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THE APPLICATION OF REAL OPTION THEORY IN ENTERPRISE RISK INVESTMENT EVALUATION

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Abstract:
Real option has a great implication in real world where the feasibility of the project is analysed not only by considering the downside risk but the opportunity of benefits due to upward variability is also taken into account. In this paper, the Real Option is discussed in detail where the mathematical models like Binomial Model, Black Scholes Model and Simulation methods for the financial option are used to value the Real Option. It is also discussed how the capital budgeting tools like NPV give a static picture of the financial feasibility of a project but, if an option is added to the analysis; the earlier rejected project may turn to be accepted. The Real Options of delay, expansion and abandonment of projects are discussed in detail with examples. Further, the difficulties of deciding the inputs and their values are also discussed with limitations in implementation to the real situation.
Keywords: Real option, binomial, put option, cash flow, NPV

Introduction

Investment decision of a firm is the part of a long term strategy where a large corpus is initially invested and its benefit arises for a long time in the future. Before proceeding with Investment, the financial feasibility of the project needs to be tested and hence, several capital budgeting tools like Net Present Value (NPV), Internal rate of Return (IRR), Profitability Index (PI) etc. are used. Apart from it, Scenario Analysis, Sensitivity Analysis and Simulation technique gives more insight to project evaluation for better cost control and proper allocation of funds and resources. With the project, the time of execution of certain activities is very important. For example, if currently, the price of raw material is too high to purchase, the project can be deferred to next year when the price will be getting low. Similarly, the addition of a new product in the existing chain of the product may be deferred if the cost of introducing the product is currently higher than the benefit arises. Hence, the decision of deferment on certain activities must be evaluated in terms of cost and benefit and here, the concept of Real Option comes into play. Option gives the holder a right to execute certain activities on the date of exercise as per his choice. Since it is a privilege, it costs whether exercise or not.

Real Option is similar to the financial option but the basic difference lies in its underlying. In the case of financial options, the underlying are financial securities like equity or bond while for real options, underlying are tangible assets like a business unit or project. So in the case of real options, the underlying risky asset is usually not a traded asset, Thus one estimates the value of underlying without flexibility by using traditional Net Present Value (NPV) techniques. The real options are different in one more aspect. The management controls over the underlying real assets on which they are written but it is no that happened in the case of financial options. In the case of both the options, the uncertainty of underlying, i.e. the risk is assumed to be exogenous.

Compared to the discounting cash flow (DCF) method, which accounts for the downside of a project by using a risk-adjusted discount rate, Real Option (RO) 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.(Kodukula et al.,2006) It is most valuable when the underlying asset value is highly uncertain and management has great flexibility to change the project process in a favourable direction and is willing to exercise the option. The real option approach is not a replacement for DCF, but a compliment to it. When contingency decisions are involved and both private and market risks exist, both tools can be integrated into a framework that provides the highest value for analysts and decision-makers.

Therefore, how to fully understand the theory of real options and apply it to evaluate the risk of a project to help decision-makers provide the optimal decision will be the theme of this dissertation. It will including what is Real Option theory, what is the difference between it and discounted cash flow theory, the calculation method of real option and its specific application case study.

Literature review

Investment outcomes can't be predicted with full certainty. Investment in projects requires a large cash outlay followed by a series of cash inflows till the life of the project. But, to what extent such cash inflows are certain and whether the investment cost will be recovered in full, is difficult to assess (Dixit &Pindyck, 1994). Further, the flexibility of timing of Investment is also present with a project. Therefore, the uncertainty and flexibility of Investment need to be taken into account for a better decision-making process. According to Teisberg (1995), dynamic Discounted Cash Flow (DCF) analysis and Real Option valuation are some of the techniques used to Investment uncertainty and flexibility. With the traditional Investment appraisal techniques like Net Present Value (NPV), the project is assessed with the projected cash outflow and inflow and the discount rate. It is the Net present value of all the expected cash flows discounted Cost of the project. If NPV comes positive, the project is accepted otherwise rejected (Brealey et al., 2001). Hence, in the absence of managerial flexibility, the NPV is the most suitable tool to assess the financial feasibility of the project. There are other tools like Internal Rate of Return (IRR), Profitability Index (PI) and Payback period (PI) that are used for Investment appraisal (Trigeorgis, 1996). But, all such tools provide the final outcome of the analysis – either accept the project or reject it. But, if we consider the flexibility of timing of Investment, the Investment decision may change. The flexibility of either delay the Investment or make the Investment before the scheduled time may profoundly affect the investment decision and the project may be accepted and more profitable with such flexibility (Dixit &Pindyck, 1994). The flexibility of waiting or delaying the Investment provides a great additional value to the Investment decision (Bodie& Merton, 2000). NPV is best suited to the project with no flexibility of Investment. Myers (1984) and Luehrman (1997) also argue that the traditional DCF model is only suitable for short-term, high certainty of one-time investment projects. In contrast, Real option theory is best suited to the projects that have great uncertainty and thus, such flexibility has a certain monetary value which is the value of the real option (Glantz, 2000). The flexibility in Investment decisions may be due to several uncertainties like change in the price level, change in inflation or Interest rate, technological changes, consumer behaviour, tax structure, any natural calamities, or anything else. Real option takes into account of such uncertainties that are not considered in DCF tools and techniques (Sporleder& Bailey, 2001).

