Project Valuation Using Real Options

A Practitioner's Guide

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REAL OPTIONS ANALYSIS: THE NEW TOOL

The discounted cash flow (DCF) method and decision tree analysis (DTA) are standard tools used by analysts and other professionals in project valuation, and they serve the purpose very well in many applications. However, as discussed in the previous chapter, these tools have certain limitations. For example, if there is large uncertainty related to the project cash flows and contingent decisions are involved, where mangers have flexibility to change the course of the project, some of the value is not accounted for by these tools. In this chapter, we demonstrate how that additional value can be captured by real options. We also compare and contrast real options analysis (ROA) with DCF and DTA.

HOW IS REAL OPTIONS ANALYSIS DIFFERENT?

Let's start with a simple example to illustrate how the real options approach is different. You have a chance to invest \$100 in a project. The payoff is expected to be between \$60 and \$160 with an average of \$110. The DCF analysis, which does not account for the uncertainty, will put the net present value (NPV) at \$10. Assume that this return does not meet your corporate standard; therefore, your decision will be not to invest in the project. But what if an initial small investment (say \$10) will help settle the uncertainty and give you an option to fully invest in the project at a later date only if the return is favorable but abandon it otherwise? You are likely to accept this idea. When the uncertainty clears over time and the return is expected to be favorable (let's say \$160), you will invest. If the return is expected to be unfavorable, you will walk away from the project. Thus, by considering the uncertainty and accounting for the managerial flexibility, you are able to make the right decisions to minimize losses and maximize returns. ROA helps you quantify the value added to the project due to the option.

A DEFERRAL OPTION

Using a more rigorous example below, we first demonstrate the value added to the project because of a deferral option, where you have a choice between investing in a project today with uncertain future cash flows and deferring the decision until next year, by which time the uncertainty is expected to clear. (This example follows that of Dixit and Pyndick, 1994.) Then we show how the option value increases as the payoff uncertainty increases.

You have a chance to invest \$100 in a project today that is estimated to yield a return of \$125 one year from now with a 50-50 chance that it may go up to \$170 (good case) or down to \$80 (bad case). But you also have the choice to defer the decision for a year, by which time the uncertainty about the payoff is expected to clear.

As shown below, using the standard DCF method with a discount rate of 15%, the project value today (time = 0), represented by its NPV, is \$9. Assuming that this return is acceptable, you may want to invest in it.

Time = 0	Time = 1 year
–\$100	\$125

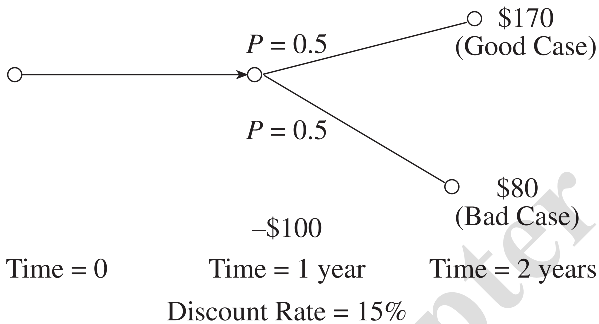
Discount Rate = 15%

$$\text{NPV} = \frac{\$125}{(1+0.15)^1} - \$100$$

$$= \$109 - \$100$$

$$= \$9$$

As mentioned, there is also a mutually exclusive alternative of deferring the decision until one year from now, by which time the uncertainty of the cash flows is expected to clear. Let's calculate the value of the project at that time for the good and bad cases (each with a probability, *P,* of 0.5), assuming the same conditions, so you can decide whether it will be to your advantage to wait for a year.



The expected NPV for the good case is:

$$0.5\left[\frac{-\$100}{(1+0.15)^1}+\frac{\$170}{(1+0.15)^2}\right] = \$21$$

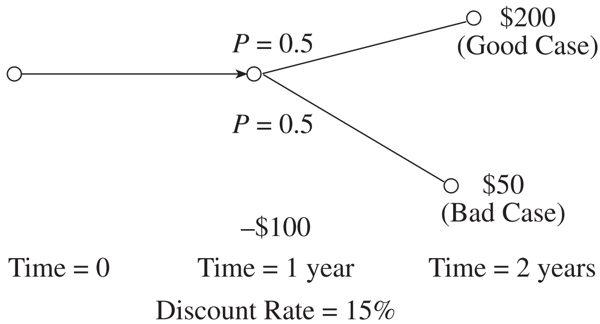
The expected NPV for the bad case is:

$$0.5\left[\frac{-\$100}{(1+0.15)^1}+\frac{\$80}{(1+0.15)^2}\right] = -\$13$$

In summary, the expected NPVs for the good and bad cases are $21 and –$13, respectively. Therefore, after one year, if it turns out to be the good case, you will invest in the project, but if it turns to be the bad case, you will not. Thus the decision to defer for one year is worth $21 today. However, the decision to invest now is worth only $9, as shown by the DCF method. Therefore, the value added because of the option to defer is the difference between the two alternatives: $21 – $9 = $12.

