

## 1.011 Project Evaluation

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### Review for Quiz 2

#### 1 Money-Time Relationships

##### 1.1 MARR

The MARR is the minimal attractive rate of return that is acceptable for a project, which depends upon the risks associated with the project, the market for capital, and the opportunity costs of the owner. The MARR will be higher for riskier projects; rising interest rates will increase the MARR; a higher number of attractive competing projects will increase the MARR.

Risk/return: the required return can be graphed as an increasing function of the perceived risk of an investment. In general, the MARR should exceed the return available from the market for investments with similar risks (ranging from treasury bonds to blue chip stocks to risky, growth stocks); it must exceed the company, organization, or agency's cost of capital; and it must exceed the hurdle limit for investments if there is a capital budgeting constraint.

Companies are often interested in the after-tax return:

$$\begin{aligned} \text{After Tax MARR} &= (1 - \text{effective tax rate}) * \text{Before Tax MARR} \\ \text{Effective Tax Rate} &= \text{State rate} + (1 - \text{State rate})(\text{Federal Rate}) \end{aligned}$$

The federal rate in the US is 34% for large, profitable companies; the state tax rate typically is 6 to 12%. A typical effective tax rate is 40%.

##### 1.2 Monetary Criteria for Accepting a Project

If all costs and benefits can be converted to monetary terms, then various engineering economic relationships can be used to determine if a project is worth pursuing.

###### 1.2.1 Net Present Value

A project is acceptable if the NPV of all costs and benefits at the MARR is greater than 0.

###### 1.2.2 Future Value

A project is acceptable if the future value of all costs and benefits at the MARR is greater than 0.

###### 1.2.3 Annual Worth

A project is acceptable if the AW at the MARR is greater than 0.

###### 1.2.4 Capitalized Worth

If a project requires an investment  $I$  and produces an infinite revenue stream of  $A$  per year and the MARR is  $i$ , then the project is worthwhile if  $A/i$  is greater than  $I$ . Note that this is an extremely useful relationship to use for estimating the value of annuities that will be received for long periods or time (e.g. 20 years or more)

#### 1.2.5 Internal Rate of Return

A project is acceptable if the IRR is greater than the MARR.

This approach may overstate benefits, since it assumes that all intermediate net cash flows can be reinvested at the IRR, which may not be feasible.

#### 1.2.6 External Rate of Return

This approach first discounts all negative cash flows to the present using the MARR, then converts all negative cash flows to the end of the project using the MARR. The ERR is then calculated as the interest rate required for the NPV of the costs to equal the Future Value of the benefits at the end of the period. A project is acceptable if the ERR is greater than the MARR.

#### 1.2.7 Benefit/Cost Analysis

This is the NPV of positive cash flows divided by the NPV of the costs. If the B/C ratio is greater than 1 at the MARR, then the project is worth pursuing.

#### 1.2.8 Modified Benefit/Cost Analysis

If the investment is clearly identifiable, then the analysis can compare the NPV of the annual net benefits (annual revenues - annual expenses) to the NPV of the Investment. If the B/C ratio is greater than 1 at the MARR, then the project is worth pursuing.

### 1.3 Capital Budgeting

#### 1.3.1 Capital Budget

If there is a constraint on the amount of capital, then projects with the greatest return (ideally ERR, but often IRR) should be pursued first.

### 1.4 Tax Effects

Taxes affect the cash flows of a project and therefore may affect the relative rankings of competing projects.

#### 1.4.1 Investment Tax Credit

An investment tax credit reduces the income tax of a sufficiently profitable company by a percentage of the qualified investments in a particular year.

## 1.4.2 Depreciation

Depreciation is a noncash expense that has the effect of reducing taxes and therefore of changing cash flows. Tax policies specify rules for depreciation that generally allow a company to write off an asset before the end of its useful life (which tends to promote investment).

Depreciation is an accounting fiction that is accepted by the government; it should not be confused with the actual deterioration of an asset, which is what is critical to a project (except with respect to estimating taxes). Methods include: straight line, double declining balance, sum-of-the years digits, and the MACRS.

The value of assets used in a project ideally will be the market value rather than the book value of the assets. Rapid depreciation means that the book value will generally fall more rapidly than market value (and market value of real estate and other assets is likely to rise over the course of a project).

## 1.5 Inflation

Analysis can be done using constant (real) prices and an MARR that reflects real interest rates. Analysis can also be done using current (actual) prices and a combined MARR that reflects nominal (actual) interest rates. For high rates of inflation, the real MARR will equal

$$\text{Real MARR} = (\text{combined MARR} - \text{inflation rate}) / (1 + \text{inflation rate})$$

For low inflation, the real MARR will be approximately equal to the combined MARR minus the inflation rate.

If prices of all of the major expenses and revenues are expected to vary with general price levels, then a constant dollar analysis will be sufficient to rank projects. If prices of one or more of the major expense or revenue components is expected to vary significantly differently than general prices, then a current dollar analysis will be more appropriate. As expected inflation rises above 5% or so annually, then it will become increasingly important to include price inflation in the analysis.

