Real Option Analysis Using Black Scholes Model

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Real options valuation is a financial technique for evaluating investments under conditions of uncertainty, particularly uncertainty associated with market variables such as future product demand or the future value of an asset. Option pricing is a well-developed area of financial engineering, dealing with the valuation of puts, calls etc., but it is understood as a real option, when it is applicable to real assets like building, plant & machinery etc.

Real option analysis has become imperative to capture the value of a company due to future growth from new product variations, expansion of capacity for existing products. Black Scholes model of option pricing is able to use variables like volatility, exercise price to predict value of a given situation.

In this paper, we explore the existence of options in business decisions. It will have a small introduction to options, determinants of option pricing and the basics of option pricing. This paper would use Black Scholes model to find real option values in a given situation of a product/service and interpret to understand its importance & implications on the future of the given situation.

Keywords: *Real Assets, Black Scholes Model, Option Pricing, Exercise Price*

INTRODUCTION

Thales, a famous Sophist Philosopher circa 600 B.C., gazed into the star-studded sky one evening and predicted an outstanding, olive harvest, the next season. For a small up-front fee, he bought the right from the owners of the olive presses to rent them for the usual rate during the harvest season. If the harvest turned out to be meager, there would be less need for the presses and Thales would not rent them, losing the up-front fee. But if the harvest was bountiful, he would rent the presses at the regular agreed upon

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price and turn around and rent them out to the farmers at a significant margin. Sure enough, it was an outstanding harvest and Thales rented the in-demand presses and made a fortune. He was apparently more interested in proving the wisdom of Sophists than making money, as Aristotle tells this story in Politics.

This is one of the highly cited examples of a real options contract, wherein Thales bought an option, a right, but, not an obligation, to rent the presses, the underlying risky asset. This is a real option as the asset involved is a real asset. Thales used a call option, an American one and exercised it when it was in the money. Let us take some contemporary example.

Gene Miracles

It is a 21st Century biotechnology company that specializes in human genomics. It invented a new technology for which it obtained two patents, based on which it plans to develop a new product. Because potential market for the product is uncertain, the management does not want to commit to fully invest in its development and chooses to create an option to sell the technology if at any time during the development effort, it becomes clear that future payoff on the product would not be favorable. Genes & Foods (G&F) is another biotech company with a market niche in genetically modified foods. It has great interest in Genes Miracles new technology, which fits very well with its product portfolio. Both companies sign an options contract, which allows GeneMiracles to sell its patented technology to G&F for a price of $ 60 million, anytime during the three years of product development time. To acquire this option, GeneMiracles pays G&F $ 10 million. After completing two years of development work, based on the most reliable market information, GeneMiracles estimates the net future payoff on the product to be paltry $ 50 million, management therefore exercises its put option by selling the intellectual property to G&F for $ 60 million.

Moneymaker drugs

A company with healthy cash reserves and good potential for future profitability, is considering to expand one of its operations by 50% by possibly acquiring a start-up company. Due to market uncertainty, executive management does not want to commit to the full investment at this point. Therefore, it creates an option to expand anytime over the next two years, which it would exercise by acquiring the start-up for $ 6 million, if market uncertainty clears and shows positive results. For the option, MMD invests $ 1 million in the start-up company. At the end of second year, market information becomes clear, showing an estimated $ 10 million payoff due to the planned expansion.

At this time, MMD exercises its option by acquiring the start-up company and expands the operations. It could have maintained the status quo and not invested in the acquisition, if the expected market value of operations expansion had turned out to be less than the exercise price of $ 6 million.

BASICS OF OPTION PRICING

The widely known Black-Scholes model, developed by Economists Myron Scholes and Fischer Black, is used to value Real Options. Black Scholes formula is the fundamental means to evaluate the worth of a call option.

The drivers of option value can be condensed into five simple inputs:

1. Current value of the underlying asset (S)
2. Strike price of the option (X)
3. Time to expiration (t)
4. Risk free Interest rate (Rf)
5. Variance in the value of the underlying asset

Table 1. **Option Pricing of GeneMiracles and Money Maker Drugs**

Characteristic	GeneMiracles	MoneyMaker Drugs
Option	To sell patented	To expand operations by 50% technology by acquiring a start-up company
Call or Put	Put	Call
Expiration Time	Three years	Two years
Price	$ 10 million	$ 1 million
Exercise Price	$ 60 million (selling price of patented technology)	$ 6 million (cost of acquiring the start-up company)
Value of underlying asset at expiration	$ 50 million (expected payoff from technology)	$ 10 million (the expected payoff from expansion)
Option value at expiration	$ 10 million ($ 60 million - $ 50 million)	$ 4 million ($ 10 million - $ 6 million)

RESEARCH METHODOLOGY

This Paper considers the case study of 'Stealth Tier' to understand the application of Real Options to Cable Sector, using Black Scholes Model.

