0011	.0081	.0244	.0512	.0879	.1323	.1811	.2304	.2757	.3125
	4	.0000	.0004	.0022	.0064	.0146	.0284	.0488	.0768	.1128	.1562
	5	.0000	.0000	.0001	.0003	.0010	.0024	.0053	.0102	.0185	.0312
6	0	.7351	.5314	.3771	.2621	.1780	.1176	.0754	.0467	.0277	.0156
	1	.2321	.3543	.3993	.3932	.3560	.3025	.2437	.1866	.1359	.0938
	2	.0305	.0984	.1762	.2458	.2966	.3241	.3280	.3110	.2780	.2344
	3	.0021	.0146	.0415	.0819	.1318	.1852	.2355	.2765	.3032	.3125
	4	.0001	.0012	.0055	.0154	.0330	.0595	.0951	.1382	.1861	.2344
	5	.0000	.0001	.0004	.0015	.0044	.0102	.0205	.0369	.0609	.0938
	6	.0000	.0000	.0000	.0001	.0002	.0007	.0018	.0041	.0083	.0156
7	0	.6983	.4783	.3206	.2097	.1335	.0824	.0490	.0280	.0152	.0078
	1	.2573	.3720	.3960	.3670	.3115	.2471	.1848	.1306	.0872	.0547
	2	.0406	.1240	.2097	.2753	.3115	.3177	.2985	.2613	.2140	.1641
	3	.0036	.0230	.0617	.1147	.1730	.2269	.2679	.2903	.2918	.2734
	4	.0002	.0026	.0109	.0287	.0577	.0972	.1442	.1935	.2388	.2734
	5	.0000	.0002	.0012	.0043	.0115	.0250	.0466	.0774	.1172	.1641
	6	.0000	.0000	.0001	.0004	.0013	.0036	.0084	.0172	.0320	.0547
	7	.0000	.0000	.0000	.0000	.0001	.0002	.0006	.0016	.0037	.0078
8	0	.6634	.4305	.2725	.1678	.1001	.0576	.0319	.0168	.0084	.0039
	1	.2793	.3826	.3847	.3355	.2670	.1977	.1373	.0896	.0548	.0312
	2	.0515	.1488	.2376	.2936	.3115	.2965	.2587	.2090	.1569	.1094
	3	.0054	.0331	.0839	.1468	.2076	.2541	.2786	.2787	.2568	.2188
	4	.0004	.0046	.0185	.0459	.0865	.1361	.1875	.2322	.2627	.2734
	5	.0000	.0004	.0026	.0092	.0231	.0467	.0808	.1239	.1719	.2188
	6	.0000	.0000	.0002	.0011	.0038	.0100	.0217	.0413	.0703	.1094
	7	.0000	.0000	.0000	.0001	.0004	.0012	.0033	.0079	.0164	.0312
	8	.0000	.0000	.0000	.0000	.0000	.0001	.0002	.0007	.0017	.0039

Linear interpolations with respect to p will in general be accurate at most to two decimal places.

RELIABILITY ANALYSIS

Objective: Compare the cost of excess capacity against the potential losses due to equipment failure.

Examples:

1) Power generation facilities offshore platforms or remote areas 2-500 KW units va. 4-300 KW units.
2) Water injection pumps for waterflood projects
3) Pumps for pipelines
4) Evaluation of need for surplus capacity and selecting the proper amount of surplus capacity.

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RELIABILITY ANALYSIS

EXAMPLE

Evaluate the need for 10,000 KW generating capacity on an offshore platform.

Alternatives:	2 – 5,000 KW	Cost 15 MM each
	3 – 5,000 KW	Cost 15 MM each
	3 – 4,000 KW	Cost 15 MM each

1)

2 – 5,000		3 – 5,000	3 – 4,000	
Power	P_i	P_i	Power	P_i
10,000	0.9025	0.9928	12,000	0.8574
5,000	0.095	0.0071	8,000	0.1354
0	0.0025	0.0001	4 000	0.0071
	1.00	1.00	0	0.0001
Average Reliability	0.95	0.9963	0.9685	

Select 3 – 5,000 KW to maximize reliability

2) Calculate cost of reliability on annual basis @ 20% and 10 years.

Alternative	Cost	Excess Capacity	Cost
2 - 5,000	30 MM	0	0
3 - 5,000	45 MM	5,000	15 MM
4 - 3,000	39 MM	2,000	6.5 MM

$$15 \text{ MM} = \text{In} \left[\frac{1 + (1.2)^{-10}}{.2} \right]$$

In = 3.57 MM/yr.

$$6.5 \text{ MM} = \text{In} \left[\frac{1 + (1.2)^{-10}}{.2} \right]$$

In = 1.55 MM

3) Compute value of lost production necessary just to justify excess capacity. Assume that 5,000 bbls. of oil are lost for each day that generators do not operate at full capacity (a simplifying assumption) @ 30 units/day.

Reliability	Days Lost	Revenue Lost/Yr.	Cost/Yr.
0.95	18.25	2.74 MM	0
0.9963	1.35	.20 MM	3.57 MM
0.9685	11.49	1.724 MM	1.55 MM

Choose 3 - 4000 units since benefits ≈ cost

NORMAL DISTRIBUTION

Equation:

$$Y = \left[\frac{1}{\sigma\ 2\pi}\right] e^{-1/2\ (x-\mu)^2/\sigma^2}$$

or

$$Y = \left[\frac{1}{\sigma\ 2\pi}\right] e^{-1/2\ z^2}$$

where $z = (x-\mu)/\sigma$

x = Value of an event

μ = Mean

σ = Standard deviation

Probability Calculation:

Given x, μ, σ, Find Z by the above equation

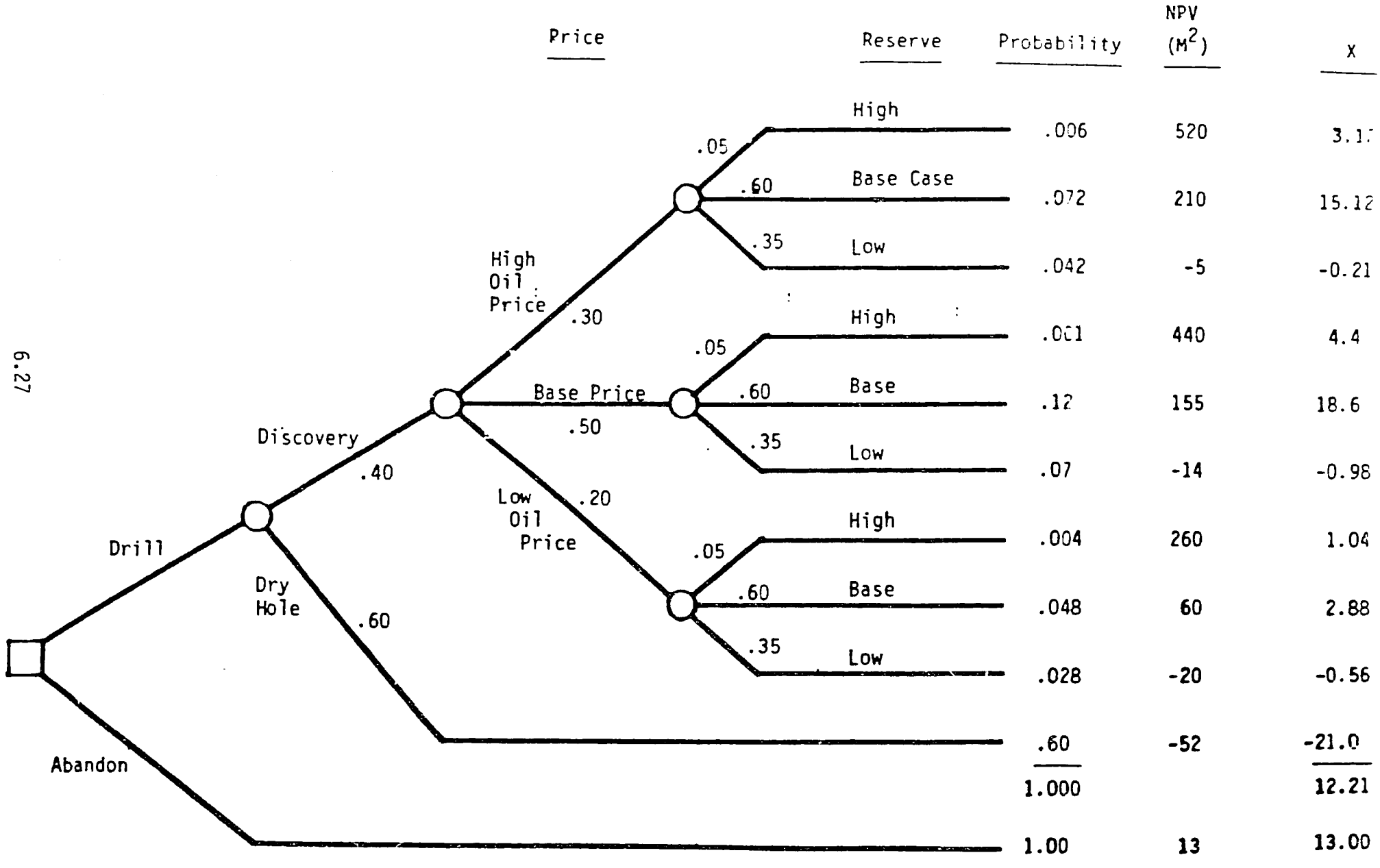
Read value of Z from table 16.1

DECISION TREE

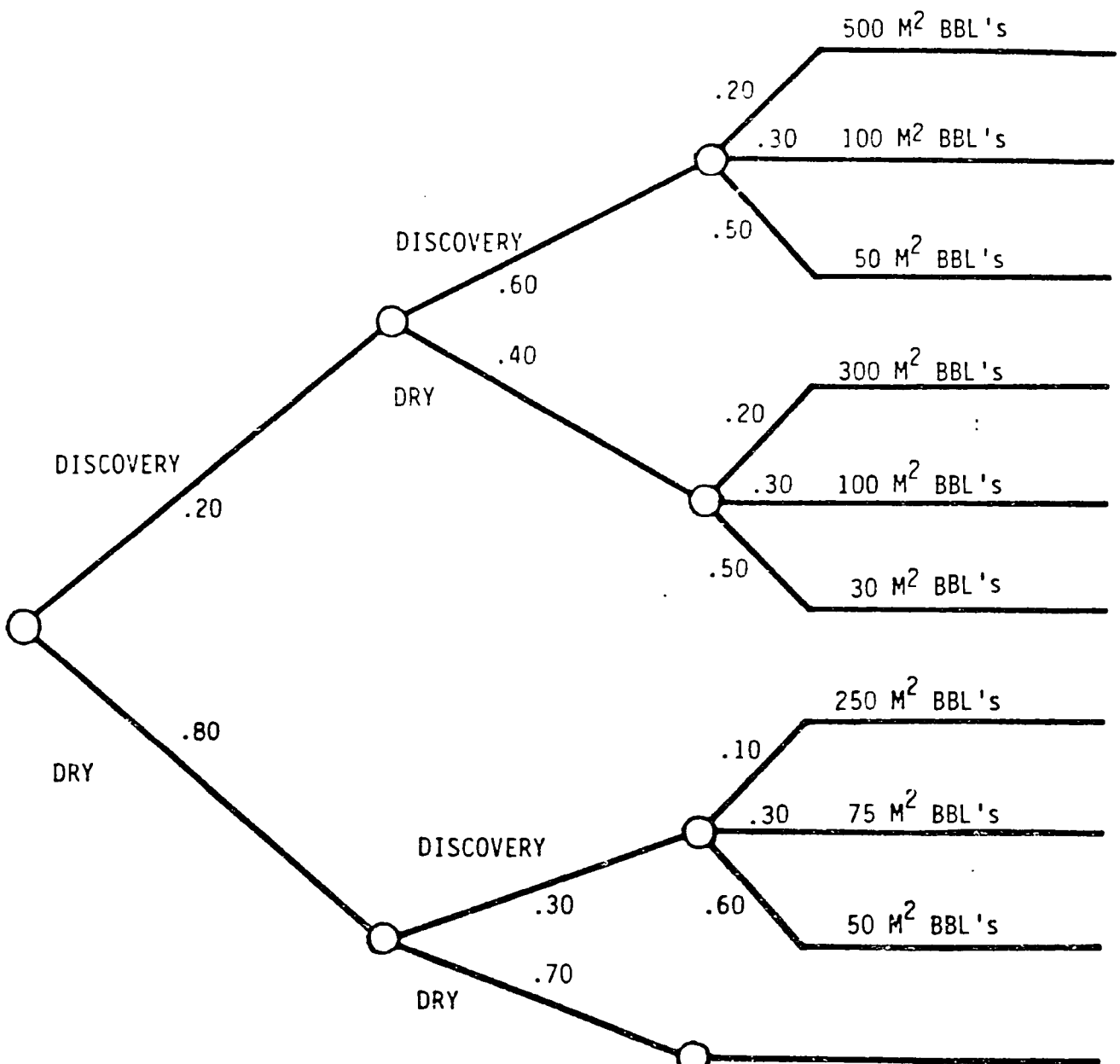
A Pictorial Representation of a Sequence of Events and Possible Outcomes.