Note (of interest but not on the quiz): in an inflationary environment, it may be useful to apply an estimate of actual physical depreciation to the inflated original value of an asset to obtain a better understanding of actual value of the asset. In inflationary times, a 5-year-old car can be worth more than its original purchase price, but a 15-year old junk car will only be worth a low value for scrap.

## 2 Benefits and Disbenefits of CEE Projects

CEE projects tend to have long lives and often have a large impact on land use and quality of life. A financial analysis alone is seldom adequate to determine which project should be pursued, when, at which location. Confusion about the relative magnitude and importance of

different types of benefits and costs, as well as the extent of impacts on various groups of people, further complicates the analysis.

## 2.1 Monetary Benefits

### 2.1.1 Direct

Investment

Annual Operating Expenses

Annual Tolls, Rents, and Other Revenues

### 2.1.2 Indirect

Increases in land value

Increases in agricultural production, valued at expected prices of products

Reductions in user time (e.g. time spent commuting valued at the average wage rate)

Reductions in expected injuries and fatalities in the use of the project, evaluated according to government guidelines (if they exist)

## 2.2 Non-Monetary

### 2.2.1 Improvements in quality of life

### 2.2.2 Improvements in accessibility

### 2.2.3 Improvements in safety

## 2.3 Disbenefits

Many possibilities, some monetary and some non-monetary.

## 3 Evaluating a Project

### 3.1 Objectives

Improve understanding of both the costs and benefits of a project and of competing projects. To the extent possible, the analysis will improve the characterization of costs and benefits:

- Non-monetary toward monetary
- Non-quantifiable toward quantifiable
- Sporadic toward equivalent continuous
- Unimportant toward important concerns
- Uncertain toward certain results
- Debate & controversy toward common understanding & consensus

### 3.2 Effectiveness of a Project

If costs and benefits are quantifiable, but not in monetary terms, it may still be possible to relate them to the monetary costs and benefits of the project. What is the incremental improvement in a non-monetary benefit per unit of investment? What is the increment change in a non-monetary cost per unit of financial benefit? With this sort of analysis, the non-monetary costs and benefits of a project can at least be compared to the affects of other projects on these categories of costs and benefits.

### 3.3 Distribution of Costs and Benefits

Who benefits and who pays are very important issues; is it possible to use some of the benefits of the project to reduce the disbenefits (externalities) that affect certain groups of users or non-users.

### 3.4 Selection of a Project

Any significant project will be complex, with different costs and benefits affecting large groups of users, neighbors, and non-users. While it is possible to develop weighting schemes to compare different projects and different approaches, an objective weighting scheme cannot determine which project is best unless one project dominates all others on all criteria. Ultimately, the selection of a project will be a political decision, and the promoters of a project must understand and work within a political process (which could be internal company politics as well as a public process involving neighborhood groups, elected officials, and legislation).

### 3.5 Alternatives to a Project

There are almost always a great many alternatives to a project - and a good analysis will try to cover (or uncover) all of the major options.

#### 3.5.1 Variations on the Project Size and Design

#### 3.5.2 Alternative Sites

#### 3.5.3 Alternative Times for Start and Completion

#### 3.5.4 Alternative Staging

#### 3.5.5 Alternatives to Satisfying the Goals of the Project

Transit instead of highway.

Coal instead of oil (or wind/water power instead of fossil fuels)

Rehabilitation of existing buildings vs. new construction

#### 3.5.6 Reducing the Demand for the Project Through Pricing or Education

Especially for water resource and energy projects.

### 3.6 Selecting from among Mutually Exclusive Alternatives

Arrange the projects in increasing order of the investment required. The project with the lowest investment that has an acceptable MARR is the initial "base" investment. Projects with higher investments are then compared to the base by considering the incremental return on the incremental investment - if this is at least as great as the MARR, then the investment becomes the new "base" investment for comparison with projects requiring even greater investments. This incremental analysis will select the project with the highest investment for which the incremental investment over the prior base is justifiable (i.e. the incremental rate of return is as great as the MARR).

### 3.7 Financing a Project

Engineering feasibility is not enough to make a project possible.

Large social benefits do not ensure that a project can be financed.

Ultimate profitability does not ensure that a project can be financed.

Ultimate unprofitability and large social disbenefits do not mean that a project will not be financed.

To finance a project, it is necessary to provide enough of a return to attract capital.

What can be built: depends upon the creativity of the engineer, engineering capabilities, time and financial resources.

What should be built: depends upon engineering economy, social costs & benefits, politics, ethical, and equity issues.

What will be built: depends upon entrepreneurial, political, and financial factors, as well as engineering economy, social costs & benefits, politics, ethical, and equity issues.

When and how it will be built: depends upon entrepreneurial, political, and financial factors, along with creativity and capabilities of engineering, as well as engineering economy.