Further, it focuses on Real Option valuation of Dyslipimedia molecule of Cadila Heathcare Limited.

This Real Option Value is calculated by taking different parameters like Underlying Asset Value, Exercise Price, Time to Expiration, Volatility (Risk) and Convenience Yield. Data has been collected from different sources for all these variables, which have been mentioned.

It also talks about the limitations of Black Scholes Model as applicable to Real Options.

CABLE'S "STEALTH TIER" - A SCALE-UP OPTION

In recent years many cable companies have upgraded their plant. The result is capacity beyond current usage. CSFB cable analyst Laura Martin used real options analysis to value this additional capacity. Of the 750 MHz available in an upgraded cable system, approximately 648 MHz are being used for four visible revenue streams (analog video, digital video, high-speed data, and telephone).

We refer to the remaining 102 MHz as the "Stealth Tier." It is the tier of future interactive services that do not exist today. However, lack of visibility does not mean a lack of value. The Stealth Tier could include services such as video telephone, interactive ecommerce, interactive games and any other application that requires enormous amounts of bandwidth. Entrepreneurs who develop an application requiring broadband delivery must pay the cable operator—the gatekeeper—for access to consumers. By calculations, the present value of the four visible revenue streams equals the current public trading value per home passed by cable wire. Accordingly, investors are attributing no value to the 17 empty 6 MHz channels on the interactive tier. Embedded in the upgrade of the cable plant is a growth option—or scale-up option, that is being overlooked. We know that the additional 102 MHz will be used, we just do not know when or how. Real options provide a framework for estimating the Stealth Tier's value.

Five potential NPV outcomes have been shown in the analysis. To minimize analytical complexity, we hold four of the five option inputs constant, making the valuation impact of the various NPV assumptions transparent. We hold volatility (?2) constant at 45% per year (the midpoint of the volatility range), time (t) constant at ten years (cable plant's life), the risk-free rate (Rf) constant at 5.2%, and the marginal cost (X) per proposed project at 50% of the project's value.

Table 2. **Black Scholes Call Option Matrix Valuation**

PV of Potential Project /Home passed (S)	$ 15	$ 25	$ 50	$ 100	$ 150
Marginal Capital Spending (X) in $	7.5	12.5	25	50	75
Time in years (t)	10	10	10	10	10
Risk free rate (Rf) in %	5.2	5.2	5.2	5.2	5.2
Volatility (?2) in %	45	45	45	45	45
Call Option Value /Home passed	$ 11.60	$ 19.40	$ 38.80	$ 77.60	$ 116.40

Source: Black Scholes Model, Credit Suisse First Boston Measures

Using these variables for each 6 MHz channel in the Stealth Tier, we can determine a range of values. Using just the 17 empty 6 MHz channels available, implies a call option value per home passed of $197-1,979 for the Stealth Tier. (Table 3.) The midpoint of this range is $1,088, representing approximately 50% of today's trading value per home passed.

Table 3. **Value of the Stealth Tier Using Real Options Theory**

PV of Potential Project / Home passed (S)	$ 15	$ 25	$ 50	$ 100	$ 150
Call value/home passed, as per Black Scholes	$ 11.60	$ 19.40	$ 38.80	$ 77.60	$ 116.40
Empty 6 MHz channels in Stealth Tier	17	17	17	17	17
Value of Stealth Tier/home passed	$ 197	$ 330	$ 660	$ 1,319	$ 1,979

Source: Credit Suisse First Boston Estimates

CADILA HEALTHCARE LIMITED

A mission to create healthier communities: The company is dedicated to life in all its dimensions. Its world is shaped by passion for innovation, commitment to partners and concern for people in an effort to create healthier communities, globally.

A vision that unleashes value: To be a leading global healthcare provider with a robust product pipeline; stepping beyond the billion, the Company shall achieve sales of over $3bn by 2015 and be a research-driven pharmaceutical company by 2020.

Cadila Healthcare Ltd. (Cadila) is a global healthcare provider and one of the top five pharma companies in India. In 1995, the group restructured its operations and now operates as Cadila, under the aegis of the Zydus group.