DECISION TREE

DRILL/ABANDON LEASE RECOMMENDATION



PROBABILITY TREE PLAY ANALYSIS



Reserves	Probability	NPV	X
500 M^2 BBL's	0.024	900	21.6
100 M^2 BBL's	0.36	300	10.8
50 M^2 BBL's	0.06	50	3.0
300 M^2 BBL's	0.016	560	8.96
100 M^2 BBL's	0.024	240	5.76
30 M^2 BBL's	0.04	34	1.36
250 M^2 BBL's	0.024	470	11.28
75 M^2 BBL's	0.072	20	1.44
50 M^2 BBL's	0.144	-30	-4.32
	0.56	-76	-42.56
	100		17.32

ROLE OF MONTE CARLO SIMULATION IN THE RISK ANALYSIS PROCEDURE

- AIDS IN UNDERSTANDING STRUCTURE THROUGH FEEDBACK OF SITUATION SENSITIVITY TO DIFFERENT VARIABLES

- HELPS QUANTIFY SOURCES OF UNCERTAINTY BY COMBINING SEVERAL ELEMENTS INTO MORE COMPLEX FACTORS

- PROVIDES A MEANS OF RELATING SOURCES OF UNCERTAINTY TO RELEVANT DECISION CRITERIA

- EVALUATES DECISION CRITERIA

- PROVIDES GUIDANCE ON WHAT INFORMATION IS MOST VALUABLE

MONTE CARLO SIMULATION

Develops a probability distribution of the investment value(PW,DCF-RO when the probability distribution of each investment uncertainty is known or can be approximated

