Project Analysis using Decision Trees and Options

Decisions on projects always involve uncertainty. *How do you deal with it*?

- *Probabilistic Analysis*: Assess risk by estimating project values for a *range* of outcomes for the underlying variables:
  - Sensitivity Analysis
  - Scenario Analysis
  - Breakeven Analysis
  - Simulations
  - Decision Trees
  - Valuing the options inherent in the project:
    - the option to delay a project
    - the option to expand in the future
    - the option to abandon the project
- *Risk Analysis*: Factor the risk into either the discount rate or the expected cash flows explicitly, and calculate *risk-adjusted* performance measures.

Sensitivity Analysis

- Project analysis is based on cash flows
- Cash flows are uncertain, and are based on assumptions
- Changes in the assumptions can change the decision

Sensitivity Analysis examines the sensitivity of a decision rule (NPV, IRR, etc.) to changes in the assumptions underlying a project.

The steps:

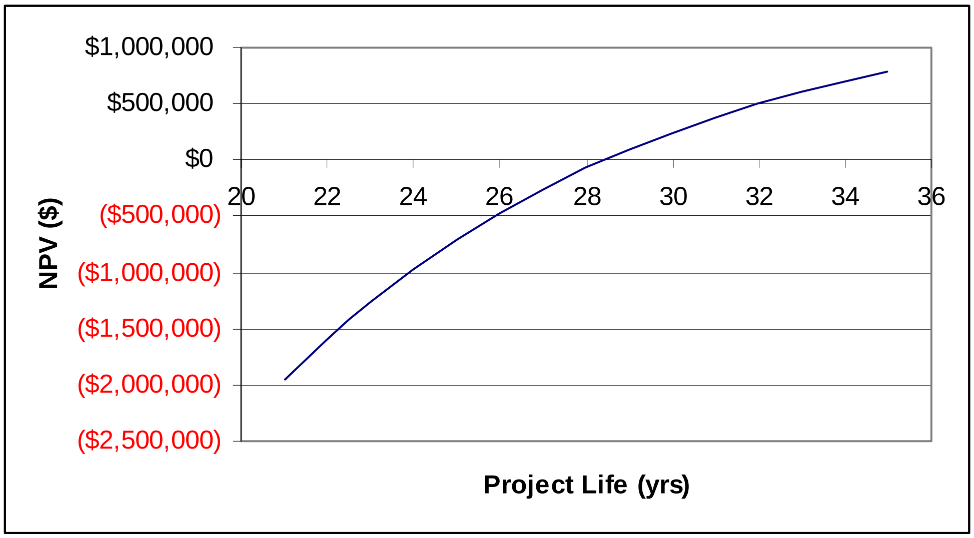
- Do a *base case analysis*, based on expectations about the future.
- Identify *key* assumptions in the base case analysis - these could be firm specific (revenue levels, operating costs, etc.) or macroeconomic (tax rates, inflation, etc.).
- Change *one* key assumption at a time, and estimate the decision criterion (NPV, IRR, etc.) - summarize the impact of changing the key assumption on the decision criterion in the form of a table or graph.
- Decide whether or not to take the project based on the *risk* of changes in the key assumptions.

The key assumptions must be either:

- those that matter the most, in terms of affecting cash flows (e.g. revenue levels), or
- those with the most uncertainty (e.g., it does not make sense to vary depreciation rates if they are fixed!).

Example:
Van Ommeren is considering construction of a new Oil Jetty at Rotterdam port for unloading petroleum products, at a cost of $40 million, which would save them $5 million every year in unloading costs paid to the Rotterdam Port Trust. The jetty has an expected life of 25 years. How sensitive is the project decision to life expectancy of the oil jetty? (assume r=12%)

- For a 25 yr life, NPV = $-0.7 mil, so it should be rejected.
- However, NPV as a function of the project life is:



- Hence, if the actual life of the jetty is 35 years, it could be a very profitable project!
- This shows how sensitive the NPV is to assumptions about project life.

Limitations of Sensitivity Analysis:

- It provides results for a range of values of key parameters, without providing any sense of the *likelihood* of these values occurring - In the previous example, how likely it is for the project life to be more than 30 years is important in evaluating the project.
- Only one assumption is changed at a time - in the real world, variables often move together. For instance, revenues may be low in precisely the cases when inflation is high and growth rates are low.

  This can be corrected using scenario analysis, where specific scenarios are developed for the future, and the viability of the projects is considered under each scenario (scenarios consider changes in many variables at one time). One can also do a best case and a worst case analysis to assess the potential upside and downside of the project.
- This analysis is used subjectively - due to different risk preferences of decision makers, one might accept the project while the other might reject it, based on the same analysis.

Breakeven Analysis

Accounting Breakeven: The number of units a firm must sell to ensure that it doesn't make an accounting loss.

- $$\text{Breakeven Units} = \frac{\text{Total Fixed Costs}}{\text{Sales Price}/\text{Unit} - \text{Variable Cost}/\text{Unit}}$$

Financial Breakeven: The number of units a firm must sell to have a zero NPV.