Over the years, Cadila has transformed itself from a primarily domestic player into a fast growing global generic player with presence in key geographies like US, France, Brazil, Japan and 26 other countries. In order to capitalize its strong manufacturing capabilities, Cadila has formed JV's with international companies like Nycomed (earlier known as Altana) and Hospira (earlier known as Mayne). In the long term, the company is pursuing a goal of becoming a global research-driven company, through its early stage R&D pipeline, which involves 5 New Molecules Entities (NME) and New Drug Delivery Systems (NDDS).

Real-Option Valuation Of R&D Pipeline

The drug development cycle of a pharmaceutical company for a researched drug shows that R&D is both time & cost intensive. The patent process takes 4-5 years time. Therefore pharmaceutical companies apply for patent right after the discovery stage along with pre-clinical trial. In other words, a drug research company applies for patent registration once a molecule shows promise of therapeutic effectiveness. This is done to ensure that patent registration is obtained when the research enters the clinical trials phase. Normally Indian companies involved in therapeutic research apply for simultaneous patent registration in India (to drugs controller general of India) as well as in the US (to food & drug administration or FDA). FDA registration is a clear passport to the export market. The FDA process is more rigorous. However drug authorities' approval has to be taken at each stage of clinical trial& only when all the four clinical trial phases are successfully completed, the product be launched. The patent period starts right from the day the patent is granted. Hence, the longer the clinical trial period (after registration), the shorter the unexpired patent period. The pharmaceutical company has to recover its costs & even profit within that protected patent period. It is, of course, true that even if the product goes off patent, revenues do not dry up. As per FDA norms, patents expire 20 years from the date of filing. Recent WTO norms also prescribe a product patent life of 20 years. This rule has been applied in India from 2005.Therefore, the moment a patent application is filed with FDA after discovery stage, the clock stars & if the patent is granted after five years then only 15 years will be the unexpired patent period. If the researcher delays further due to clinical trials, the unexpired patent period gets even reduced.

It costs around US $350 million to US $500 million to develop a drug & the average time taken is 14 years (Vikalpa, 2003). This cost may be significantly lower for an Indian pharmaceutical company developing a drug in-house.

Developing an innovative new drug, from discovery to worldwide marketing, now involves investments of around $1 billion and global industry's profitability is under constant attack as costs continue to rise and prices come under pressure. Pharmaceutical production costs are almost 50 percent lower in India than in Western nations, while overall R&D costs are about one-eighth and clinical trial expenses around one-tenth of Western levels. India's long-established manufacturing base also offers a large, well-educated, English-speaking workforce, with 700,000 scientists and engineers graduating every year, including 122,000 chemists and chemical engineers, with 1,500 PhDs. Costs of clinical trials in India are around one-tenth of their levels in the U.S., and it is estimated that they could be worth $300 million to India by 2010. CHL has new molecules under discovery phase in four broad therapeutic segments – anti-obesity, anti-diabetes, dyslipidemia, inflammation & pain

Variables Affecting Cadila Healthcare Limited (Chl)

Underlying Asset Value

Black-Scholes model uses continuously traded underlying assets, for which continuously time series data are available. In case of R&D projects, the underlying investment is not traded & hence market value cannot be determined. Most of the studies use future cash flows of the R&D project as the proxy for the underlying asset. However, the future cash flows would largely depend on the probability of success of the drug. A successfully tested drug may not be successful in the market. A drug reaching the market could fall unto one of five quality categories: (a) dog, (b) below average, (c) average, (d) above average, or (e) breakthrough. The revenues attached to each quality category are highly skewed & the variance can be as high as 95%. Thus estimating the underlying asset value for a researched drug could be very complex. In this study, it has been assumed that each of the molecules under development would be a breakthrough. Hence the underlying asset value for each of the molecule would be equivalent to its market potential & share of CHL within that market.

Exercise Price

Exercise price may be known (e.g., in case of fixed price stock option) or stochastic. The exercise price of an R&D project is not always known. In the present case, as both the compounds have entered the clinical phase, it is assumed that all the three phases of clinical trial will be carried out & hence the present value of R&D costs has been considered as the sunk cost. The exercise price of the option to commercialize the products after clinical trials is, therefore, the investment required for launching the products.

Time to Expiration

Like exercise price, the time to expiration can neither be known or unknown. Competition may force early investment but a regulation may delay the time to maturity. Usually stock options have a comparably shorter time to maturity. But, real options have a longer maturity period. Since CHL has applied to FDA as well for patent registration, we assume that it will get FDA approval for 20 years patent period. Clinical trials may take 6-8 years & hence the time to expiration could be 6-8 years at the earliest. This CHL will get only 12-14 years of patent life after the products are launched. We will not consider revenue post-patent period in our study. We assume here that CHL will not wait after successful completion of Phase III. The products will be launched immediately.