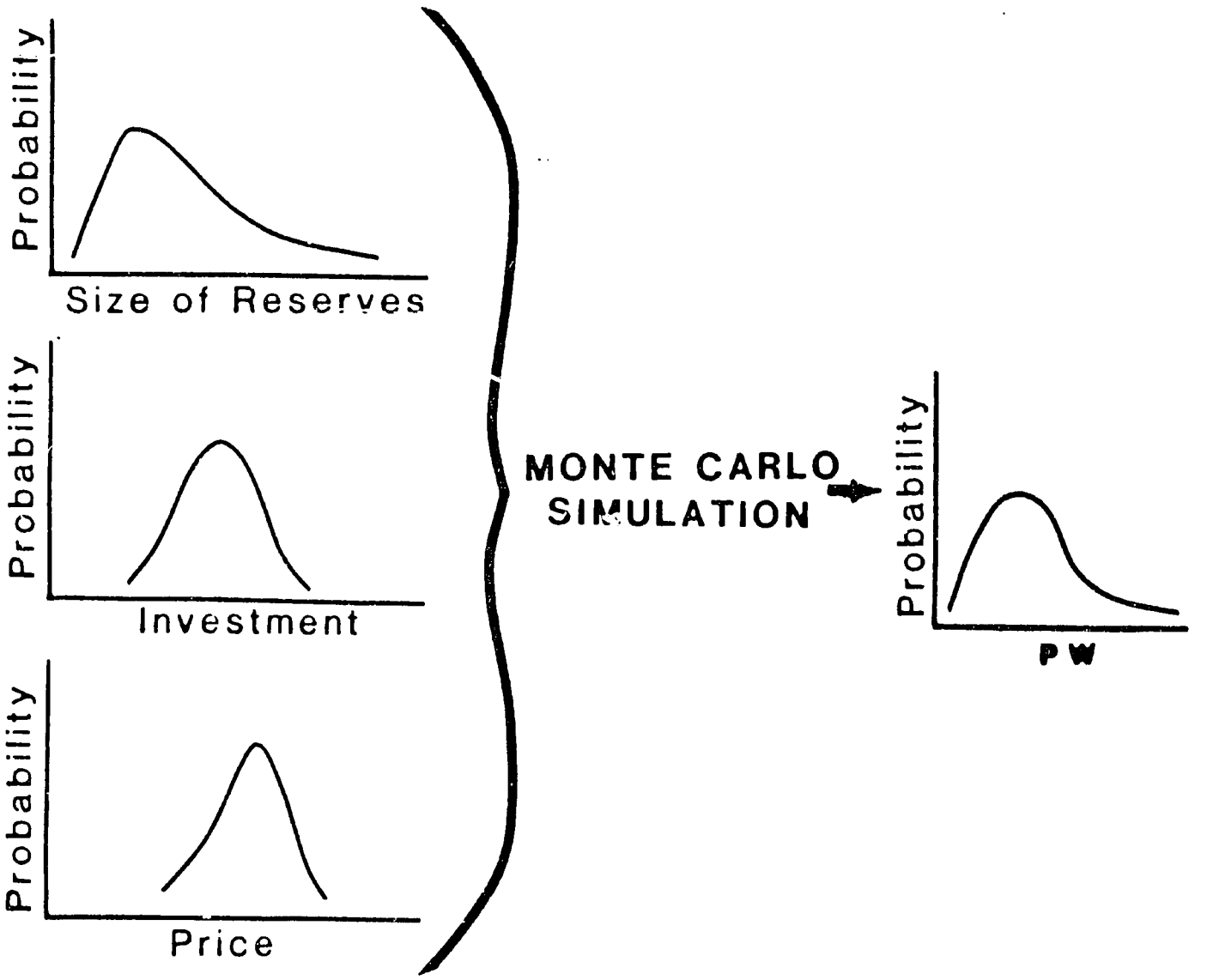


Exhibit 6.13 Development of Probability Distribution for Recoverable using Monte Carlo Simulation

Recoverable Reserves = (Reservoir Thickness) (Reservoir Area)(Net Oil Recovery)

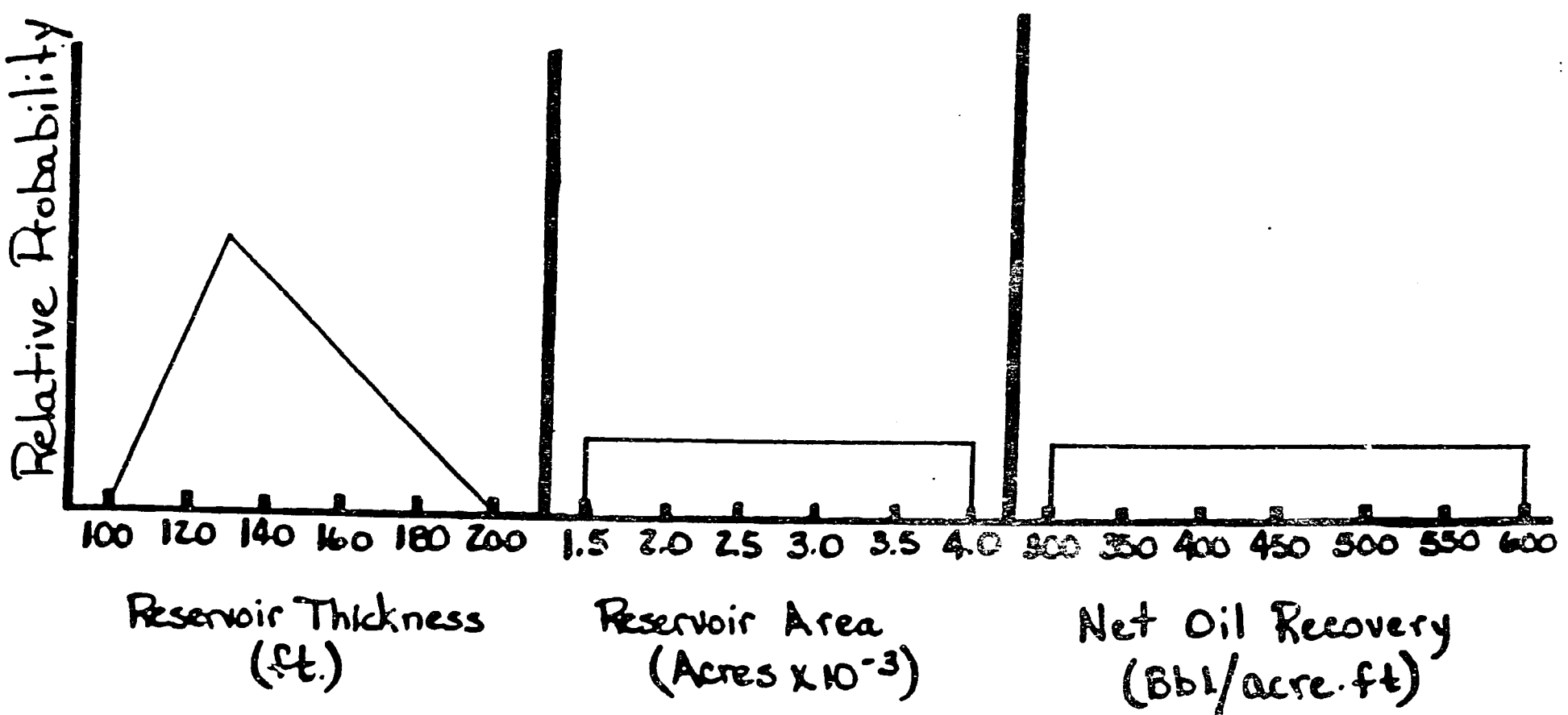
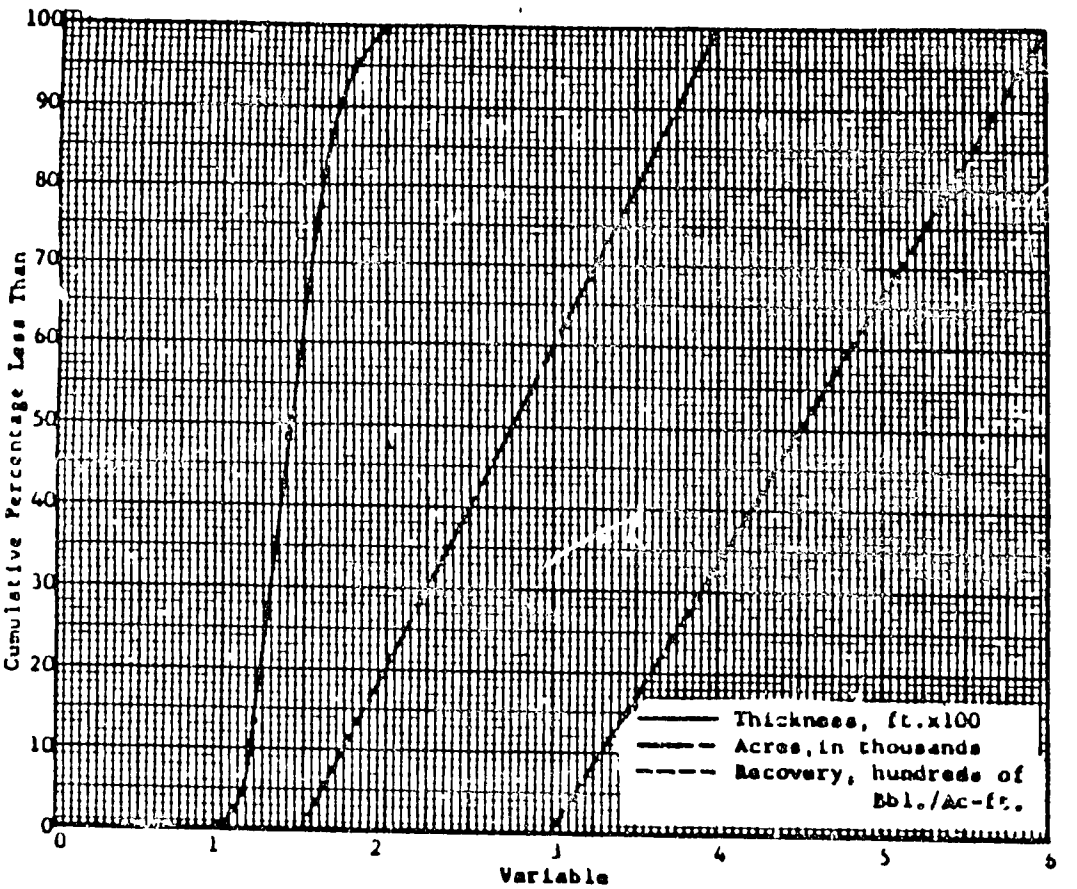


