Financial Assessment

I will gladly pay you Tuesday for a hamburger today.

J. Wellington Wimpy (Popeye's friend)

Introduction

No project is undertaken solely to make money, but money is a consideration in every project. Entrepreneurs are in the game primarily to make a lot of money, even though the projects they contemplate are at some level aimed at satisfying someone's needs or desires. Even if a project is contemplated solely for some marvelous cultural or aesthetic benefit, it will still be necessary to pay the carpenters and buy the lumber. We therefore must be prepared to deal with money, to understand why someone would be willing to invest in a project, and to understand how entrepreneurs and investors think about projects and about money.

Owners and entrepreneurs need funds up front in order to create their projects; they expect future profits to be sufficient to provide an attractive return on their investment. If they try to raise money from a bank or from investors, they must prepare a financial plan that shows how the project will generate sufficient cash flows to pay off the interest on the loans or bonds, while increasing the value of the company for stockholders. When trying to raise money, what the owners and entrepreneurs think the project is worth does not necessarily matter very much. What matters is what the bankers and other potential investors think the project is worth. If they perceive the project to be very risky, they will use a higher discount rate. If their portion of the project can be made less risky, then they will use a lower discount rate and be willing to invest more in the project. It is conceivable that projects that appear very profitable to the proponents may appear to be too risky to investors, who will therefore be unwilling to provide the funds needed.

In general, a project must satisfy three criteria to be worth pursuing:

- The benefits expected from the project must be greater than its costs.
- The project must be viewed as a good way to achieve these benefits, because there may be engineering or institutional alternatives that are as good or better.
- There must not be better ways to use the resources that would be devoted to this project; maybe it would be better to invest in housing than in transportation.

Basic methods of engineering economics can be used to assess competing projects based upon analysis of their projected cash flows and any economic impacts that can be expressed in monetary terms.

Maximizing Net Present Value

The net present value (NPV) of a project is the difference between the present value of the net benefits over the life of the project and the present value of the investment. The NPV of a project will depend upon the costs and benefits that are considered, the project life, and the discount rate. In general, the objective will be to maximize the net present value when evaluating alternative projects.

If the NPV is positive, then any equivalent annuity and any equivalent future worth will also be positive. If the NPV of one option is better than the NPV of another project, then any equivalent annuity A or future value FV will also be better for this option. Whichever measure is used, the ranking of any options will be the same. Depending upon the situation, it may make sense to focus on future worth or annuities rather than NPV, as shown by the following examples:

a. Planning for a major future event, such as replacing a bridge: the basic question is how much to allocate each year to a sinking fund so that the future value of that fund will be sufficient to pay for the bridge replacement.
b. Incorporating equipment costs in operating budgets: operating budgets can easily include weekly or monthly expenses. Converting the purchase price into an equivalent weekly or monthly cost is therefore a convenient way to allocate costs of equipment.
c. Construction of an office building: the critical time is likely to be the completion of construction, so it will be useful to estimate the future value of construction costs as of that time. It will then be useful to convert the FV of the construction cost into an annuity that could be used compared to anticipated annual rent payments and maintenance costs.
d. Investments aimed at improving the environment, where the benefits may be measurable but not in monetary terms. If it is not possible to monetarize the benefits, then it will be impossible or meaningless to talk about the NPV of such benefits. Instead, convert the investment cost into an equivalent annuity over the life of the project. That way, the comparison of alternatives can be based upon cost effectiveness by comparing the expected annual benefits of each alternative to its annual cost.

NPV analysis is widely used because it can translate the cash flows of complex projects into equivalent amounts that are very easy to understand and to compare, assuming that a reasonable discount rate is used and acknowledging the fact that different parties involved in a project may have different discount rates.

The choice of a discount rate will be extremely important in determining what kinds of projects are most appealing. If a very high discount rates is used, then the NPV will be based primarily upon what happens in the first 5-20 years of a project. Small projects with immediate benefits will look better with a higher discount rate, whereas large projects with benefits that extend far into the future may fare poorly. If a very low discount rate is used, the opposite will be true: future costs and benefits will be much more heavily weighted.

In planning for public projects, use of a low discount rate may promote undertaking very large-scale projects while ignoring very important current needs. On the other hand, use of a very high discount rate may prevent a company or a country from ever undertaking large-scale projects.

Importance of Project Life

Projects need to be evaluated over a reasonable project life. Several factors enter into the choice of a "reasonable" life:

- The economic life of the project: the period of time for which the project is expected to be in use.
- The period of time for which discounted cash flows are relevant to the analysis.
- Knowledge concerning any dramatic costs or benefits that might be expected in the distant future.

The economic life of a project can be much less than the physical life of the structures that are constructed. If a railroad is built to a mine, the railroad might be expected to last indefinitely so long as it is maintained properly. The facilities at the mine may also be constructed to standards that would ensure a life of 30-50 years. However, the ore may be gone after just 20 years, so that the economic life of both the railroad and the mine would be 20 years.

Unless very low discount rates are used, a 20 to 50 year life is usually sufficient for analysis. Because of discounting, the costs and benefits from more distant years will not add much to the NPV, so it will not be necessary to include them in the calculations.