The Net valuation of Investment under the 'real Option' theory is either equal to or greater than the value of the Investment under the NPV approach. NPV neglects the elasticity of the project and hence the value of the flexible Investment project is underestimated under the NPV approach (Bodie& Merton, 2000). For a static project, the value is equal to the NPV that is the difference of the present value of all cash inflows and Initial investment. But, if we add the flexibility of Investment decision to the project, the value of the project would be:

Total value = NPV + Value of flexibility (Real option value)

Therefore, the traditional DCF valuation and the Real options are complementary to each other. “The DCF techniques provide the base estimate and the Real option adds in the impact of positive uncertainty (Putten& McMillan, 2004).” Thus, there are two components of the project's value. One is the DCF component that uses a high discount rate to discount the expected cash flows to adjust the high degree of uncertainty in the future and thus, the DCF components gets lower. The other component is the Real option component that’s value will be high due to high degree of uncertainty. Its converse is also true.

Real Option Valuation Methodology

The Option on financial securities has mainly two variants – Call Option and Put Option. Call option is the right to purchase the security at an exercise price on a fixed date and Put option is the right to sell the security at an exercise price on a fixed date. The option is either exercised or not depends upon the type of option, Market price of the security on the date of exercise and the exercise price. Therefore, the value of the Option is Max (S – E, 0) and the value of Put option is Max (E – S, 0). A similar theoretical concept is also applied with Real option. The value of the Real option is driven by the degree of uncertainty where the company can make large gains due to upside variation but limit the downside loss by abandoning the project. Hence, the downside risk gets limited but the upside gain is reaped by the business through Real option."The value of an option must therefore increase as the uncertainty (and therefore the potential upside) surrounding the underlying asset increases, whether that asset is financial or real (Putten& McMillan, 2004).” The Real option can be in the analogy of financial options like Call and Put. The option to expand or continue the project can be viewed as Call options while the option to abandon the project can be viewed as Put option. A comparative view of variables used in financial option and Real option is given in table 1 below.

Table 1: Financial Option Vs. real Option

Symbol	Financial Option	Real Option
S	Stock price	Investment for purchasing an asset or proceed with the project
K	Strike price	The Current value of Assets or project
T	Time to Maturity	Time period of getting the opportunity
σ	Volatility	Project or Assets' riskiness
r	Risk-free rate	Interest rate
Div	Dividends	Cash flow from Assets or project

The financial option pricing model like Black-Scholes Model, Binomial Model or Monte Carlo Simulation technique can be used for pricing of Real option. According to the time to exercise, there are two types of Option – (i) European Option (ii) American Option. European Option are those options that are exercised at the expiration date while American option can be exercised at any time prior to the date of expiration. The Real option is generally the American option because the option of expanding or abandoning the project is exercised prior to the maturity life of the project. The three major methods of Option valuation is discussed as below -

Black-Scholes Model

Black schools model is option pricing model to determine the fair price of an European option based on six variables such as volatility, type of option, underlying stock price, time to expiration, strike price of option and risk free rate of return.