Exhibit 6.13 cont'd



Cumulative Probability Distribution

Simulation-

	Random #	h	A	Bbl/ac-ft	Reserves
Pass #1	53 97 66	145	3930	499	284×10^6
Pass #2	99 30 81	198	2250	545	243×10^6
Pass #3	19 09 31	123	1720	393	83×10^6

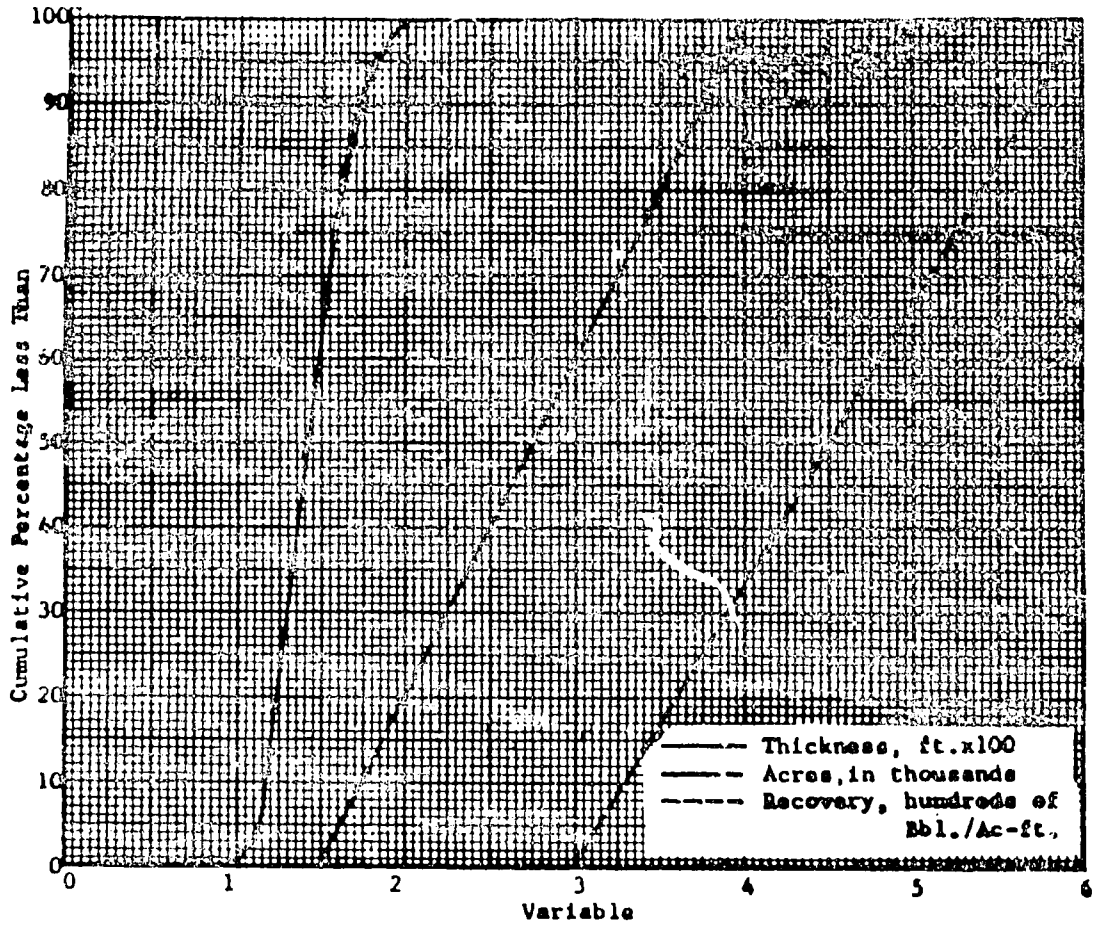


Figure 8.7 Cumulative "% less than" Curves for Example Problem

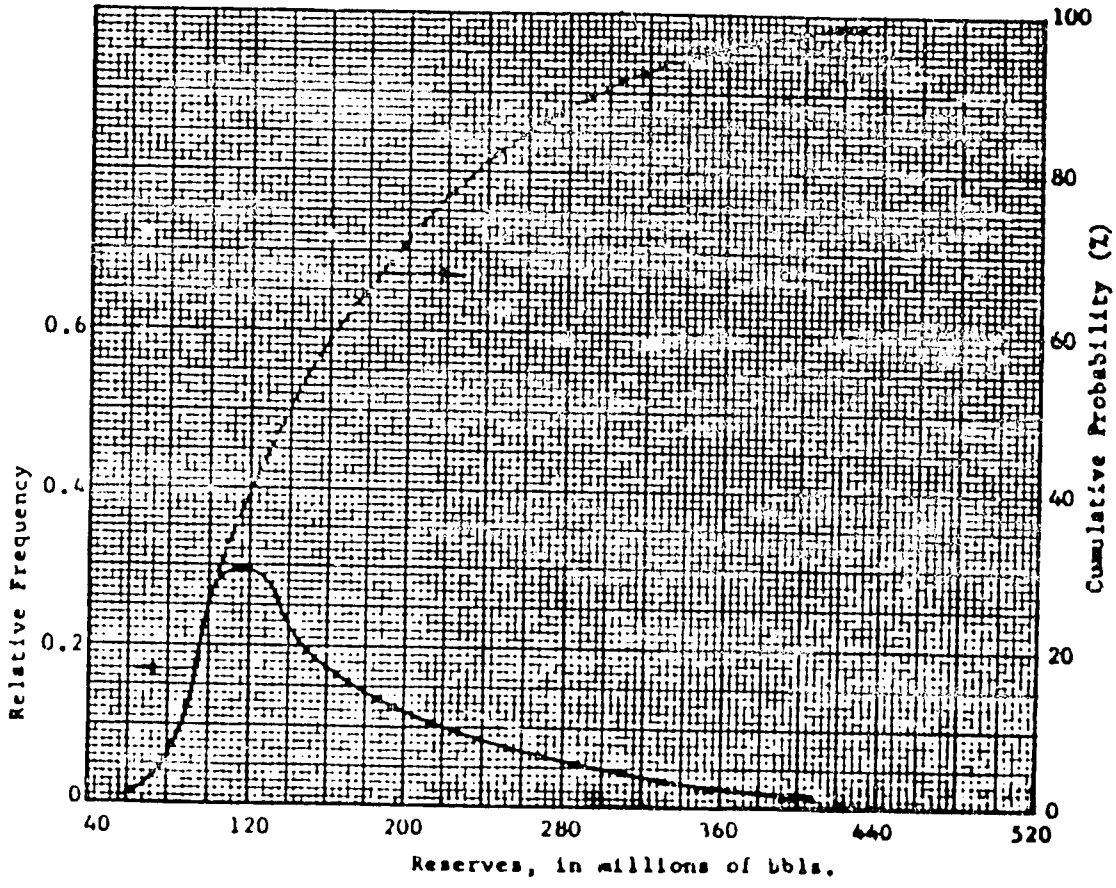
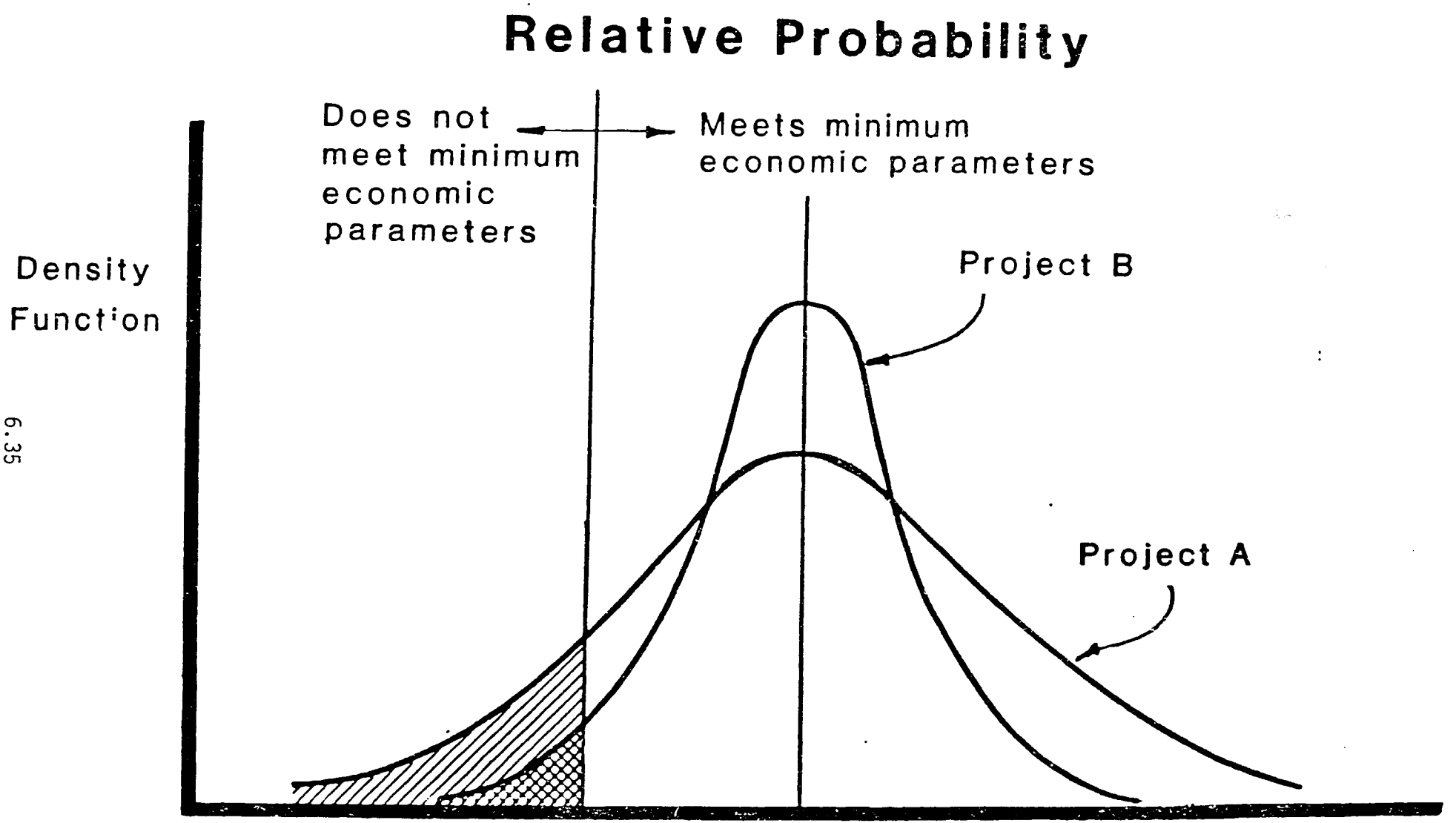