Ignoring the out-years has been viewed by some as something very bad, as it means that the analysis would be ignoring the impacts of current decisions on unborn generations. Some have called for the use of a zero-discount rate so that the needs of future generations would be considered properly. In a financial analysis, however, it is foolish to talk of a zero-discount rate since in fact investors and the financial markets that provide the funding for projects do discount cash flows – and the amount of money that can be raised for projects depends upon their discount rates. Potential benefits that occur in the far distant future will not attract additional funding from the markets.

Of course there may be some merit to the argument that current projects may be damaging the environment, creating hazards or promoting serious financial problems in ways that will not be apparent for 20 or more years. If a 20-year life is used, then such problems may conveniently be overlooked. This problem can be dealt with by requiring additional considerations in the choice of the time period:

- Are benefits expected to continue to exceed costs for an indefinitely long period?
- Will the project need to be decommissioned at the end of its useful life, and is the cost of that decommissioning included at the end of the assumed project life?
- Are there potential catastrophic consequences that could be caused by the project beyond what is considered within the chosen period for the analysis?
- Are there extraordinary costs or benefits that can be expected after the proposed project life?

For projects where nothing unusual is expected in the distant future, the use of a 20-50 year project life will be long enough to capture the relevant costs and benefits associated with a project. For discount rates of 5% or more, the out-years will contribute very little to the analysis, and it will be rather meaningless to make projections further into the future. If the economic life of the project is less than 20 years, then a shorter life should be used. If there is reason to expect extraordinary costs or benefits that would be apparent only after a period of 20-50 years, then the project life should of course be extended. In normal circumstances, using a discount rate and limiting the life of the project should not be seen as somehow damaging to future generations – it is simply reflecting the reality of money and the principle of equivalence.

Does Discounting Ignore Future Catastrophes?

To answer this question, we need to define what is meant by a catastrophe and what the costs of a catastrophe might be. To provide some perspective, we can look at the more dismal side of history. There have been numerous instances where natural disasters – earthquakes, hurricanes, or tsunamis - have killed tens of thousands of people, and there have been outbreaks of disease that have killed that many people in a single year in many different cities. In 2010, a horrendously devastating earthquake destroyed much of Port Au Prince and other cities in Haiti, killed on the order of 100,000 people, and left more hundreds of thousands injured or homeless. In a few minutes, this earthquake caused double the amount of casualties suffered by US troops in all of this country's wars from Viet Nam to Afghanistan, and it caused 30 times the loss of human life suffered on 9/11. Wars with tens of thousands of casualties are commonplace in history, and the world wars of the 20th century killed tens of millions. Epidemics, often initiated as a result of natural disasters or warfare, can have the most devastating impacts on humanity. Millions of people died during the Great Influenza of the early 1920s, and the Black Plague reduced the population of Europe by a third during the 14th century. Diseases introduced by Europeans wiped out an even larger proportion of the native populations of North and South America during the 16th century.

Natural disasters, warfare and disease will unfortunately continue to afflict humanity with catastrophic consequences far into the future. Whether we are planners, engineers, political leaders, or private citizens, we should all be concerned with ways that we could limit the frequency or the consequences of such catastrophes. If discounting really does make it possible to ignore catastrophic events far in the future, then that would be a severe flaw in the methodologies commonly used in project evaluation. However, the financial, economic, and social costs of catastrophes can be so large that they cannot be ignored, even if the risks are small or far distant in time.

For example, consider the possibility of an epidemic that could break out in 50 years, taking the lives of 1 million people. Suppose that steps could be taken today that would reduce the expected fatalities by 90% or defer the epidemic for another 50 years. What would the benefits be, assuming a discount rate of 8%?

We can quantify the magnitude of such a disaster using an approach that various countries have adopted in managing risks associated with accidents, infrastructure failure, and natural disasters. This approach evaluates the cost effectiveness of risk reduction strategies by comparing the costs of a strategy to the expected reduction in fatalities. In the United States and in Europe, government safety regulations can be justified if the costs of improving safety are less than about $2.5 million per expected life saved.

If we use this approach, then an event that led to 1 million deaths would have a cost to society of 1 million deaths multiplied by $2.5 million per fatality for a total of $2.5 trillion (i.e. $2.5 x 10^{12}). This is an extremely large number. Even if this occurs 50 years in the future, the NPV of such a disaster is very large. With a discount rate of 8%, the NPV would be $2.5 trillion $(1/1.08)^{50}$ = $2.5 trillion (0.02132) = $53 billion, which is not an insubstantial sum of money! Thus efforts that could reduce the expected fatalities by 90% would be worth nearly $50 billion today.

If the disaster occurred 100 years in the future rather than 50, then the $2.5 trillion would be further discounted by another factor of 0.02131, and the NPV would be reduced from $53 to a bit more than $1 billion. Thus, reducing the magnitude of this catastrophe by 90% or deferring the epidemic for another 50 years would each have a NPV of approximately $50 billion. Discounting does not allow us to ignore future catastrophes; it provides a rational way to assess the cost effectiveness of strategies for preventing, preparing for, or dealing with potential catastrophes.

What would projects look like that had the effect of reducing the frequency or consequences of future disasters? For reducing the probability and severity of a pandemic, doctors can work to develop better drugs, public health officials can work to eliminate unhealthy slums and improve water supplies, and governments can stockpile emergency supplies of medicine and other supplies. To reduce the consequences of earthquakes and other natural disasters, governments can impose building codes that limit or require sturdier construction in dangerous areas, they can provide better communications and warning systems, and they can prepare for rapid response to natural disasters. A lot can be done in each of these areas for $50 billion!

