1.011Project Evaluation: Comparing Costs & Benefits

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- Basic Question:
  - Are the future benefits large enough to justify the costs of the project?
- Present, Future, and Annual Worth
- Internal & External Rates of Return

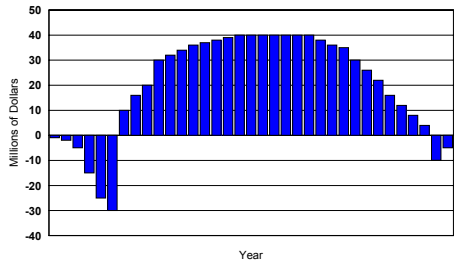
What Is a Project?

- For the planner (dreamer?):
  - A vision, a dream or a hope
  - A monument
  - A way to solve a problem
- For the construction company:
  - A specific task to be completed within a specific time
  - A way to make money through construction
- For the owner:
  - Potential benefits over the life of the project
  - A way to make money through operation
  - A monument
- For others:
  - Potential improvement in opportunities, environment, etc
  - Potential disruptions and degradation in environment

How Do We Justify a Project?

- Is this project worthwhile?
  - *Are the benefits greater than the costs?*
    - ***Are MY benefits greater than MY costs?***
- Is this the best way to achieve these benefits (either engineering & institutional options)?
  - *Can similar benefits be achieved more efficiently by some other approach?*
- Is this the best place to allocate resources?
  - *Do other projects have greater payoff?*
  - *Are other types of benefits more important?*

Cash Flow of a Typical CEE Project



Evaluating a Time Stream of Monetary Costs & Benefits

- Key concepts:
  - Time value of money
  - Risk vs. required return
  - Present Worth (= Net Present Value)
  - Equivalence (for PW, FW, and AW)
  - Project Life

Present Worth (Net Present Value)

The "Present Worth" of a project is commonly referred to as its "Net Present Value".

The NPV for the project is obtained by summing the discounted benefits for each year (using a discount rate i = MARR):

$$\text{NPV of Project} = PW = \Sigma[(B_t - C_t)/(1+i)_t]$$

We know that this NPV can be transformed into an equivalent annual or future worth.

Equivalent PW, AW, and FW

- Reduce all costs and benefits to time 0
- Compute the equivalent time stream of costs and benefits over the life of the project using standard formulas or spreadsheet commands:
- Use equations, tables or spreadsheet functions to calculate equivalent annuities (AW or "Equivalent Uniform Annual Benefits") or FW
- Be careful whether cash flows occur at the beginning or the end of the period (Annuities are generally assumed to be received at the END of the period)

Meaning of NPV

- NPV > 0, using a discount rate of i%
  - ►This project is better than making an investment at i% per year for the life of the project
  - ►This project is worth further consideration
- NPV < 0, using a discount rate of i%
  - ►This project does not provide enough financial benefits to justify investment, since alternative investments are available that will earn i% (that is what is meant by "Minimum Acceptable Rate of Return")
  - ►The project will need additional, possibly non-cash benefits to be justified

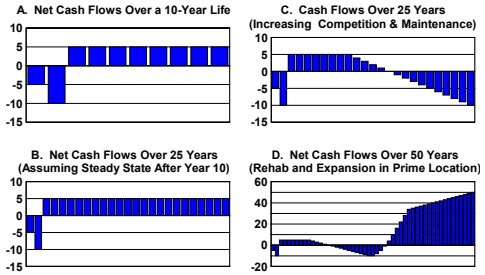
Importance of the Discount Rate

- Very low rates favor large projects with distant benefits
  - ►*Using very low discount rates may lead a country to undertake massive projects while ignoring current needs*
- Very high rates favor staged investments with quick payback
  - ►*Using very high discount rates may prevent a country from ever undertaking large infrastructure investments*

Importance of the Project Life

- Projects need to be evaluated over a reasonable project life (and the economic life will be shorter than physical life)
  - ►However, your choice of a project life should NOT determine the outcome of the analysis (if it does, you must show sensitivity of the results to project life)
- Because of discounting, the "out years" do not add much to the NPV, so a 20 to 50 year life is usually sufficient for analysis
  - ►The proper assumption is that the very long term effects will be positive or neutral - NOT that we can live it up now and let our children and grandchildren worry about the future!
- Risks increase with time
  - ►So we don't want to be dependent on long-term benefits to recover our investment.