Figure 8.8 Results of Simulation Example.

Table 8.3 Example of a Random Number Table.

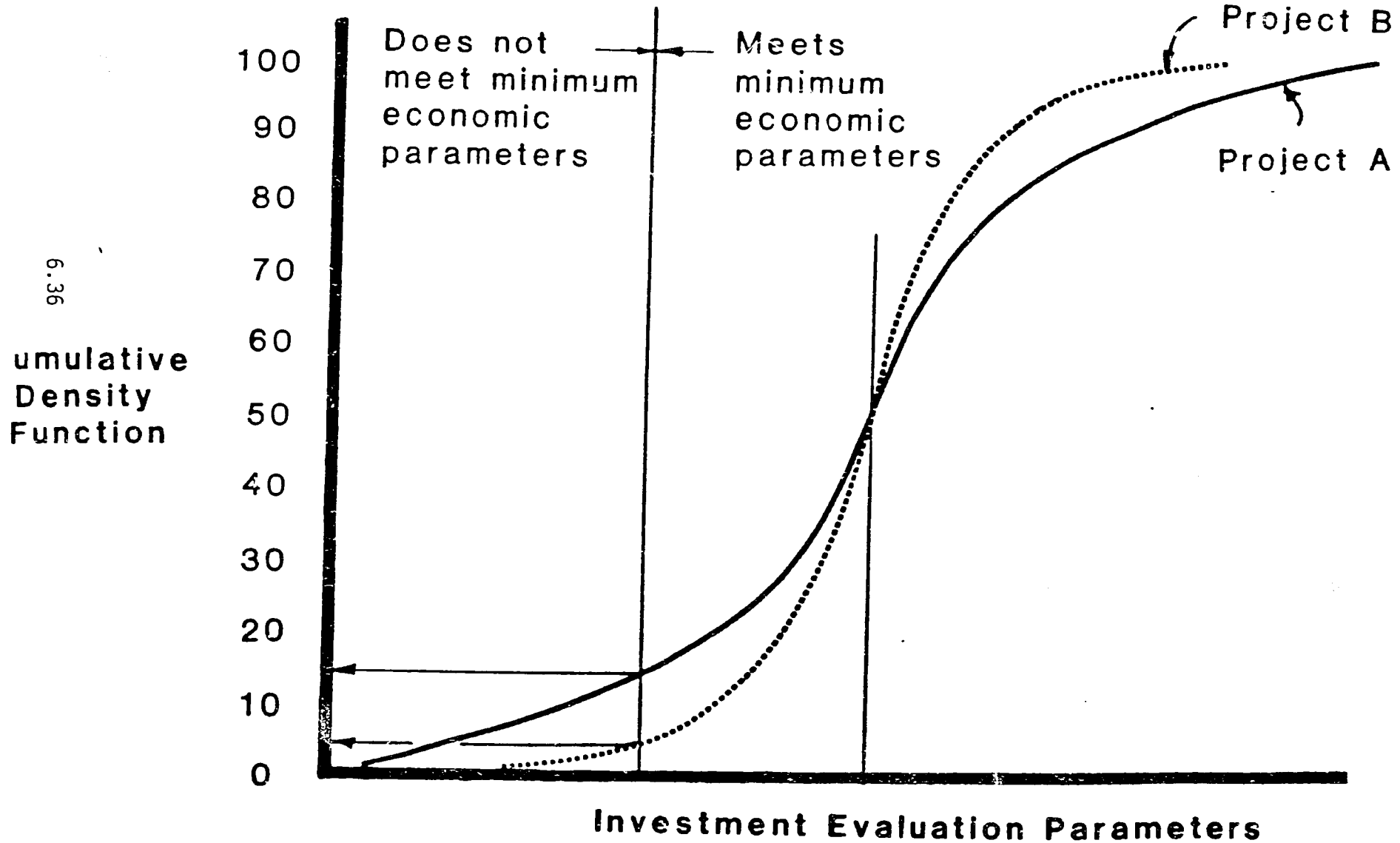
53479	81115	98036	12217	59526	40238	40577	39351	43211	69255
97344	70328	58116	91964	26240	44643	83297	97391	92823	77578
66023	38277	74523	71118	84892	33956	98899	92315	65783	59640
99776	75723	03172	43112	83086	81982	14538	26162	24899	20551
30176	48979	92153	38416	42436	26636	83903	44722	69210	69117
81874	83339	14988	99937	13213	30177	47967	93795	86693	98854
19839	90630	71863	95053	55532	60908	84108	55342	48479	63799
09337	33435	53869	52769	18801	25820	96198	66518	78314	97013
31151	58295	40823	41330	21093	93882	49192	44876	47185	81425
67619	52515	03037	81699	17106	64982	60834	85319	47814	08075
61946	48790	11602	83043	22257	11832	04344	95541	20366	55937
04811	64892	96346	79065	26999	43967	63485	93572	80753	96582
05763	39601	56140	25513	86151	78657	02184	29715	04334	15678
73260	56877	40794	13948	96289	90185	47111	66807	61849	44686
54909	09976	76580	02645	35795	44537	64428	35441	28318	99001
42583	36335	60068	04044	29678	16362	48592	25547	63177	75225
27266	27403	97520	23334	36453	33699	23672	45884	41515	04756
49843	11442	66682	36055	32002	78600	36924	59962	68191	62580
29316	40460	27076	69232	51423	58515	49920	03901	26597	33068
30463	27856	67798	16837	74273	05793	02900	63498	00782	35097
28708	84088	65535	44258	33869	82530	98399	26387	02836	36838
13183	50652	94872	28257	78547	55286	33591	61965	51723	14211
60796	76639	30157	40295	99476	28334	15368	42481	60312	42770
13486	46918	64683	07411	77842	01908	47796	65796	44230	77230
34914	94502	39374	34185	57500	22514	04060	94511	44612	10485
28105	04814	85170	86490	35695	03483	57315	63174	71902	71182
59231	45028	01173	08848	81925	71494	95401	34049	04851	65914
87437	82758	71093	36833	53582	25986	46005	42840	81683	21459
29046	01301	55343	65732	78714	43644	46248	53205	94868	48711
62035	71886	94506	15263	61435	10369	42854	68257	14385	79436
38856	80048	59973	73368	52876	47673	41020	82295	26430	87377
40666	43328	87379	86418	95841	25590	54137	94182	42308	07361
40588	90087	37729	08667	37256	20317	53316	50982	32900	32097
78237	86556	50276	20431	00243	02303	71029	49932	23245	00062
98247	67474	71455	69540	01169	03320	67017	92543	97977	52728
69977	78558	65430	32627	28312	61815	14598	79728	55699	91348
39843	23074	40814	03713	21891	96353	96806	24595	26203	26009
62880	87277	99895	99965	34374	42556	11679	99605	98011	48867
56138	64927	29454	52967	86624	62422	30163	76181	95317	39264
90804	56026	48994	64569	67465	60180	12972	03848	62582	93855
09665	44672	74762	33357	67301	80546	97659	11348	78771	45011
34756	50403	76634	12767	32220	34545	18100	53513	14521	72120
12157	73327	74196	26668	78087	53636	52304	00007	05708	63538
69384	07734	94451	76428	16121	09300	67417	68587	87932	38840
93358	64565	43766	45041	44930	69970	16964	08277	67752	60892
38879	35544	99563	85404	04913	62547	78406	01017	04187	22072
58314	60298	72394	69668	12474	93059	02053	29807	63645	12792
83568	10227	99471	74729	22075	10233	21575	20325	21317	57124
28067	91152	40568	33705	64510	07067	64374	26336	79652	31140
05730	75557	93161	80921	55873	54103	34801	03157	04534	81368