Return on Investment and Internal Rate of Return

When reporting their financial results, companies produce reports that follow generally accepted accounting procedures to document profitability and return on investment (ROI). The ROI for a given year is calculated by dividing the company's annual profit by the company's net investment. By projecting a company's revenues and expenses into the future, financial analysts can predict future levels of profitability and ROI.

When evaluating investment opportunities, companies seek projects that will increase ROI for the company as a whole. To do so, a new project must, over time, provide a return on the new investment that is greater than the company's actual ROI. Thus, while an engineering economist might prefer using NPV analysis, senior management might prefer to know the expected ROI for a project. Some projects are very straightforward. If a new machine costs $100,000 and saves $15,000 per year in operating expense, then the ROI will be 15% per year. However, major infrastructure projects will never be so simple, because the initial investment may be spread out over several years, and the anticipated cash flows will likely vary from year to year.

It is of course possible to convert the initial investment into an equivalent investment I at time 0 and to convert the net revenues into an equivalent annuity A that will continue forever. Once this is done, the return on investment is readily seen to be A/I. This is a very useful concept, but the result depends upon the discount rate that is used, and the choice of a discount rate depends upon the perspective of the user. Another approach makes it is possible to estimate of ROI for a project without depending upon a pre-determined discount rate: simply find the discount rate that will make the NPV of the project's cash flows equal zero, in which case the ROI will equal the discount rate. This rate is known as the **internal rate of return (IRR).** The higher the IRR the better, and companies in the private sector commonly use this method to characterize the profitability of proposed projects.

Ranking projects by IRR only works for projects that are independent. If projects are mutually exclusive, then a smaller project with a high IRR may prevent a larger project with lower IRR but much greater total returns.

For example, suppose a company has identified four options for expanding their operations, all of which would use the same site. Various financial measures are given in Table 1 for each of these projects, and you are trying to decide if the annual net benefits are large enough to justify any of the investments. The annual benefits are expected to continue for a very long time, so the net present value of the benefits was estimated using the capital worth method, i.e. by dividing the annual benefits by 10%, which is your firm's minimum acceptable rate of return. The annual net benefits of $90,000 for Project A would therefore be worth $90,000/10% = $900,000. Since this is less than the investment cost, project A has a negative net present value and should not be pursued. For the other three projects, the present value of the benefits exceeds the investment cost, so that the NPV for each of these projects is greater than zero. Projects B, C, and D can therefore all be justified financially. If only one of the projects can be undertaken, then C is the best, as it has the highest NPV.

Table 1 Investment and Benefit Data for Four Projects

Project	Investment (NPV as of time zero)	Equivalent Annual Net Benefits	Present Value of Benefits (Using capital worth method)	Net Present Value of Project	IRR
A	$1 million	$90,000	$0.9 million	($0.1 Million)	9%
B	$2 million	$440,000	$4.4 million	$2.4 million	22%
C	$3 million	$600,000	$6.0 million	$3 million	20%
D	$4 million	$480,000	$4.8 million	$0.8 million	12%

The internal rate of return can easily be calculated for these projects by dividing the equivalent annual net benefits by the investment, with the results shown in the final column of the table. Since the IRR is greater than the firm's MARR of 10% for projects B, C, and D, these projects are all acceptable, but Project A with its return of only 9% is unacceptable. If only one of these projects can be undertaken, then selection based upon IRR would choose project B – but didn't we just figure out that Project C was the best? What's going on? Why doesn't the IRR method result in the same choice as the NPV method? The fact that projects cannot simply be ranked by their IRR is a serious problem with using this measure.

A second problem with the IRR is that the process for estimating it could produce multiple answers. The problem of dueling IRRs could arise whenever the stream of annual cash flows switches from positive to negative more than once, which is why the IRR method is seldom praised by academics. In most projects presented to the board of directors, however, there will be a pretty clear initial investment that produces positive annual net benefits that continue for an indefinite period with at most a heavily discounted cost for decommissioning in the distant future. With such projects, there will be an unambiguous result, which is why this method is commonly used in business.

A third problem arises because the IRR methodology assumes that any cash received during the course of the project can be reinvested at the same IRR, while future costs can be discounted using the IRR. For projects with a very high IRR, both assumptions could be very unrealistic.

External Rate of Return

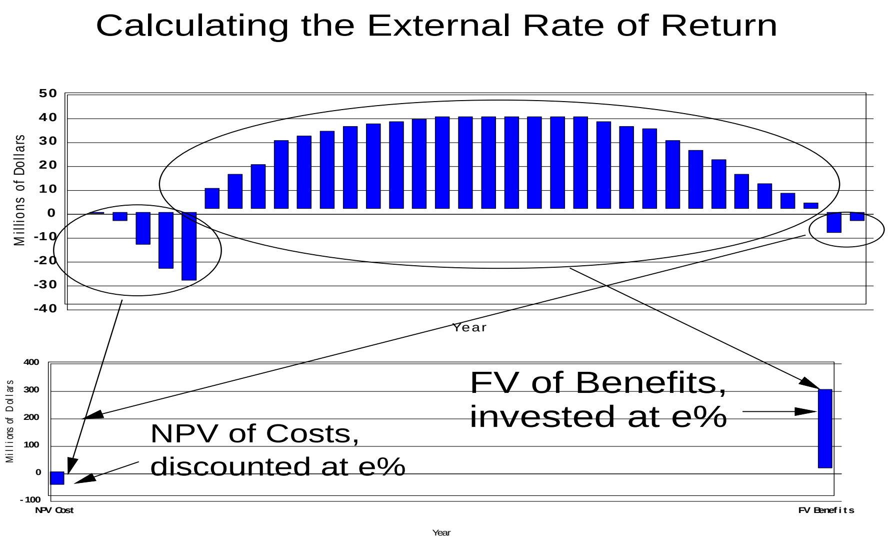
Since the IRR method is so commonly used in business, it is important to understand how to deal with these problems that might arise when it is used. A somewhat more complicated approach avoids the problem of multiple values for the internal rate of return as well as the difficulty of assuming that costs and benefits can be discounted with what could be a very high IRR. This approach uses what is called the **external rate of return** along with equivalence relationships to create an easily understandable comparison between costs and benefits:

- First, divide all of the periods considered in the analysis into periods where the cash flow is negative and periods where the cash flow is positive. There is no need to distinguish between investment costs, rehabilitation costs, or operating losses.

- Next consider the periods with negative cash flow. For each such period, we could establish a fund that would be expected to grow over time so that it could be used when needed to cover the negative cash flow. The size of the fund could be determined by using a discount rate that is consistent with the company's expected overall return on investment during the intervening years. This discount rate – the **external rate of return** – could perhaps be the company's minimum acceptable rate of return or the company's average rate of return. All of the negative cash flows could be converted to an equivalent present value using this external rate of return for a discount rate.

- Next, using the same external rate of return, all of the positive cash flows could be converted into a future value. The logic in extrapolating these funds to the future is that any extra cash generated by a specific project will be used to promote the overall activities of the company. For example, if the company has historically enjoyed a rate of return of about 10%, and if conditions in the future are expected to be no different, then the company could expect that the earnings from any new project in year t could be re-invested and earn 10% per year from year t until the end of the analysis period.

Figure



The discount rate used in these calculations is referred to as the "external rate of return", where "external" indicates that the rate of return is based upon factors that are unrelated to the specific project that is being investigated. The same external rate of return would be used for evaluating any project; it is not something that would have to be defined for each specific project.

Given an external rate of return, the following comparison between the future value of the positive cash flows and the present value of the negative cash flows can then be used to determine the return on investment (ROI) for this project:

(Eq. 1) FV positive cash flows = $(1 + \text{ROI})^n$ (PV costs)

Before using this equation, the external rate of return "e" must be used to calculate both the present value of costs and the future value of benefits. The ROI that satisfies the equation can readily be obtained by trial and error using a spreadsheet. The ROI could by coincidence equal "e", but most likely will be higher or lower.[1]

[1] This section uses the term "external rate of return," which is the term commonly seen in engineering economic textbooks. ERR is presented as a measure that is similar to, and better than, the internal rate of return, but it is not clear what is really meant by "e", the external rate of return. However, consider a company that uses their own discount rate to determine the present worth of the

The external rate of return approach is favored by academics, as it avoids the necessity of implying unreasonable returns for reinvesting profits, and it provides a reasonable means of dealing with future periods with negative cash flow. However, this approach is unlikely to be encountered outside of textbooks. Public agencies are apt to consider ratios of benefits to cost rather than ROI, while private companies use the internal rate of return as an easier and apparently more objective result.

Constant Dollar vs. Current Dollar Analysis

The discount rate observed in the financial markets reflects three factors: the return available on risk free investments, a risk premium, and inflation. Any analysis that uses historical or projected interest rates is using data that reflects past and future expectations concerning inflation. Inflation expectations are also among the many factors that affect the price of stocks and real estate. Inflation is also a factor in MARRs of individuals, companies and government agencies.

It is important that inflation be treated consistently when evaluating projects. In estimating costs and revenues, it is often convenient to ignore inflation. So long as the major elements of cost and the major sources of revenue all increase at about the same rate, a constant dollar analysis will result in a reasonable projection of cash flows. If there are some components that are expected to perform much differently, then some adjustments would have to be made in projecting cash flows. For example, the costs of computers and communications have declined for decades, so that it would be reasonable to assume that these costs would continue to decline relative to other costs. Over the last 20 years, energy costs have risen relative to other costs, and it would be reasonable that this trend would continue. Any project that had significant costs related to communications, computers, or energy therefore might require adjustments in projections of constant dollar costs and revenues.

Given projections of cash flows, it is necessary to ensure that the discount rates are consistent with the assumptions about inflation. Two sets of assumptions are reasonable:

- Constant dollar: neither cash flows nor discount rates consider inflation
- Current dollar: cash flows and discount rates both reflect inflation

If cash flows are provided in constant dollars, but are discounted with real discount rates, then future cash flows will be discounted too much. If cash flows are provided in current (i.e. inflated) dollars, but are discounted with discount rates that do not consider inflation, then future cash flows will be insufficiently discounted.

Inflation in even the most stable economies during the most stable economic conditions will usually be at least 1-2% a year; in other circumstances, inflation easily could be 3-4% per year in the most stable economies and much higher elsewhere. This is not a factor to be overlooked, as the mistakes could be considerable.