Volatility (Risk)

Measuring the volatility of an R&D investment project is difficult because it is difficult to get historical volatility data. Merck & company of US use's the historic volatility of a bio-technology index of related stocks, which are traded at NASDAQ. In absence of such information, volatility of stock prices of pharmaceutical companies may be used as a weak surrogate. We have assumed volatility of 36%. In fact the annualized variance on the basis of monthly variance of CHL'S share on the NSE comes out to 3.1372%, which is equivalent to a variance of 36%.

Convenience Yield

For a traded underlying asset, convenience yield is the annual dividend yield on traded asset. For R&D projects, estimating an appropriate convenience yield is a difficult task. An investment project generates cash flows that are often not exactly known by time, frequency or amount. For a pharmaceutical company evaluating an R&D project, convenience yield should indicate the estimated net revenue that would have been lost due to not being able to market the drug after patent registration. It is argued that the potential for excess return exists only during the patent life of the drug & therefore, competition will wipe out excess returns beyond the patent period. Hence any delay in launching the drug by a year will cost the firm one year of patent protected excess returns (Source: Vikalpa, 2003). In case of CHL, the current cash operating margin is 20%. If the expected future margin from patented four compounds is 25%, the excess return that CHL may lose in the clinical phase will be the difference between expected operating margin & current operating margin. This would give cost of delay of 5% per annum for CHL.

Table 4. **Parameters for Real Option Valuation of ZYH1 : Dyslipidemia Molecule**

Input	Assumptions
Underlying Asset (**S**)	Present global market size for Dyslipidemia drug=US$20 bn with 10% annual growth rate. Assume a share of 0.5% for CHL & through various adjustments, value has been derived as Rs 27507 Million. (Source: Analyst-Pharma Sector, Kotak Securities)
Exercise Price (**K**)	Cost of launching the products is assumed to be Rs 2750.7 million, which is equivalent to the entireestimated cash flows in the first year of launch(Source: Myers and Howe (1997) showed that in the very first year of product launch, the entire Revenue is spent as marketing expenses)
Time to Expiry (**t**)	4 Years (½ Phase II +Phase III =(2*1/2+3) Years)
Volatility (variance) (**ó**)	36 per cent
Cash operating Margin	25 per cent
Effective tax rate	13 per cent
Convenience yield (**y**)	5 per cent

Real Option Valuation Of Zyh1 : Dyslipidemia Molecule

$$C = SN(d1) - Ke^{-rt}N(d2)$$

Where,

$$d1 = \frac{\ln(S/K)+(r - y + \sigma^2/2)t}{\sigma\sqrt{t}}$$

$$d2 = d1 - \sigma\sqrt{t}$$

These yield the following estimates for d & N (d):

d1 = 25.0215 N (d1) = 1.0000

d2 = 24.9015 N (d2) = 1.0000

Real Option Value:

= [27507*1.0000] – [2750.7$e^{(-0.07*4)}$*1.0000]

= Rs. 25261.61 Mn.

LIMITATIONS OF BLACK SCHOLES RELATED TO APPLICATION IN REAL OPTIONS

I) It is difficult to explain the derivation of the equation due to its mathematical complexity. This promotes a "black box" approach, where intuition behind the application is lost, thereby, making it difficult to get management buy-in.

II) Black and Scholes developed their model for European financial options which means that the option is exercised only on a fixed date and no dividends are paid during the option life. Real Options can be exercised at any time during their life and there can be leakages, which are equivalent to the dividends of a financial security. Black Scholes equation can be adjusted for leakages, when it is at a constant rate, according to Damodaran (2002)

III) Black Scholes assumes a lognormal distribution of the underlying asset value, which may

not be true with the cash flows related to real assets.

IV) Black Scholes also assumes that the increase in the underlying asset value is continuous as dictated by its volatility and does not account for any drastic ups and downs (jumps).

V) Black Scholes allows only one strike price for the option, which can change for a real option during its life.

CONCLUSION

1) Real Options Analysis is able to predict the value in a given situation, for e.g. in Case of Stealth Tier, Call option value per home passed is in the range of $197-1,979 for the Stealth Tier. The midpoint of this range is $1,088, representing approximately 50% of trading value per home passed.

2) Real Option Value for Dyslipidemia molecule has been calculated as 25,261.61 million. This is value realised as payoffs of drug developed from the given molecule.

3) Black Scholes model provides a value for real options, but it is not still clear, whether it is the best Method, since it's equation is mathematically complex and has been developed for European Financial options, which have different characteristics as compared to Real Options.

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