Mathematically it is calculated by using the formula –

$$C = S_t N(d_1) - Ke^{-rt} N(d_2)$$

$$where:$$

$$d_1 = \frac{ln\frac{S_t}{K} + (r + \frac{\sigma_v^2}{2})\, t}{\sigma_s \sqrt{t}}$$

$$and$$

$$d_2 = d_1 - \sigma_s \sqrt{t}$$

Where, C = Call option price, S = Current stock price. K = Strike price, r = Risk free rate of return, t = time to maturity and N = a normal distribution

The assumptions taken in Black Scholes Model are:

- Volatility - Volatility of price of underlying assets is assumed to be constant till the expiration of the option.
- No dividends – It is assumed that there is no dividends or cash flow from assets/projects during the life if option. If any such dividends or cash flow occurs, the value of an underlying asset is adjusted accordingly.
- Constant Interest rate – Like the volatility, Black Scholes Model assumes the constant interest rate over the life of the option. The constant interest rate is taken as risk-free rate of return.
- Log normally distributed return – Another assumption is log-normal distribution of Assets' return
- No transaction cost – Transaction cost is assumed to be NIL.

Once, the Value of Call option is determined, the Value of Put option can be determined through Put-call Parity theorem –

$c + K \cdot e^{-rT} = p + S$

Where C is the Call option price and P is the Put option price. The remaining variables have their own meanings.

The Binomial Model

As Black Scholes Model uses the continuous-time dynamics the Binomial Model uses the discrete-time dynamics and is "particularly useful for analysing the effects on option values of one-time events such as bankruptcies or mergers; and recurring events such as quarterly dividends; in addition to modeling the American option exercise (Sutherland & Williams, 2008, pp.08)." Calculating the Call option value through the Binomial Model uses the same five variables – price of underlying Assets, Strike price of Option, the Risk-free rate, Time to exercise of Option and Volatility of underlying Assets.

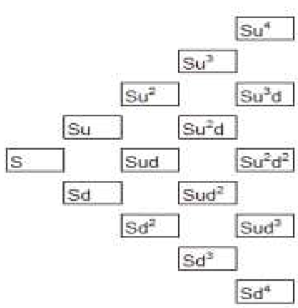
The time period of expiration of option is divided into sub-periods marked by 'nodes'. The price of underlying assets rises and falls according to its volatility and thus, the price of underlying is discovered at each node. The rising factor of the underlying price is denoted by 'u' that is calculated by the formula, $u = e^{\sigma * sqrt(t)}$ and the decreasing factor of the underlying price is denoted by 'd' that is calculated by formula, d = 1/u.

The probability of 'u' step is calculated by formula, $P_u = [e^{(r-y)} - d] / (u - d)$ and

The probability of 'd' step is calculated by formula, $P_d = 1 - P_u$

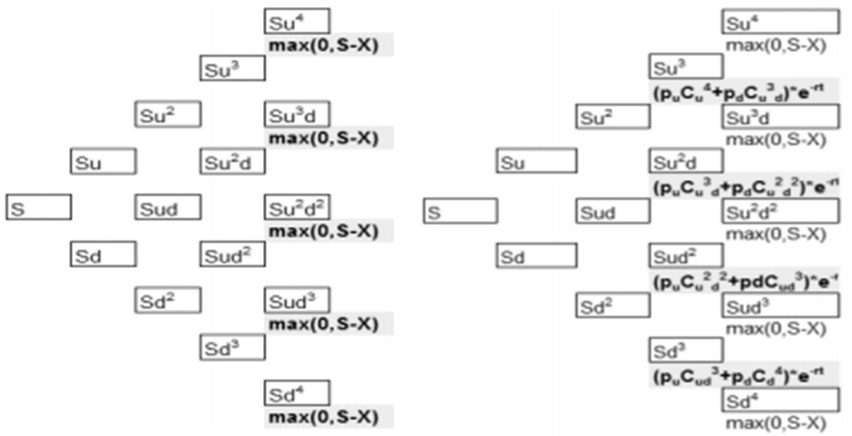
The graphical representation of Asset price movement through the branches of the binomial tree is as given in figure 1 below.

Figure 1: Binomial price path



The price of the underlying asset moves up by factor 'u' and moves down by factor 'd' at each time period. The value of the Call option can be determined at each of the ending nodes by using the formula – Max (0, S-X) where S is the price of underlying assets and X is the strike price of an option. Figure 2 shows the option price at each of the ending nodes. The value of the option at nodes before the last node can be calculated as given in figure 3.