Choosing Among Independent Investment Options

Consider a company that has many independent investment opportunities. These opportunities are independent in the sense that choosing any one of them does not require or preclude any of the others. The company could decide to choose none, any, or all of the options. In theory, the company could decide to invest in any project with positive NPV. If the NPV is positive, that means that the project will produce cash flows that will, when discounted at the company's MARR, be equivalent to having more money today. However, the company's MARR will be at least as great as its weighted average cost of capital, and the cost of capital conceivably could rise if the company attempted

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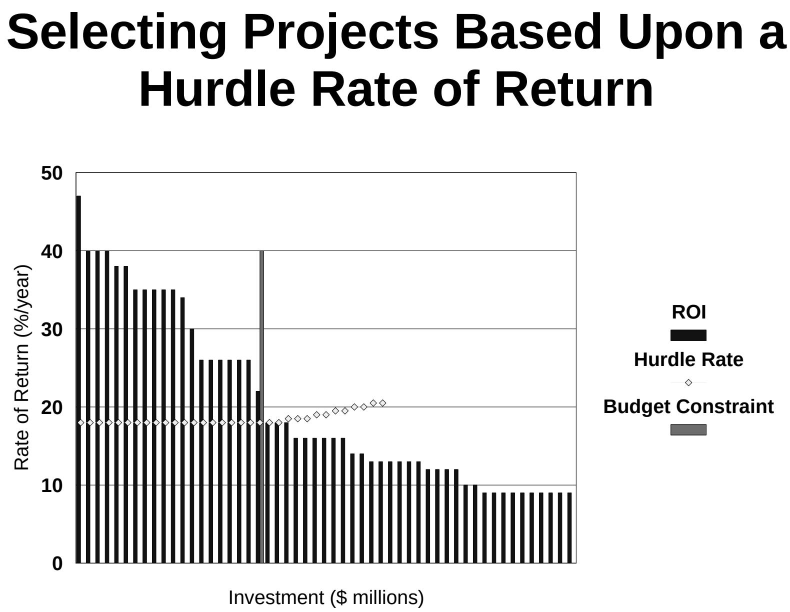
costs of a project and the future worth of the benefits. "Return on investment" for a particular project would then be defined as the annual growth that would be needed for the present worth of project costs to grow into the future value of project benefits at the end of the project life. With this approach, there is no need to introduce "e" as something new, because the usual discount rate would be used in the calculation. The return on investment for the project would then be seen as a clearly defined measure that is naturally dependent upon the use of the proper discount rate, just as NPV is dependent upon the use of the proper discount rate.

to raise excessive amounts. The company's executives and board of directors would also have some concerns about the quality of the analysis and the possibility that some projects might prove to be less successful than they hoped for. As a result, the funds available for projects would likely be limited, and only the best projects would be chosen. The objective would therefore be to maximize NPV subject to a capital budget constraint, which would be equivalent to maximizing the return on investment for the capital that is budgeted.

In practice, ma d to rank all
projects accor e companies
MARR (usuall aightforward
(Figure 2), at l g as the IRR
exceeds the hu



This process of ranking projects by their IRR assumes that the risks associated with the project are similar, so that they can each be compared to the same hurdle rate. A large company with many diverse opportunities for cutting costs or expanding markets will in fact have many investment options with similar risks: they know what to expect if they decide to make the investment. If the company is moving into a new type of business or if an investment is believed to have unusual risks, then a higher hurdle rate could be used. If an investment is deemed essential to the company's safety or to its continued operation, then the investment will be made even with an IRR lower than the hurdle rate.

As with so many elegant frameworks, this clear and logical process for selecting projects may not work so clearly or logically in practice. While a company indeed should know its MARR, that may be a subject of debate or it may not be something that is ever explicitly defined. The elegant model indicates that all projects whose expected return exceeds the MARR should be approved, ignoring the fact that there is always some kind of limit for capital expenditures. The limit is undoubtedly flexible, but that means that marginally acceptable projects may be approved only if they are supported by people with the power or persuasiveness necessary to convince the board of directors. The decision model depicted above also assumes that there is an ordered list of all of the feasible projects, none of which are mutually exclusive. No one who has ever seriously considered design will assume that they can ever know all of the alternatives, many of which will certainly be mutually exclusive. In a large organization, whether public or private, leaders from each department will be promoting their own projects; those who are more diligent, more eloquent, or closer to the senior officials may be the ones whose projects are approved.

There may well be many better projects that no one thought of or that no one wanted to champion. If you are an analyst or a consultant or a reviewer of a project, it is your job to look for some of those other options. Some possibilities would include:

- Use of better materials and techniques to build the same facility
- A better structural design to serve the same purpose
- A different location for a similar project
- A different scale – many smaller projects or fewer larger projects

In general, no one can prove that their design or proposed project is the best. They can only defend, refine, or abandon their proposal in response to whatever feedback and opposition they receive.

<u>Ranking Independent Projects using Present Value, Future Value, Annual Value or IRR</u>

If making money is your objective, then ranking projects by present, future or annual value would certainly seem to be the correct approach. The rankings obtained by using any of these three approaches would be the same, as the differences among them depend upon factors that vary only with the discount rate and the period of the investments. If the projects are independent and budgets are unlimited, then any project with positive NPV would be worth pursuing. If the NPV is greater than zero, then the internal rate of return will be greater than the discount rate, so that the IRR will also identify which projects should be pursued. However, as shown in the next subsection, the projects will not always be independent, and that is when difficulties are likely to arise in ranking projects using the IRR.