Effect of Uncertainty

In the above example, let's say that the net project cash flow is still expected to be $125 but with an increase in the uncertainty. What would be the effect on the option value if the payoff is expected to go up to $200 (good case) or down to $50 (bad case) with a 50-50 chance?



The expected NPV for the good case is:

$$0.5\left[\frac{-\$100}{(1+0.15)^1}+\frac{\$200}{(1+0.15)^2}\right] = \$32$$

The expected NPV for the bad case is:

$$0.5\left[\frac{-\$100}{(1+0.15)^1}+\frac{\$50}{(1+0.15)^2}\right] = -\$25$$

You would exercise your deferral option for the good case (NPV = $32), whereas you would let the option expire for the bad outcome (NPV = –$25). Even with the higher uncertainty in this scenario, the NPV calculated by DCF is still $9; therefore, the value added to the project when the deferral option is considered is $32 – $9 = $23. In the first scenario with lower uncertainty, the additional value was only $11. This shows that the option value increases with uncertainty.

DISCOUNTED CASH FLOW VERSUS REAL OPTIONS

Whereas DCF is a deterministic model, ROA accounts for the change in the underlying asset value due to uncertainty over the life of a project. In the above example, to keep it simple, we considered only two possible outcomes to represent the uncertainty. But there can be a range of possible outcomes over the life of a project, with the uncertainty increasing as a function of time. As a result, the range of asset values would take the shape of a curve, called the "cone of uncertainty" (Figure 4-1). ROA accounts for this whole range of uncertainty using stochastic processes and calculates a "composite" options value for a project, considering only those outcomes that are favorable (i.e., options are

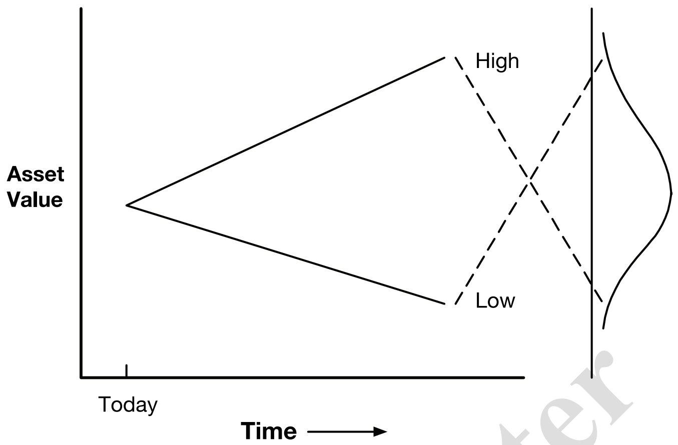


Figure 4-1. Cone of Uncertainty

exercised) and ignoring those that are not (letting the options expire). This assumes that the decision makers will always take the value-maximizing decision at each decision point in the project life cycle.

DCF accounts for the downside of a project by using a risk-adjusted discount rate. ROA, on the other hand, captures the value of the project for its upside potential by accounting for proper managerial decisions that would presumably be taken to limit the downside risk. Table 4-1 summarizes the major differences between DCF and ROA.

DECISION TREE ANALYSIS VERSUS REAL OPTIONS ANALYSIS

Both DTA and ROA are applicable when there is uncertainty about project outcomes and opportunity for contingent decisions exists. There are two basic differences between them:

1. As discussed in Chapter 3, DTA can account for both private and market risks, but ROA addresses only the market risk. The solutions to real options problems will not be valid for private risk, because the theoretical framework behind the solution development does not apply to it.
2. DTA accounts for the risks through probability of project outcomes. While it basically considers only two, three, or a few mutually exclusive possible outcomes, ROA accounts for a wide range of outcomes. This