Figure 2: Option value at ending nodes Figure 3: Option value at nodes prior to ending nodes



With the same recursive approach, the value of the option can be determined at the starting node of Binomial tree.

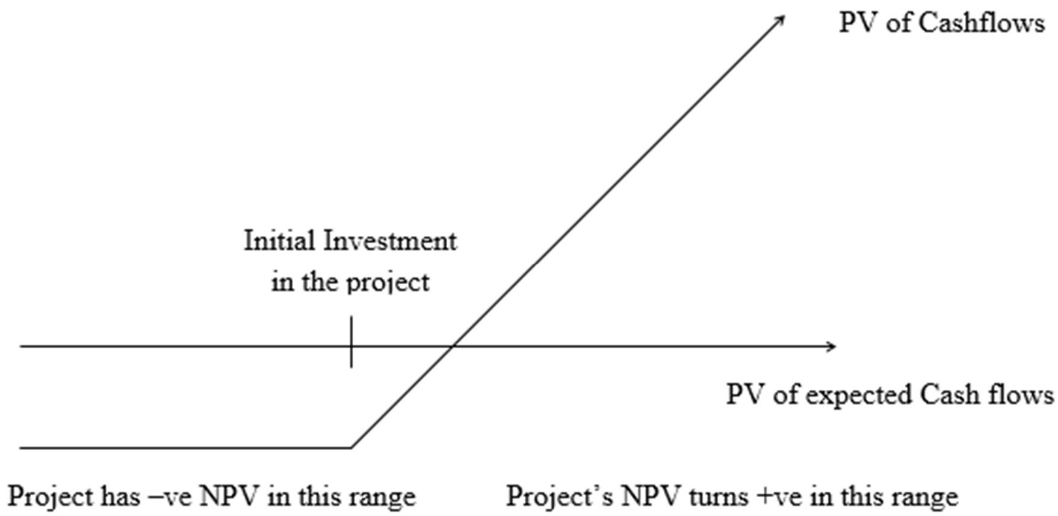
Whatever, the method we use to value of the Option, we have at last the value of the flexibility that can be used to decide on further expanding the project or delaying or abandoning it completely. Investment in risky assets may result in both high abnormal profit as well as a huge loss. The traditional DCF technique assumes only the possible downside risk and therefore, a high discount rate for all or later cash flows are used to discount for appraising the project in the worst scenario. In Real Option, we use the latest knowledge, information and expertise to reduce danger while expanding the opportunities. The three possible actions can be taken with risky Investment – First, the possible profit can be increased with sound knowledge and good fortune; this is the option to expand. Second, completely abandon the project when we receive bad news or we have sufficient information that the project is going to turn into a disaster and hence, we limit the loss. It is called Option to abandon. The third is holding the further Investment in the project when the future prospect of the project has a mix of good and bad sentiment. Hence, these three kinds of options can be exercised on the availability and nature of the information we receive. Accordingly, the potential downside loss can be limited but at the same time, good profit is made due to upside opportunities. But, such flexibility has a price that we need to pay.

Real Option Analysis

The Option to delay the project

A project is analyzed on the cash flows associated with it and the discount rate used to discount all the expected cash flows. Net Present Value (NPV) is the sum of the discounted value of all the future cash flows associated with it. If NPV is positive, the project is accepted and if NPV turns to be negative, the project is rejected. Therefore, NPV provides a static result for the Acceptance or rejection of the project. However, the underlying variables – expected cash flows and discount rate are subject to change, NPV is highly likely to be positive that was earlier negative and the project turns to be profitable in the future. For example, a projected is earlier proves to be rejected due to negative NPV. However, it is highly likely that the next year, the federal government will reduce the interest rate and correspondingly, the cost of capital will significantly reduce to the firm. Thus, due to the lowering of the Cost of capital or discount rate, the NPV turns to be positive and the project may be highly profitable. Similarly, the existing product is being undergone research and development and it is expected that in the next couple of years, the product will come to the market with innovative and unique technology and will swipe all the similar products. The consumer will prefer to buy and hence, the cash flows to the company will significantly rise. Hence, in both situations, the firm should wait for a while and then launch the project. However, such a wait will cost the firm in the terms of losing revenue and market share for the said period. Thus, the change in the project's value over time is the characteristic of Call Option.

The following pay-off diagram represents a call option.