Choosing Among Mutually Exclusive Projects

Sometimes competing projects cannot all be pursued. They may both use the same land (should we build a hotel or an office building on this site?), they may offer different solutions to the same problem (should we build a bridge or a tunnel?), or they may be related to competing strategies of production and distribution (small retail outlets in every neighborhood or large box stores to serve the entire region?). There will also be variations in projects related to design and scale of effort: should the sports stadium seat 30, 50, or 75 thousand spectators? Should the bridge have four or six lanes? Should apartments have four rooms or five rooms? In cases like this, once a particular design is selected, the others are no longer available; the choices are mutually exclusive.

When selecting from a group of mutually exclusive projects, it does make sense (from a financial perspective) to maximize the net present value of cash flow. The best project will indeed be the one that is equivalent to the largest amount of money today.

However, if a company evaluates projects by choosing the ones with the highest IRR, problems are likely to arise. A prior example has already shown that the project with the highest IRR may not be the best project. The following example shows that the key to properly using IRR is to consider the rate of return on each increment of investment. If an incremental investment exceeds the MARR, then that increment can be justified, even if it lowers the IRR for the project.

Table 2 summarizes the investment and expected annual net income for four options for developing a site: build a parking lot or construct a building with one, two or three stories. If we assume that the same net income would continue indefinitely, then the annual rate of return would be the net income divided by the investment. For example, the parking lot's rate of return would be $22,000/$200,000 = 11%. We could also estimate the present worth of the income using the capital worth method: present worth equals annual income divided by our discount rate, and the NPV of the project would be the present worth of the income minus the investment cost. For the parking lot, assuming a 10% discount rate, the NPV would be $22,000/10% - $200,000 = $20,000. Table 3 shows the rate of return and the present worth for these four options.

Table 2 Mutually Exclusive Options for Developing a Site

Project	Investment Required	Annual Net Income
Parking lot	$200,000	$22,000
One-story building	$4,000,000	$600,000
Two-story building	$5,500,000	$720,000
Three-story building	$7,500,000	$960,000

Table 3 IRR and NPV for the Mutually Exclusive Options for Developing a Site

Project	Internal Rate of Return	Net Present Value
Parking lot	11.0%	$20
One-story building	15.0%	$200
Two-story building	13.1%	$170
Three-story building	12.8%	$210

If our hurdle rate equals our discount rate of 10%, then all of the projects are acceptable, whether we consider the IRR or the Net Present Value. However, if we have to choose just one of these, then we have a problem. Considering only the return on investment, the best choice appears to be the one-story building with its 15% return. However, the three-story building has a higher net present value. Which is really the best project? In your presentation to the board of directors, do you recommend the one-story building because the company always uses IRR to rank projects? Do you recommend the three-story building because the text books always recommend maximizing NPV? Do you accept a suggestion to compromise on a two-story building? What should you do?

To deal with these questions, it is necessary to do the analysis one step at a time, beginning with the option that requires the least investment, which in this case is the parking lot. Since the IRR of this project exceeds the hurdle rate of 10%, it is acceptable. The question now concerns the additional benefits that might be obtained from additional investment in this site. The one-story building requires an additional $3.8 million dollar investment in order to gain an additional $578 thousand in annual income. The rate of return for this incremental investment is therefore $578/$3800 = 15.2%, which is well above the hurdle rate. The NPV for this building is ten times greater than the NPV for the parking lot, so both measures indicate that the one-story building would be a good investment. Now we need to consider the benefit to be gained by the additional investment required to go from one to two stories. The additional investment of $1.5 million produces additional net income of $120,000 per year, so the ROI for the increment is only 8%, which is less than our hurdle rate of 10%. Thus, the two-story building is not as good as the one-story building. Although the IRR for this building is 13.1%, which is well above the hurdle rate, the incremental return for the additional $1.5 million is unacceptable. If we just look at the NPV, we immediately reject the two-story building because the NPV is $30,000 less than the NPV of the one-story building.

Now we proceed to the fourth and final option, the three-story building. We compare this building to the best of the previous options, namely the one-story building. The incremental investment in this case is $3.5 million and the incremental net income is $360 thousand, so the incremental return is 10.3%, which is just over the 10% hurdle rate. Therefore, the incremental investment is in fact justifiable. Once again, the NPV immediately gives the same result: the three-story building has the highest NPV and therefore is the preferred investment.

It is conceivable that the board of directors might be unwilling to commit $7.5 million to this site. If so, someone who hadn't followed the logic very closely might suggest cutting back to the two-story building, which after all has an IRR of 13.1% (perhaps snidely noting that this is higher than the 12.8% for the option recommended by the junior analyst). That would be the point in the meeting where you have to stand your ground: if the board is unwilling to commit $7.5 million, then they should stay with the one-story building because it has a higher NPV than the two-story building. And, if necessary, explain that the incremental $1.5 investment required for the two-story building would be better invested in another of the company's projects.

The procedure illustrated in this example can be used with any set of mutually exclusive investment alternatives:

- Rank the alternatives in increasing order of investment required.
- Estimate the IRR for the each alternative.
- Choose as a base case the first alternative whose IRR exceeds the hurdle rate.
- Compare the next alternative (i.e. the alternative with the next highest investment requirement) to the base case:
  - Calculate the IRR for the incremental investment.
  - If the incremental IRR is unacceptable, consider the next alternative and repeat this step.
  - If the incremental IRR is acceptable, make this alternative the new base case and repeat this step until either the capital budget is reached or all alternatives have been tested.