Table 4-1. Discounted Cash Flow and Real Options Analysis Comparison

Discounted Cash Flow	Real Options Analysis
All or nothing strategy. Does not capture the value of managerial flexibility during the project life cycle.	Recognizes the value in managerial flexibility to alter the course of a project
Uncertainty with future project outcomes not considered.	Uncertainty is a key factor that drives the option's value.
Undervalues the asset that currently (or in the near term) produces little or no cash flow.	The long-term strategic value of the project is considered because of the flexibility with decision making.
Expected payoff is discounted at a rate adjusted for risk. Risk is expressed as a discount premium.	Payoff itself is adjusted for risk and then discounted at a risk-free rate. Risk is expressed in the probability distribution of the payoff.
Investment cost is typically discounted at the same rate as the payoff, that is, at a risk-adjusted rate.	Investment cost is discounted at the same rate as the payoff, that is, at a risk-free rate.

makes a difference in the discount rate used to discount the cash flows. As discussed in Chapter 3, there is no general agreement in the finance community on what the most appropriate discount rate is for decision trees, whereas a risk-free rate is established to be appropriate for ROA. The drawback with DTA is that probabilities of outcomes have to be estimated, which involves subjectivity.

In the absence of market risks, DTA is more appropriate for project valuation, but ROA is a better tool when such risks exist. The real options approach is not a substitute for but rather a supplement to decision trees. When there are contingent decisions involved and both private and market risks exist, both tools can be integrated into a framework that can offer the highest value to the analyst and the decision maker.

WHEN IS REAL OPTIONS ANALYSIS MOST VALUABLE?

ROA is most valuable when there is high uncertainty with the underlying asset value and management has significant flexibility to change the course of the project in a favorable direction and is willing to exercise the options. When there is little uncertainty and not much room for managerial flexibility, the real options approach offers little value (Figure 4-2).

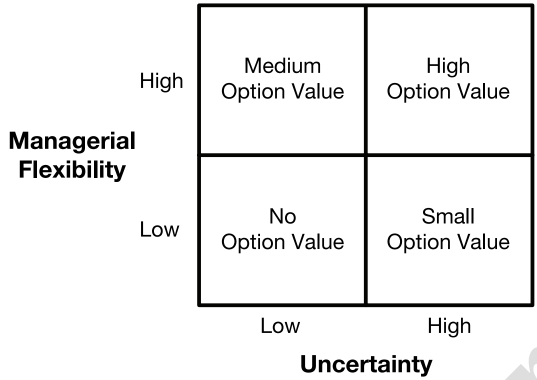


Figure 4-2. When Does Real Options Provide Value?

ROA does not provide much value in investment decisions on projects with very high NPVs, because the projects are already attractive for investment and the additional value that may be provided would not change the decision. Similarly, on projects with very low NPVs, the additional value provided by real options would most likely be so negligible that the investment decision would still be a "no go." As illustrated in Figure 4-3, real options offer the greatest value on projects with an NPV close to zero (either positive or negative) and high certainty.

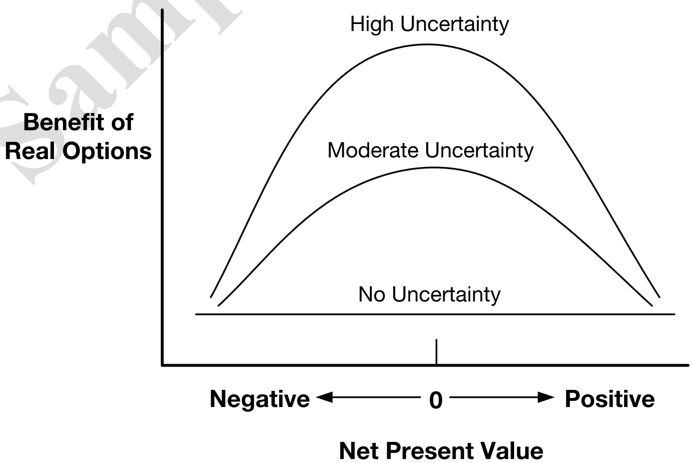


Figure 4-3. Benefits of Real Options Analysis Relative to Net Present Value

WHY IS REAL OPTIONS ANALYSIS VALUABLE?

A project with a high option value reflects high market uncertainty and high upside potential. More information may be obtained about such a project to study and resolve the uncertainty to facilitate the future contingent decisions. Instead of making a full-blown investment in a project or committing to it, you may conduct a market survey or execute a product rollout in a limited test market to resolve the uncertainty first. If the results are favorable, you would move forward with the full-scale project or even scale it up, thus taking advantage of the upside potential of the project. On the other hand, in the case of unfavorable results, you may scale down or abandon the project altogether, thereby limiting your losses to the small investment made to resolve the uncertainty.