- Estimate the annual cash flow needed to make the NPV zero.
- Back out the revenues needed to generate these cash flows.
- Estimate the number of units that must be sold to create this revenue.

Financial breakeven is not only a higher hurdle, but also a more realistic hurdle, since it factors in the opportunity cost of funds invested in the project.

Example: The Boeing 777 project.

Sales price per plane	=	\$130 million
Variable cost per plane	=	\$ 97.50 million
Total fixed costs	=	\$2.35 billion

therefore,

Accounting breakeven = 72.31 planes

i.e., Boeing must sell at least 73 planes per year to cover its fixed costs and not show an accounting loss.

Financial Breakeven:

- The free cash flows can be estimated for the project for various sales levels (planes per year).
- For each of these cash flows, the NPV can be computed.
- The NPV can be plotted as a function of the sales level, to see at what sales level the NPV is zero.

In this example, the financial breakeven comes to about 78 planes per year.

Caveats:

- Breakeven analysis by itself does not answer the question of whether we should accept or reject the project - it just provides additional information to use in the decision
  - it provides a measure of margin of safety the decision maker has if the project is accepted.
  - Once the project is accepted, it provides a useful benchmark against which actual performance can be compared.

Decision Trees

This is a presentation of the decisions and possible outcomes, with probabilities, at each stage of a multistage project.

- Break the project into clearly defined stages.
- List all possible outcomes at each stage.
- Specify probabilities of each outcome at each stage.
- Specify the effect of each outcome on expected project cash flows (the discount rates may also vary at each stage).
- Evaluate the optimal action to take at each stage in the decision tree, based on the outcome at the previous stage and its effect on cash flows and discount rate, beginning with the final stage and working backwards.
- Estimate the optimal action to take at the very first stage, based on the expected cash flows over the entire project, and all of the likely outcomes, weighted by their relative probabilities.

Example:
Home Depot is considering introducing a new in-home computer shopping service. Knowing little about the business, they propose to make the investment in three stages:

- A ***market test*** on very few consumers, at a cost of $1 million. The likelihood of success is believed to be 75%.
- A ***partial introduction***, over one year, if the market test is successful. In this test, some widely used items will be put on-

line and marketed it to a wider audience. This much tougher test (50% chance of success) would cost $2.5 million.

- ***Full introduction*** at a cost of $15 million, if the previous test is a success. This will happen only by the end of the second year, and the service will start generating revenues only by the end of the third year. The three possible outcomes, along with the revenues (million $) over 4 yrs (yrs 3-6) and probabilities are:
    - Huge Success (12, 15, 18, 21, prob 25%)
    - Moderate success (7, 9, 11, 13, prob 50%)
    - Disaster (-2, -4, -6, -8, prob 25%)

Should Home Depot embark on this project?

- Construct a decision tree
- List all the outcomes, the cumulative probabilities of each outcome, and the corresponding NPVs.

Outcome	Probability	NPV
Full investment: huge success	0.09375	$23,066
Full investment: moderate success	0.18750	$7,978
Full investment: disaster	0.09375	-$26,252
Partial investment: stop	0.37500	-$3,222
Stop after market test	0.25000	-$1,000

- Compute expected NPV across all outcomes.
- In this case, the expected NPV is -$261, hence Home Depot should not embark on the project.

Limitations of Decision Trees:

- Decision trees provide a wealth of information to the decision maker, but they also require a wealth of information. Estimating all the outcomes and the probabilities is very difficult when the product or service is new or unique, and the firm has no past experience of similar projects.
- The project has to be analyzed in stages, hence decision trees are difficult to apply when investments occur gradually over time, rather than in clear stages.
- The outcomes have to be discrete (e.g., drug will be approved by FDA - yes / no). If the outcomes are not discrete (e.g., how high will the sales be), they have to be discretized into broader classes for analysis (e.g., the sales can be high / medium / low).

Hence, decision trees are most likely to work when:

- The firm makes decisions on the project in clear stages.
- The outcomes at each stage can at least be classified into broader classes.
- The probabilities of the outcomes and the effect on cash flows can be estimated at the start; this usually implies that the firm has done similar projects in the past.

Very often used by oil companies in evaluating opportunities to drill for oil.

Project Options

One of the limitations of traditional investment analysis is that it is *static*, and does not do a good job of capturing the options embedded in the investment:

- The first option is the ***option to delay*** taking a project, when a firm has exclusive rights to it, until a later date.
- The second option is taking one project may allow us to take advantage of other opportunities/projects (***option to expand***) in the future.
- The last option embedded in projects is the ***option to abandon*** a project, if the cash flows do not measure up.

These options all add value to projects and may make a “bad” project (from traditional analysis) into a good one.

The Option to Delay

- When a firm has *exclusive rights* to a project or product for a specific period, it can delay taking this project or product until a later date.
- A traditional investment analysis just answers the question of whether the project is a good one *if taken today*.
- Thus, the fact that a project does not pass the NPV or the IRR criteria today, does not mean that the *rights* to this project are not valuable.
- Having the exclusive rights to a product or project is valuable, even if the product or project is not viable today.
- The value of these rights increases with the volatility of the underlying business (i.e. uncertainty).
- The cost of acquiring these rights (by buying them or spending money on development - R&D, for instance) must be weighed off against these benefits.