This process will find the highest investment that can be justified among the competing projects. It will also select the project with the highest NPV – which is why it is desirable to estimate the NPV even when you must present results in terms of IRR.

Dealing with Unequal Lives of Competing Projects

Competing projects may well have different project lives. If so, then several approaches can be taken to ensure that comparisons are done in a reasonable manner.

One possibility would be to choose a longer period that is an integral multiple of the lives expected for each of the projects. It could then be assumed that the projects would be repeated two or more times over the course of extended period of analysis. For example, if competing projects have lives of three years or four years, then the analysis of each could be done for a period of 12 years, as this would involve four cycles of the three-year projects and three cycles of the four-year projects. This approach could lead to some extraordinarily long life cycles if there are many projects with many different lives. For example, if projects have lives of five, seven or ten years, then a 70-year project life would be needed to have an integral number of cycles for each project. The problem with such a long project life is that it is very likely that technology, population, related development, and prices would change so much as to make very long-term estimates very questionable. It is not reasonable to use a 70-year horizon to compare options that all have lives of at most ten years.

A second approach would be to use the annuity value rather than the net present value. The assumption underlying this approach would be that any of the projects could either be extended at the same or a similar annuity value or be replaced by better projects. If the projects have similar, but not identical lives, the differences will not be dramatic:

> *Fundamentally, Equivalent Annual Cost is a robust measure regardless of the alterations from the original project and its identical repetition assumption. ... In reality, projects often do not repeat, but are rarely divested during their first life and dramatic cost change occurs only in the long run.*[2]

For typical projects, where the effect of unexpected early termination is minor and discount rates exceed 10%, the equivalent annual cost is reasonable to use even though projects have different lives. For riskier projects or projects with great uncertainty in cash flows, sensitivity analysis must be done to consider the effect of early termination and variable cash flows on the equivalent annual cost.[3]

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[2] Ted G. Eschenbach, Robert B. Koplar, and Alice E. Smith, *"Violating the Identical Repetition Assumption of EAC",* **1990 International Industrial Engineering Conference Proceedings,** Institute of Industrial Engineers, pp. 99-103

[3] Idem.

A third approach would be to include a residual value for each project at the end of the analysis period. The assumption underlying this approach is that it is possible to estimate residual values, which may be feasible, but which may also be much more trouble that it is worth.

A fourth approach is simply to use a long enough time period that any differences would be minimal. If discount rates are greater than 10%, then what happens after 20-30 years will have minimal impact on NPV.

As always, it is important to use common sense. When in doubt, do some sensitivity analysis using different time periods to determine to what extent, if any, the choice of the period of analysis is causing differences in rankings among the alternatives. There is no "right" method that must be followed.

Splitting a Project into Pieces for Different Parties

So far, we have considered the perspective of entrepreneurs, developers, companies, or agencies as they evaluate their options for undertaking construction projects. The discount rates and hurdle rates that they use will reflect their own investment opportunities, their own cost of capital, and their own perceptions of the risks associated with the projects that they are examining. If their projects are funded entirely by cash on hand, then this is the only perspective that matters.

More commonly, financing a project is only possible if a major portion of the money required for the investment can be raised from outside investors. If this money is a small portion of the total funds sought by the company, then the cost of the capital required (i.e. the interest rate on loans or bonds and the price per share of stock that is sold) can be assumed to relate to the overall financial strength of the company or agency. The discount rate used in the calculation of the present worth and the hurdle rate would be at least as high as the organization's weighted average cost of capital, and the financing of any particular project would be a small part of the overall financial management of the company or the agency.

Additional analysis will be necessary if the project is undertaken as a stand-along activity of a new company, if the project requires funding that is tied to its actual results (rather than to the overall financial strength or the organization), or if the project is a major departure from prior activities of the company. The project may require loans from a bank that are secured by the expected rents, tolls, or other proceeds of the project. The value of the company's stock could be related directly to the success of the project, taking into account the interest payments which must be paid to banks or bondholders before any dividends can be paid to stockholders. In these situations, it is necessary to consider the different perspectives of the potential investors.

A mortgage is a loan that is secured by a lien on the property. If mortgage payments are not made in a timely fashion, the mortgage holder has the right to foreclose on the property. Since the loan is backed by property, the mortgage is less risky than an unsecured loan, and the interest payments on a mortgage will be lower than the interest on an unsecured loan. It is possible to have multiple mortgages on a property. If so, then the mortgage agreements will state the order in which payments will be made if there is insufficient cash to make all of the contractual payments. The first mortgage will generally have priority over the second or any other mortgages, meaning that the holder of the first mortgage has first call on the cash flows of the company. The risk of not getting paid is therefore higher for the holder of a second mortgage than for the holder of the first mortgage.

After the payments are made on secured loans, the next priority will be to make payments on unsecured loans and to pay interest on bonds. If a company is unable to make such payments, then it can be forced to declare bankruptcy. A bankrupt company can in many cases suspend mortgage payments, interest payments, taxes and other fixed charges in order to reduce the outflow of cash while attempting to reorganize.

After all of the fixed charges and taxes are covered, whatever cash is left over can be paid out as dividends to stockholders or re-invested in the company. This portion of the cash flow will vary with the success of the company or the project; the higher the fixed charges as a total proportion of expected cash flows, the more uncertain the prospects for the company. The value of the company to the owners depends upon this portion of the cash flow: the higher and the more reliable the cash flow, the greater the value of the company.