Small investments made to clear market uncertainty are called active learning. You may also decide not to invest at all and let time take its course to resolve the uncertainty, which may occur due to changes in market conditions. This is known as passive learning.

Resolution of market uncertainty is necessary but not sufficient to capture the true options value, if the private uncertainty related to the technology effectiveness is high. Resolution of such private uncertainty requires active upfront investment. For example, a prototype may need to be built to demonstrate that the technology works, or a drug must pass clinical trials to prove its effectiveness.

Whereas DCF provides a fixed path for investment decisions, ROA offers a strategic map that outlines the contingent decisions, especially those related to private and market uncertainties. ROA will help you evaluate possible alternatives, so you can take advantage of the potential project payoff while minimizing the downside. ROA is not a substitute for but rather an extension of the DCF method. Every real option valuation starts with the underlying asset value, which is the expected payoff calculated using the DCF method, where risk premium is added to the discount rate to account for the uncertainty. Adjustments are then made to this value, taking into consideration the contingent decisions. ROA thus takes the DCF to the next level, making it a more sophisticated tool. It captures the additional value created by the options embedded in a project when the payoff uncertainty is high.

ROA offers valuable information for go/no-go decisions based on evaluation of projects not only for their own merit but also for their relative merit against other competing projects in a portfolio. When the option value is significant, less attractive projects ranked lower based on DCF alone can move higher on the ranking scale and receive approval for investment, bumping other projects. ROA can become a "tie breaker" where two or more competing projects have similar NPVs.

ROA, in lieu of the DCF method, should not be construed as a means to justify projects that should be turned down in the first place. If a project has a very high negative NPV, it probably should be rejected. Trying to justify such a project using real options would be a meaningless exercise.

When both market risks and private risks exist as well as opportunities for contingent decisions to change the future course of the project, ROA in combination with DTA can provide better valuation. ROA is not a substitute for either DCF or DTA. It supplements and integrates the traditional tools into a more sophisticated valuation technique.

TYPES OF OPTIONS

Options can be grouped into two basic categories: simple options and compound options. An example of a simple option is a deferral option (discussed earlier in this chapter), where you have the right to delay a project. This option exists on every single project. Option to expand is another common example, where you have the right to expand a project through additional future investments. Both of these are American call options, where the option can be exercised on or at any time before the expiration date and you acquire the right to invest (buy) in the project. Option to contract involves the right to scale back on a project by selling some of the assets when market conditions are not favorable to you. Option to abandon, which exists on every project, gives you the right to sell off all the assets and totally terminate the project. Options to contract and abandon are American put options, where you can exercise the option on or before its expiration date by selling your project assets.

Chooser option is an option that gives you the right to choose from a variety of options, including deferral, expansion, contraction, and abandonment. With a switching option, you have the right to switch between two modes of operation; an example would be switching between natural gas and fuel oil for boilers at a manufacturing facility. Chooser and switching options include both American calls and puts.

The value of a compound option depends on the value of another option rather than the underlying asset value. Compound options are common in many multiphase projects, such as product and drug development, where the initiation of one phase of the project depends on the successful completion of the preceding phase. For example, launching a product that involves a new technology requires successful testing of the technology; drug approval is dependent on successful Phase II trials, which can be conducted only after successful Phase I tests. With compound options, at the end of each phase, you have the option to continue to the next phase, abandon the project, or defer it to a later time.

Each phase becomes an option that is contingent upon the exercise of earlier options. For phased projects, two or more phases may occur at the same time (parallel options) or in sequence (staged or sequential options). These options are mostly American with the right to buy (call) or sell (put).

A compound option can be called a learning option if it involves resolution of either private or market uncertainty. For example, in the case of a product development project, a pilot test planned to resolve the technological (that is, private) uncertainty (predecessor option of a sequential compound option) leading the way to the product launch (successor option of a sequential compound option) would be considered a learning option.

Similarly, an initial market test performed to clear the market uncertainty is also called a learning option. In this case, the market test is the first and the product launch is the second sequential option. Organizations often do not commit full investments up front on large projects in order to take advantage of the compound options embedded in them. The initial phases of the project are used as the predecessor options for later phases of the project. For example, you may not start the construction of a chemical plant until the design/engineering work is complete, which you may not commence until the required permits are obtained. The idea is to watch for the uncertainty to clear as you go through the project phases and make go/no-go decisions on each phase accordingly. This is considered passive learning since it does not involve up-front investments exclusively made for the uncertainty to clear. Therefore, such options are not considered learning options. Thus, learning options are not different types of options per se, but are simply part of compound options that help clear uncertainty through active learning.