To value the Call option (Option to delay), we need all the relevant inputs as we need to value final options. Those inputs are – (i) the value of the underlying assets which is the sum of the present values of all expected cash flows, (ii) variance of the cash flows (iii) Strike price of the option which is the Investment to the project (iv) life of the option (v) riskless rate and (vi) Cost of delay which is same is equivalent to dividend yield in financial option. Such inputs are, however, difficult to estimate.

Illustration –

Consider the example of a gold mine a company owns. The estimated reserve of a gold mine is 1 million ounces and the output capacity of the mine is 50,000 ounces per year. It is expected that the price of gold will rise by 3% per year. The company has the right to mine for the next 20 years. For starting the gold mining, the company has to spend a significant amount of $100 million initially and the average production cost is estimated to be $250 per ounce. It is expected that production cost will grow by 5% per year. The current gold price is $375 per ounce and it is expected that the price will vary by 20%. Currently, the risk-less rate of interest is 6%. These inputs are used in Black Scholes Model to value the option.

Therefore,

Value of the underlying asset is calculated as follows –

Present value of expected revenue = $(50{,}000*375)*[1-(1.03^{20}/1.09^{20})]/(.09-.03)$

= $ 211.79 million

Present value of expected Cost = $(50{,}000*250)*[1-(1.05^{20}/1.09^{20})]/(.09-.05)$

= $164.55 million

Hence, value of the assets = $ 211.79 million - $ 164.55 million

= $ 47.24 million

Now, Exercise price of the option = Investment required to open the mine

= $100 million

Variance in gold price= $(0.20)^2$ = 0.04

Time to expiration = 20 yrs (life of the project)

Risk free Interest rate = 6%

Dividend yield= Cost to delay = 1/20 = 5%

Since, the company has the right to use the mine for 20 years, therefore, the cost to delay implies the loss incurred per year for every year of delay.

Put these inputs in the Black Scholes model of Call option valuation,

d1 = -0.1676 ⇒ N(d1) = 0.4334

d2 = -1.0621 ⇒ N(d2) = 0.1441

The value of Call option $= 47.24 \exp^{(-0.05)(20)} (0.4334) - 100 [\exp^{(-0.09)(20)} (0.1441)]$

= $ 3.19 million

Therefore, if the project of mining is delayed by one year, the mining is worth $3.19 million while from the simple capital budgeting tool NPV, the project is worth now -$52.76 million ($47.24 million - $100 million)

This example shows that based on simple NPV analysis, the project is worthless but due to the option to delay, the project may still be valuable. Hence, a project that is currently supposed to be rejected may turn to be valuable if the option is attached to it.

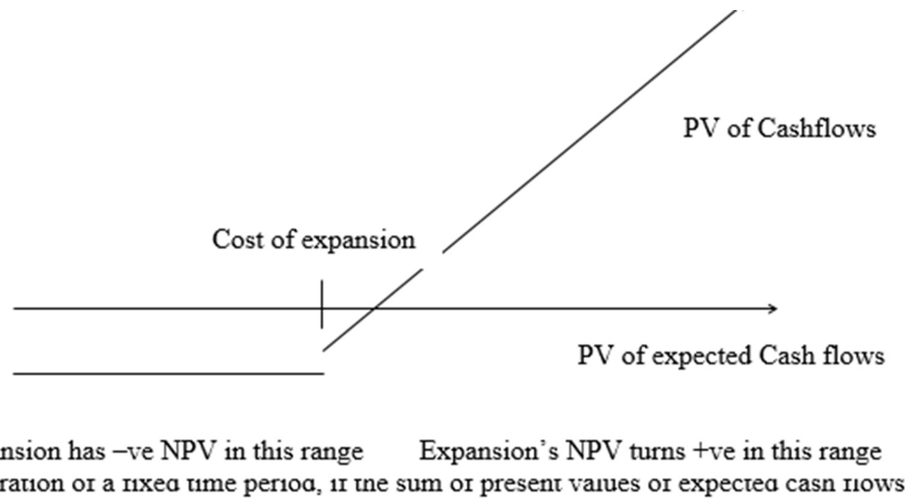
Here a certain number of assumptions are required to be made –