Summary

Maximize the Net Present Value of Cash Flows

The equivalent worth methods provide the best way to compare alternatives. If the net present value is positive, then a project is worth pursuing, at least from the financial perspective. If the net present value is negative, then it is not worth pursuing. If the net present value is positive, then any future values and annuity values will also be positive, so any of these measures can be used to determine whether or not a project is worthwhile from the financial or economic perspective. Moreover, each of these measures will produce the same ranking of independent alternatives and the same choice among mutually exclusive alternatives.

Using the Internal Rate of Return to Rank Projects

Companies commonly use a different measure, the internal rate of return, to rank competing proposals for projects. The internal rate of return is useful because it can be calculated without reference to any pre-determined discount rate. It therefore appears to provide an objective assessment and an obvious means of ranking independent alternatives. However, there are three potential problems in using this measure to rank projects:

- If cash flows are highly variable, with multiple periods where cash flows are negative, then the methods used to estimate IRR may come up with two values.
- This method implies that all positive cash flows can be reinvested at the IRR over the life of the project. In fact, cash obtained from the project may have to be invested in ways that have much different returns.
- This method does not provide the correct rankings for mutually exclusive alternatives. It is necessary to consider the incremental return for incremental investments to determine which of such alternatives is best.

The IRR can be modified to deal with the first two problems by using an external rate of return for converting all periods with negative cash flow to an equivalent present value and converting all periods with positive cash flow to an equivalent future value. The rate of return is then uniquely defined as the annual return that will cause the present value of the costs to grow into the future value of the benefits. This approach will still require analysis of incremental returns for incremental investments in order to obtain the correct selection among mutually exclusive alternatives.

The Importance of Project Life

When comparing alternatives, the time period needs to be chosen with some care. In general, a period of 20-30 years will be sufficient because the discounted costs and benefits of more distant benefits will add very little to the present worth of a project. The choice of a time period should not determine the outcome of the analysis. If costs and benefits have both reached a steady state by the end of the analysis period, then there is no reason to worry about the choice of the project life, so long as the discounted cash flows from the excluded years contribute little or nothing to the present worth. If either costs or benefits are expected to rise or fall sharply just after the end of the analysis period, then a longer period will be needed. For example, if extensive rehabilitation is anticipated around 22-25 years, then the use of a 20-year life could be very misleading and a 30-year life would be better. In some cases, where there are extraordinary costs or benefits in the far distant future, much longer time periods should be considered. For example, the costs of dismantling an obsolete nuclear power plant and the ultimate costs of safely disposing or sequestering spent nuclear fuel should be included in the analysis, even if such costs are expected only after 40 or more years of operations.

Choosing Among Mutually Exclusive Alternatives.

If selecting one option precludes other options, then the options are mutually exclusive. The basic rule is to choose the option with the highest NPV (which will also have the highest annuity value and the highest future value),

If the internal rate of return is used, then care must be taken in ranking projects, because the project with the highest IRR will not necessarily be the best project. Constructing a smaller project with a higher IRR may preclude a larger project with a lower, but still acceptable IRR. It is therefore necessary to follow a well-defined procedure in determining which project is best.

- Rank the mutually exclusive projects in order of increasing investment requirements
- Determine the IRR for each project
- Starting with the smallest project, select the first project with an acceptable IRR as the base project
- Calculate the incremental costs and incremental benefits for each larger project.
- Calculate the incremental rate of return for each larger project.
- Select the first project larger than the base project that has an acceptable incremental rate of return. This becomes the new base project.
- Repeat the analysis of incremental costs relative the most recent base project.
- If there are no projects for which the incremental benefits justify the incremental costs, then the most recent base project is the best project.

Discussion: the Limits of Financial Analysis

In the private sector, financial performance will usually be what is most important in project evaluation. However, in the public sector, where projects are undertaken to meet public needs rather than to make a profit, economic, social, environmental, and sustainability issues will also be relevant. To the extent that economic factors can be expressed in monetary terms, it will be possible to use the same methodologies to calculate the NPV and the IRR. However, these global measures will not be the only things to consider when evaluating any complex project. Other economic issues will include distributional equity (who wins and who loses), regional economic impact (the use of local labor and resources and the multiplier effect on the local economy), and non-financial externalities (environmental and social impacts and the need for remediation). Any large project will have an impact on the public, and there will likely be many costs and benefits that are difficult to quantify and even more difficult to value. In some cases, non-quantifiable factors will be the major issues in project evaluation.

In conclusion, despite spending a great deal of time focusing on financial matters and believing that financial feasibility is essential for any project, we must recognize that financial feasibility may have little or nothing to do with project desirability. Whether or not it is possible to get money to build something is much different from whether or not something should be built. Financing difficulties may preclude certain highly desirable projects, yet encourage other clearly undesirable projects.

Engineers, managers, planners, and politicians have some personal responsibility for pursuing desirable projects that are financially feasible. Project evaluation depends upon proper presentation of estimated costs and benefits and disclosure of assumptions concerning discount rates, project lives, and the types and distribution of costs and benefits. It is not enough to show that a particular project can be justified; it is also necessary to show that it is better than the available alternatives.

Resource: Project Evaluation: Essays and Case Studies
Carl D. Martland