CHAPTER 2
Chapter 2: Literature Review

2.1) ARTICLE REFERENCES

Applicability and value of real options analysis in developing an oil field, has been illustrated in this thesis and its potential in terms of its support, with decision analysis can maximize the returns on a given project and minimize the losses. In case of technical uncertainties existing in field development, capacity flexibility, as an option to change scale of a project, can significantly add value to a project. Original project team’s assumptions and expectations, key uncertainties and the final outcomes, have been highlighted through Sample and Rotherfield case study, presented in this thesis. Alternate approach to the problem using real options analysis, has been recommended, to add more value to the project. It is felt that it would be more beneficial to obtain the option, to add capacity to the field development, for the given case study. Various development scenarios, have been shown, to maximise gains & minimise losses, by means of level of capacity flexibility, that adds the most expected value.

Investment decisions are usually based on NPV returns, calculated for a given assumption of oil price, changing from one company to another, particularly, in oil field developments. Conceptually, this method suffers from flaws, as it assumes a single line of development for a project and simply incorporates the probability of failure into the overall expected value for the project. Since, the discount rate typically is adjusted for the level of risk associated with the project, it can become difficult to assign a value to the probability of failure, which, is taken as the discount rate.

Based on above reasons, for an oil field development project, where several uncertainties exist, traditional methods for making investment decisions are not highly effective. Considering uncertainty and building flexibility in the system. Real Options Analysis (ROA), is seen as a useful tool, for making investment decisions. In case of projects, that, are suffering from lack of historical statistics, ROA is useful, for example, a new oil field development. For a field development decision process, risk is used to add value to a project, through application of real options; thereby, showing its potential benefit.

Applicability of real options, for oil field development, has been always questioned, by
many project managers. In such a decision process, where the main uncertainties that exist are technical in nature (e.g. reservoir properties) or are market uncertainties (e.g. oil price), it is not always clear, where or how, real options can be effectively utilised. Application & value of real options and its use along with decision analysis, can maximize the returns on a given project and minimize the losses. With the level of uncertainty involved in such projects, traditional methods used for investment decisions in field developments may not be optimal.

Many uncertainties exist in the oil industry: in form of oil prices, in oil and gas reserves in the ground, in geological and reservoir structures etc. Decisions for the future of any project, should be made, after considering these uncertainties and weighing them. Best choices are made for developing oil and gas fields, by project managers and designers in the oil industry, who, are involved in dealing with given uncertainties. Capital investment assessments are done by tools such as payback period, simple interest rate, discount or net present value (NPV) and internal rate of return (IRR), which are traditional methods, used for making investment decisions. Unpredictability of certain variables, which may exist in the future and hence, are inadequate for making a good investment decision, specifically in large projects; is not considered by any of these methods. Cost has to be incurred to drill an exploratory well and information obtained for such ventures; is not accurate. Oil exploration is a business, full of risks. There is a high cost associated towards developing an entire oil field in an environment, with lot of uncertainty. Sample and Rother project team, has applied real options, along with decision analysis and shown that work has shown, ways of maximizing the expected value of the project; decrease in waste, that may be associated with upfront capital expenditure, not required and built in flexibility, available with the project, to take advantage of the things not known, considering the uncertainty in the future. Rigid assessment method, would not have made it happen, for the result, which was achieved. Real option analysis, in this work, does not entirely take into consideration, impact of complex criteria on the decisions made. As noted earlier in the thesis, various other factors like safety, environment, laws, regulations and contract terms, can play their role in the decision process for field developments, in different cases. [1]
State of ‘Real Options’ as a topic on an analytical level from a potential practitioner’s point of view is problematic. There appears to be a great deal of agreement about the appeal of the underlying concepts. Variety of contradictory approaches, have been suggested for implementing real options in practice. The assumptions underlying these different approaches and the conditions that are appropriate for their application are typically not spelled out. Where they are spelled out or can be inferred, they differ widely from approach to approach. The difficulties in implementing the approaches are rarely discussed and the pros & cons of alternative approaches are not explained. This situation leaves potential practitioners in troubling circumstances. In principle, the concept seems valuable and has inherent appeal. However, in practice, there is a good chance that one could apply an inappropriate approach and/or apply an approach inappropriately. The result is not simply a lack of academic correctness, but incorrect investment decisions and lost value.

The purpose of this article is to help remedy this situation by describing, contrasting and critiquing the major proposed analytic approaches, to applying real options, typically termed “real options analysis” or “real option valuation.” The emphasis is not on mathematical details, but on three fundamental issues surrounding each proposed approach:

1. Applicability: what does the calculated “real option value” represent and where is it appropriate to use this calculation?
2. Assumptions: what are the notable assumptions, underlying the approach and what is the evidence regarding the validity of these assumptions?
3. Mechanics: what steps are involved in applying the approach and what are the associated difficulties?