- Available reserves of the gold or any other natural resources can't be estimated accurately and immediately. Therefore, with the help of geologists and other innovative technologies, a thorough study of mines is required and then only, an accurate estimation can be made.
- The estimated cost of development of the project which is also the Initial investment in the project is the exercise price of the option and it is estimated based on past experience, similar projects or mathematical models.
- The natural life of resources or Inventory of the project is defined as the time to expiration of the option. It is also sometimes defined as terms of ownership.
- The variability in the value of underlying assets may be either due to variability in the price of the quantity of reserve or both. However, such variability is difficult to measure and it is taken as variance in underlying assets for the option.
- The cost to delay is the net revenue loss as the market value of assets or reserve and it is treated as dividend yield in pricing the option. In the case of extraction of natural resources, there is a time lag between the decisions taken for extraction and the actual extraction of resources. Thus, the loss of cash flows during the development period is adjusted for time lag by discounting back the developed reserve.

The Option to expand the project

A firm that undertakes a new project may have future planning of entering a new market, capturing the market share, or expand its existing business. Therefore, the initial projects can be treated as an option that allows the firm to undertake another project in the future. The initial project may have a negative NPV but still firm can undergo with this project in the anticipation of getting a higher and positive NPV from the future project.

Now, let the Initial investment required to take the new project is X and the sum of the present value of all the expected cash flows from this new project is V. Further, after a certain fixed time horizon, the firm has to decide whether it has to take this opportunity of expansion or starting the new project. The option pay off of this scenario is as follows –



At the expiration of a fixed time period, if the sum of present values of expected cash flows exceeds the cost of the project, the firm should undertake the new project.

Illustration –

A company - Home Depot deals in home essentials and it has exclusive stores across the city. The company is planning to open a new store in New York. The cost of building a new store is \$100 million and the present value of expected cash flows is \$80 million. Thus, at the first sight, the project has a negative NPV and is not feasible to start.

However, if Home Depot opens a new store, it has an opportunity or option to expand it in a much larger size after 5 years. The cost of expansion is assumed to be \$200 million and the present value of cash flows from the expansion is projected to be \$150 million. The condition of the market, the demand of the products and consumers' taste are not known and hence there is an uncertainty of cash flows with the variance of 0.08.

Now, by taking these inputs, the value of option of expansion is calculated as follows –

Value of the underlying assets = \$150 million (PV of expected cash flows)

The Exercise price = \$200 million (Cost of expansion)

Variance in assets' value = 0.08

Time to expiration = 5 years (it's the time period after which the right to expansion is exercised)

If the risk free rate is 6%

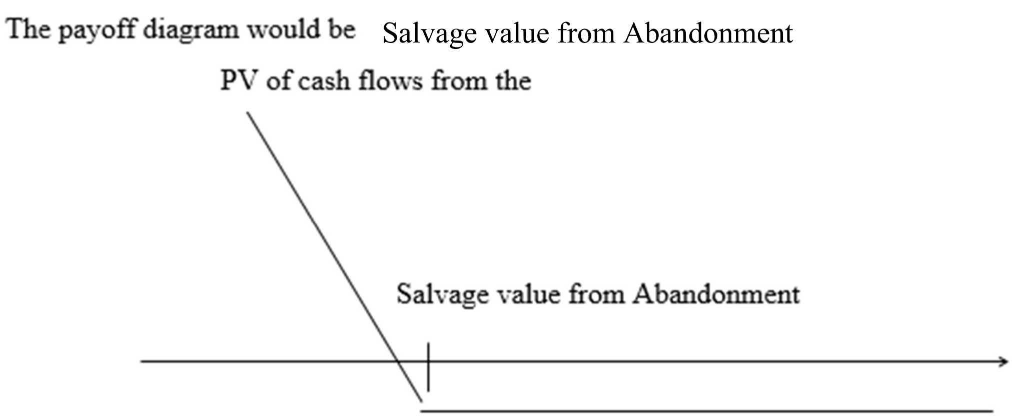
The value of the Call option = $150\exp^{(-0.06)(5)}(0.6314)-200(\exp^{(-0.06)(20)}(0.3833)$

= \$37.91 million

Therefore value of the option to expand is \$37.91 million.