Example: (Valuing a drug patent)

A pharmaceutical company has the patent rights to a new ulcer drug for 20 years. Although the drug shows promise, it is still very expensive to manufacture ($500 mil.) and has a small market (PV of cash flows from introducing the drug *now* is $350 mil.). The technology and the market are volatile, and the annualized variance in the PV is 0.05. How valuable are these patent rights?

- The NPV of introducing the drug is negative, but the *rights to this drug* may still be valuable due to the uncertainty in the PV of the cash flows.
- This drug *may be* profitable some years from now (we cannot rule that out due to the uncertainty).
- If this project becomes profitable, the firm has exclusive rights to exploit this opportunity - otherwise, the firm just lets the patent expire, which costs nothing (remember, R&D costs are *sunk costs*!).
- Hence, these patent rights give the firm an upside potential with some positive probability, and no downside potential at all!
- Therefore, this possibility of a profit in the future, with no possibility of a loss, must have some value.
- This value (of the patent rights) is the *value of the option to delay* investing in the project till it is profitable.
- If the project doesn't ever become profitable, the firm would just let the option expire unexercised.
- The value of this (call) option, using option pricing theory, comes to $51.02 million.
- Thus, this ulcer drug, which has a negative NPV if introduced now, is still valuable to the owner!

Question: Would you offer to pay $51.02 million for the rights to this drug today? Why/why not?

The Option to Expand

- Taking a project today may allow a firm to consider and take other valuable projects in the future.
- Thus, even though a project may have a negative NPV, it may be a project worth taking if the option it provides the firm (to take other projects in the future) provides a more-than-compensating value.
- These are the options that firms often call "strategic options" and use as a rationale for taking on negative NPV projects.

Example:

- Disney is considering investing $100 million to create a Spanish version of the Disney channel to serve the growing Mexican market.
- The PV of cash flows from this investment is only $80 million, i.e., the new channel has a negative NPV (of -20 million).
- If the Mexican market turns out to be more lucrative than currently anticipated, Disney could expand its reach to all of Latin America with an additional investment of $150 million, any time over the next 10 years. While current expectations are that the PV of cash flows from having a Disney channel in Latin America is only $100 million, there is considerable uncertainty about both the potential for such a channel and the shape of the market itself, leading to significant variance in this estimate.

Should Disney open the Spanish channel in Mexico?

- Disney can only expand into Latin America if it first tests the channel in Mexico, i.e., not entering the Mexican market rules out expanding into Latin America.
- If Disney enters the Mexican market, it also gets the option to expand into Latin America - if the market turns out to be good, it can make profits by expanding, otherwise, it just sticks to the Mexican market.
- Again, *once having invested in Mexico*, the firm has upside potential (profits from Latin America if scenario turns out to be good), with no downside potential (don't expand if things are not good!).
- This positive probability of a profit, with no probability of losses, must have value.
- The value of this option to expand into Latin America only arises if the firm enters Mexico.
- Therefore, the value of this option must be considered as a benefit of taking up the Mexican project.
- Using option pricing theory, the value of this option to expand is $45.9 million.
- Therefore, the NPV of the project (Disney channel in Mexico), *with the option to expand*, is:

  NPV = -20 million + $45.9 million = $25.9 million
- Therefore, take the project!

The Option to Abandon

- A firm may sometimes have the option to abandon a project, if the cash flows do not measure up to expectations.
- If abandoning the project allows the firm to save itself from further losses, this option can make a project more valuable.

Example:

- Disney is considering taking a 25-yr project which
  - requires an initial investment of $250 million in a real estate partnership to develop time share properties with a South Florida developer,
  - has a PV of expected cash flows of $254 million.
- While the NPV of $4 mil. is small, assume that Disney has the option to abandon this project anytime in the next 5 years by selling its share back to the developer for $150 million.
- The variance of the PV of cash flows is 9%.

How should Disney value this project?

- There is uncertainty about future cash flows.
- Disney has a *fallback* alternative - if things turn out to be very unfavorable in the next 5 years, they can still recover $150 million from the developer.
- There is no downside to this fallback alternative - if things are good, they continue with the project, if things are bad, they abandon the project and recover $150 million (*remember, we don't know which one of these will happen! - in all these cases, its the uncertainty that gives value to these options - in a world with perfect certainty, we know what would happen, so there is no "optionality"*).
- Therefore, Disney has a (put) option that must be valued, and added to the NPV of the project.
- In the next 5 years, *if* the PV of the expected cash flows from the project drops below $150 million, Disney will abandon the project and collect $150 million.
- The value of this abandonment option can be estimated to be $7.86 million (using option pricing theory).
- This option value ($7.86 mil.) must be added on to the NPV of the project of $4 mil., yielding a total NPV of $11.86 mil.