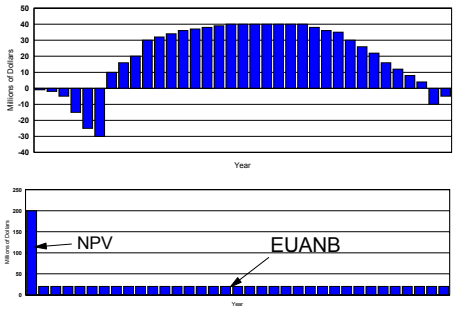
Choice of a Project Life Should NOT Determine the Outcome of Your Analysis!



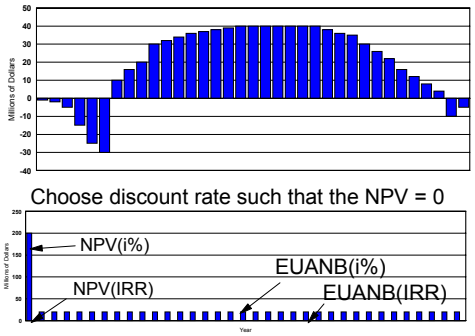
Other Ways to Evaluate Cash Flows

- Benefit/Cost Ratios
  - ►NPV(Benefits)/NPV(Costs)
  - ►Commonly used in public policy analyses
    - –Required in order to ensure that benefits (by SOME measue at least!) are greater than costs
    - –A political, not a methodological statement!
- Internal and External Rates of Return (IRR and ERR)
  - ►Very common in private sector, but there may be problems with IRR (which can be fixed by using ERR)
- Payback Period
  - ►How many years to recoup my investment? (A rather unsatisfactory approach that may be useful for quick assessment of some projects)

Cash Flows, NPV, and Equivalent Uniform Annual Net Benefits



Calculating the Internal Rate of Return



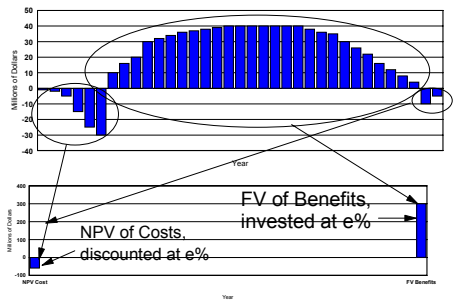
Problems With the Internal Rate of Return

- If the cash flows switch signs more than once, there could be two or more IRR for which NPV(IRR) = 0
- This method assumes that all intermediate cash flows can be discounted/reinvested at the IRR
  - This is unrealistic when the IRR is very high
- The private sector uses this method very commonly despite these problems

A Better Approach: The External Rate of Return

- Use a different discount rate (called the "External Rate of Return") to
  - Discount all expenses to time 0
  - Reinvest all benefits for the remaining time in the project life
- Then compare the NPV of the costs and the Future Value of the benefits
  - The external rate of return is the discount rate s.t. the NPV of the costs is equivalent to the FV of the benefits

Calculating the External Rate of Return



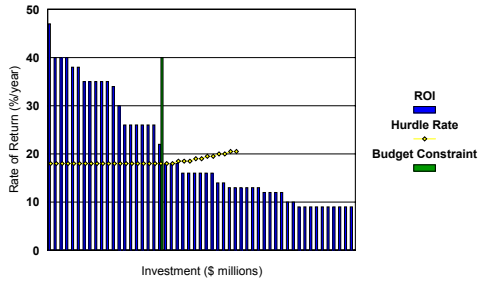
Are There Alternatives For Achieving the Objectives of this Project?

- The NPV analysis only shows that a project can be justified relative to the discount rate that is used
- There may be other projects that are even better for achieving the same objectives:
  - Better materials & technologies to build the same facility
  - Different design for a structure to serve the same purpose
  - Different location for a similar structure
  - Different scale (larger or smaller)
- In general, you cannot prove that your design is the best, you can only defend and refine (or abandon) your design in response to other options

Can We Justify this Project Against Competing Projects?