If we combine this value to the NPV of store,
The NPV of the store with option to expand = \$37.91 million – 20 million i.e. \$17.91million
So, here we can observe that initially, the project seems to be not attractive because of negative NPV but when the project is analysed with option to expand, the project turns to be lucrative and hence, Book Depot should start the project despite of negative NPV initially.
There are few companies from IT or computing Industry as well from Biotechnology Industry that have a volatile business and there is a high possibility of yielding higher returns from their project. Thus, for such business, the Option to expand is more valuable than those businesses that are stable and generally earns stable and low returns on their project (eg – real estate Industry, Automobile sectors, utilities etc).
The Option to abandon the project
In a real-world situation, there may be instances when abandoning the project becomes more profitable than continuing with it. Suppose, at a certain point of time, V is the value of the project that is PV of remaining expected cash flows till the proposed life of the project and if the project is abandoned at a certain point of time, L is its liquidation value. Now, if V is higher than L, the project should be continued otherwise, it should be abandoned.
So, if the abandonment option is owned, the payoff would be

$$\text{Pay off} = \begin{cases} 0 & \text{if } V > L \\ L - V & \text{if } V <= L \end{cases}$$



Here, the Option of abandonment is Put option.

Illustration –

Suppose a firm wants to undertake a project where the initial investment of \$100 million is required and the PV of expected cash flows is \$110 million. The life of the project is 10 years. If the market condition is unfavorable and demand for the project is not generated sufficiently, the firm can abandon the project at any time during the next 10 years and in that situation, the firm can get \$50 million from selling off its assets. It is expected that the variance of the present value of cash flows is 0.09.
Now, putting all the inputs, the value of the Put option can be determined as follows –

Value of the underlying assets = \$110 million (PV of expected cash flows)
Strike price = \$50 million (Value of the project on abandonment)
Variance of the value of the underlying assets = 0.09
Time to expiration = 10 years (When the abandonment option is exercised)
If the riskless rate is 6%, the value of the Call option would be
Call Value = 110 (0.9737) -50(exp$^{(-0.06)(10)}$ (0.8387)) = \$ 84.09 million
Using Put-Call parity,
The value of Put Option = \$ 84.09 - 110 + 50 exp$^{(-0.06)(10)}$ = \$ 1.53 million
If the value of this Put option is added to the NPV of the project, the NPV of the project with abandonment option would be \$10 million + \$1.53 million i.e. \$11.53 million.
As the remaining life of the project decreases, the abandonment option will become more attractive due to a decrease in the PV of expected cash flows.
Here, we have assumed the salvage value of the project constant at the starting of the project but, practically, the value of abandoning the project changes over time. Second, the liquidation value of the project can be negative due to the different costs incurred on abandonment. Further, if the loss is incurred during the life of the project, it must be considered as dividend yield while calculating the option value. Therefore, the theoretical option value technique is difficult to implement in real-world due to high uncertainty in underlying variables.

Limitations

Despite of immense benefit of real option, it has certain limitations. With the different options to the project, the nature of limitations also varies. Correct estimation of underlying variables is a difficult task and it is common for all kinds of options. But, an option may have some specific limitations. For example, Option of delaying the project may have a severe limitation of correct estimation of macro-economic variables that make the project feasible if starts delay. Similarly, option to expand is based on the earlier project experience and may not be in the line of expected payoff from the project. Option to abandon may turn the salvage value negative and right to abandon may be contractual that is renewed year to year. Therefore, such limitations make the option pricing difficult to estimate. In addition, qualitative factors are completely ignored in option valuation. Therefore, the correct data and inputs are imperative for getting the full advantage of option. Otherwise, the downside risk can't be compensated correctly with upside benefits

Conclusion

Valuation of real option has a great implication in real-world situations where a company undertakes several projects and it has an option to delay, expand or abandon the project. Such option provides great flexibility to the business to make appropriate decisions for undertaking the project. However, the valuation of real option is difficult and even complex than financial option due to the correct measurement of underlying variables. In real-world, several exogenous factors work together on underlying assets, expected cash flows, variability in PV of cash flows and time to exercise the option. Therefore, the correct estimation of such variables is a difficult task. Further, the option valuation gives a quantitative figure of accepting or rejecting a project but qualitative factors are completely ignored. For example, a project may adversely affect the environment, society, and the health condition of workers that are completely ignored in option valuation. Hence, a project may seem highly profitable but not in favour of people at large. Overall, it is concluded that if we include the option in the project appraisal, then a project may be highly acceptable that is rejected earlier. The upside benefits due to uncertainty are correctly captured along with the consideration of downward risk. Hence, option in complement of NPV analysis provides a better insight into the feasibility of the project.

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