There is another group of options called rainbow options, which may be either simple or compound. Options for which multiple sources of uncertainty exist are called rainbow options. The uncertainty may be related to one or more of the input parameters used in options valuation or to the individual components that make up an input parameter, or there may be changes in the uncertainty itself over the option lifetime.

Examples of Different Types of Options

Option to defer — EnergyNow has acquired a 20-year lease for an oil field. It will cost $100 million to develop this oil field for extraction. Based on the estimate of the oil reserves and the current oil price, the DCF analysis based on a risk-adjusted discount rate shows a negative NPV for the project. But oil prices are highly volatile and may go up in the future. Therefore, based on the high options value of the project, EnergyNow decides to defer the exploration project until the market price of oil becomes favorable.

Option to expand — TaxTricks, a highly profitable tax-related software development company, is interested in expanding rapidly into other financial areas. The company has healthy cash reserves and can easily afford to acquire a small company that provides synergy to its current portfolio of products. But the current uncertainty shows a high value for the option to expand, which helps TaxTricks chart out a strategic map for future growth.

Option to contract — Super Shrinkers has been a very successful company focused on drugs for niche population groups. Due to changing and uncertain demographics, the market demand for its products is shrinking, and the company is evaluating an option to contract its operations in the near future through outsourcing and internal cost reduction.

Option to abandon — RoboPharms is a manufacturing firm that supplies drug-making equipment to pharmaceutical companies. It is concerned that it may have to close one of its major plants due to competitive market conditions. There is a great deal of uncertainty about the fate of this industry, especially due to potential new international trade legislation that would go into effect in the near future. Senior management feels that the uncertainty will clear in the next two years, allowing additional time to make a better informed decision using an option to abandon.

Option to choose — Choose 'n Chase Autos is an automobile manufacturer faced with the realities of today's globalization. It has to make a difficult choice between four strategies: continuation of the status quo, expansion, contraction, or total abandonment of some of its manufacturing operations. It uses a chooser option to optimize its decision and make the right choice.

Parallel compound option — BigWig Pharma is going through the final phase of human trials for a new drug and preparing the application package for FDA approval. Upon approval, the company will launch the drug with a marketing campaign. FDA approval provides BigWig an option to launch the drug, and successful completion of human trials provides an option to apply for the approval; hence this is an option on an option. Because both options are active simultaneously, this is called a parallel compound option.

Sequential compound option (option to stage) — Creative Chemicals is considering investment in a new plant to manufacture a chemical called creatin. Because of the market uncertainty regarding the profitability of creatin, the company uses an options approach to facilitate a go/no-go investment decision. The project is divided into three phases: permitting, design/engineering, and construction. Before constructing the plant, the design/engineering phase must be completed, before which the company must obtain permits. Thus, the project involves a phased investment and is a classic example of a sequential compound option, where the value of a predecessor option depends on the value of the successor option.

Learning option — In the parallel compound option example above, the final phase of human testing is a learning option, because it helps resolve the uncertainty related to the effectiveness of the test drug through active learning. (There are no learning options in the sequential compound example above, because there is no active learning associated with the options.)

Rainbow option — In the sequential compound option example above for the manufacture of creatin, the payoff is subject to two different sources of uncertainty: one related to the chemical's future sales and the other to the price of its primary ingredient. Because of more than one source of uncertainty, it is a rainbow option.

The next two chapters focus on the option valuation models and the process; Chapters 7 and 8 present the step-by-step options calculations for the different types of options introduced in this chapter.

PROBLEM

4-1. A major business unit of a global corporation is evaluating a portfolio of projects for next year's investments. Preliminary analysis of the projects provided the following information. What projects would you strongly recommend for further analysis using ROA?

Project No.	*Investment Cost (Millions)*	*DCF-Based Payoff (Millions)*	*Payoff Uncertainty*	*Flexibility with Contingent Decisions*
1	\$10	\$2	High	High
2	\$18	\$20	High	Moderate
3	\$26	\$62	High	High
4	\$55	\$53	Low	High
5	\$15	\$14	High	None
6	\$45	\$44	High	High
7	\$38	\$39	Moderate	High
8	\$22	\$22	Low	Low