- In principle, any project with NPV > 0 is worth pursuing.
- In practice, capital budgets are limited, so that choices must be made:
  - *What set of projects gives the greatest benefits from using the available resources?*
- Common approach in private sector: Hurdle rate of return:
  - Rank independent projects by rate of return (typically IRR, but should be ERR):
  - Choose projects (or sets of projects) with highest return subject to a budget constraint

Selecting Projects Based Upon a Hurdle Rate of Return



Broader Economic Issues

- Prices of resources may not reflect their true costs
  - Local rather than world rates for energy costs
  - Natural resources priced at extraction cost rather than at market cost
  - Opportunity cost of land may be omitted (build the highway through the park)
  - Government may require use of excess labor as a public policy
- Generational equity
  - Discounting of future costs and benefits may lead to long-term decline in the environment
  - "Worry about today and the future will take care of itself"

Broader Economic Issues (Continued)

- Distributional Equity
  - Costs and benefits will be unevenly distributed
  - If total benefits exceed total costs, there is at least a possibility of compensating the losers
  - Pareto optimality - some are better off and none are worse off (after compensation)
  - "No one is hurt" (a very strong constraint on development)\
- Regional Economic Impact
  - Multiplier effect of project expenditures on the local economy
  - Use of local labor & resources
- Non-financial Externalities
  - Many impacts - both positive and negative - may be left out of the cash flow analysis
  - Environmental impacts & need for remediation

Broader Economic Issues - Conclusions

- For any large project, there will be additional costs & benefits that must be considered in addition to the cash flows directly related to the project
- Some of these costs and benefits cannot readily be reduced to monetary measures
- Distribution of costs & benefits will be a concern
- In some cases, the non-quantifiable items will be the most important items to consider

Dealing with Multiple Attributes

	NPV	Capacity Increase	New Jobs	Decline in Air Quality	Land Required	Effects on Congestion
Project 1	**$100**	**80%**	-15%	High	500 acres	Much more
Project 2	$50	75%	20%	Medium	200 acres	**Lower**
Project 3	$20	40%	**30%**	Medium	250 acres	Moderate
Project 4	$15	20%	20%	**Low**	**100 acres**	None

Dealing with Multiple Attributes

- There may be a clear winner, but unless one option is the best in all categories, it is impossible to say it is the best overall
- Weighting schemes may help, but the weights themselves are inherently a value judgement
- Selection of the best project in complicated cases will be a political issue rather than an economic issues

Dealing with Multiple Attributes: What Can An Engineer Do to Help?

- Clarify and quantify costs and benefits
  - Highly vocal objections may be based upon false assumptions - analysis can reduce these objections
  - Some objections may be perfectly true - but minor in the overall context of the project
- Conduct an incremental assessment of costs and benefits
  - The best project may be a larger or smaller version of the project under consideration
  - Staging may help to reduce initial costs and allow some benefits to be achieved earlier
- Consider options for ameliorating negative impacts
  - Minor additional investment
  - Somewhat broader scope for the project
- If there are major concerns, structure a political process for reviewing options, costs, benefits, and major decisions

Cost Effectiveness

- If the objective can be quantified, but not in monetary terms, we can calculate the cost effectiveness of various options
  - What is the cost per unit improvement in the objective for each alternative?
  - Even if we cannot put a value on the improvement, we know that it is good to
    - Minimize the cost per unit of improvement
    - Maximize the improvement per unit of cost
- How much to spend per unit of improvement becomes a political issue

Financing a Project

- The investor provides money for the project in return for a share of the benefits
  - Debt: low interest rate if cash flows are believed to be very secure
    - Comparison of debt payments to expected net cash flow
    - Could be based upon the credit of the owner rather than the quality of the project
  - Equity
    - Depends upon the expected cash flows after debt payments (including subsidies)
    - The higher the debt payments, the greater the risk
- Who bears the risks is a key concern for the owner, the contractor & sub-contractors, and the investors

Financial Feasibility vs. Project Desirability

- These two concepts are very different
  - Can we get money from someone to build the project?
  - Should we build the project?
- Financing restrictions may preclude certain highly desirable projects, yet encourage other clearly undesirable projects
- Engineers have some responsibility for pursuing desirable projects that can be financed
  - Proper presentation of estimated costs and benefits
  - Consideration and presentation of alternatives to the proposed project