PROBABILITY DISTRIBUTIONS



EVALUATION PARAMETERS
NPV, PW/I, DCF-ROR

CUMULATIVE PROBABILITY



PARAMETER METHOD

Advantages (Under Normal Assumptions)

1) Do not have to establish entire probability distributions for the input values

2) Simple, utilizes only two parameters of the probability distribution (μ, σ^2)

3) Can be performed manually or with little time

4) Relatively easy to understand since calculations are "visible"

PARAMETER METHOD - PROCEDURE

1) Develop the relationship between the "quantity of interest" (normally NPV) & the uncertain independent variables which affect it

2) Estimate the mean & variance of the uncertain variables

3) Compute the mean & variance of the "quantity of interest" NPV)

4) Make an assumption about the probability distribution for the "quantity of interest" NPV)

   a) Normal

   b) Log-normal

5) Develop probability statements for project presentation

PARAMETER METHOD - EXAMPLE

1) Develop NPV Relationship

$$NPV_7 = Rev_7 - O\ \&\ M_7 - ICAP_7 - TCAP_7$$

NPV_7 = Net Present Value
Rev^7 = Present Value of Revenue
$O\ \&\ M_7$ = " " O & M
$ICAP_7$ = " " Intang. Inv.
$TCAP_7$ = " " Tang. Inv.

DATA	MOST LIKELY	LOW	HIGH
Rev_7	850	-20%	+10%
$O\ \&\ M_7$	174	-10%	+25%
$ICAP_7$	80	-10%	+50%
$TCAP_7$	160	-10%	+100%

2) Estimate Mean & Variance o
Each Variable

Mean: $\mu = \left(\frac{L + 2 \times ML + H}{4}\right)$

L = low value
ML = most likely
H = high value
μ = mean

Variance: $\sigma^2 = \left[\frac{H - L}{2.65}\right]^2$

$\sigma = \sqrt{\sigma^2}$

	μ ($MM)	σ ($MM)
Rev	828.7	92.5
O & M	180.5	22.7
ICAP	88.0	18.1
TCAP	196.0	66.4

Resumé

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Dr. Stuart Brown is an Associate Professor of Finance at Florida State University. He has a wide range of teaching experience in the area of energy finance and banking. He has taught courses in Oil Property Evaluation, Money and Banking, Financial Management, Investments, International Finance and Commercial Bank Administration. Dr. Brown also teaches at the Florida School of Banking, and is affiliated with John M. Campbell and Company. He has published numerous articles on energy, statistics, and finance.

Dr. Brown, who received his B.S., MBA, and Ph.D. from the University of Florida was a U.S. Steel Fellow at the University of Florida in 1973-1974 and an academic intern at the Chicago Board of Trade in June of 1980. He is a member of the Jacksonville Financial Analyst Society, the Financial Analyst Association, the American Finance Association, and the Southern Finance Association.