A single example is used to elucidate these points and contrast the approaches. A firm is evaluating an uncertain investment. The uncertainty is perceived to come primarily from two sources. One uncertainty is the size of the business that the investment will create. Another uncertainty is the profitability of that business. Both uncertainties are dynamic and some learning is expected to occur over time. The firm can commit to the investment immediately, reject it, or invest in an opportunity to learn (an option) before making the
commit/reject decision. For simplicity, we assume that the costs associated with creating the business, specifically the cost of the investment and the option, are not a major source of uncertainty.

For illustrating the mechanics of the approaches, we rely on an oil and gas version of this example. However, the results are not limited to oil and gas and it would be just as easy to create a pharmaceutical, high tech or other industry version. In the oil and gas version, the investment being considered by an oil and gas firm is acquisition of an undeveloped natural gas field in Western US. The “size of the business” uncertainty is represented by the amount of natural gas in the field. Proved reserves are currently estimated by the firm at 100 BCF. The “profitability of the business” uncertainty is represented by the future price of natural gas. The firm can acquire and develop the field for $175 Mn., decide never to acquire and develop the field, or acquire an option to acquire and develop it in two years for $20 Mn. For simplicity, development is assumed to take essentially zero time so revenues begin immediately after the acquisition and development decision. The right will expire if not exercised at the end of 2 years. In the 2-year period, the value of the field may change as uncertainty evolves regarding the amount and price of natural gas. Information about the amount may be obtained through geologic testing and test drilling, while information about the price may be obtained through market observation. [2]

It talks about business plan of New microbrewery launched by Portlandia Ale, where 4 million was needed for product development (0.5/quarter for 2 years), 12 million to launch the product 2 years later, expected sales was 6 million per year, value of established firm was 22 million (based on market value-to-sales ratio of 3.66). Based on calculations, traditional NPV based on DCF model comes to – 0.23, while real option NPV based on Black Scholes model comes to 1.13. This additional value is coming from flexibility, changes of the investment schedule in response to market uncertainty, option to launch and continue market development. [3]
Traditional Monte Carlo simulation has been considered a powerful and flexible tool for capital budgeting, for a very long time. It is a recommended methodology for capital budgeting decisions in many Corporate Finance textbooks. Actually, it permits to include a wide set of value drivers, it is flexible enough to cope with many real life situations and it does not suffer the “curse of dimensionality” affecting other numerical methods. Yet, as pointed out by many authors, it seems not so suited to tackle capital budgeting problems with (potentially) many real options.

Mason and Merton, first, described a capital budgeting problem as a collection of real options, i.e. a set of opportunities that managers (usually) have to deviate from a previously decided course of actions. Real options are capital budgeting decisions, contingent on some relevant and well specified state variables, affecting the value of an investment project. Projects involving individual options have been studied since the early stage of development of the real options theory. Numerical techniques for financial options can be successfully employed to evaluate single real options: as far as the mathematics of real option valuation is concerned, there would be no need of a theory specifically devoted to individual real options. An exception is represented by Brennan and Schwartz, who evaluate the investment in a mine considering the compound effect of the flexibility to temporarily shut down and restart operations and to abandon the project. A widely accepted classification of simple real options is presented in Mason and Merton, which includes the option to defer an investment decision, the option to partially or completely abandon operations, the option to alter the scale of current operations, the options to switch the existing assets to an alternative use and many others. The valuation of these options can be easily done by employing the same techniques used for financial option pricing. [4]

Research article, has exhibited, a pharmaceutical company, that, can be valued with potential in terms of research products in pipeline. Traditional DCF method, could hardly explain approximately 39% of market capitalisation of the company. Cash flow model, is unable to capture future values, arising due to growth from joint venture initiatives,
possible growth from drug discovery initiatives etc. Underlying value of R & D investments is being recognized by option pricing model and real options model has significantly improved the valuation

US based, Merck & Company, had used real options framework, to take decisions regarding R&D investments and also for pricing it’s acquisition programmes (Nichols, 1994). Kellogg and Charnes (2000), have made an attempt for valuing one anti-HIV new molecular entity of a bio-technological company, named Agouron Pharmaceuticals, by using Binomial Method. R&D project of a pharmaceutical company, have been valued by using compound option model (Geske Model), by Perlitz, Peske and Schrank (1999). Various studies have highlighted the fact that R & D investments are high value and high risk propositions. Property exhibited for R&D that it is both time and cost intensive, has been shown by drug development cycle of a pharmaceutical company for a researched drug.

Peculiar uncertain business environment, is being faced by pharmaceutical companies. It has been seen that normally, one in 10,000 chemicals, for exploration, becomes a prescription drug (Nichols, 1994) and around, 30 per cent of drugs, become successful in recovering their costs, after commercialisation. It has been assumed that both the compounds would fall under the category of “successful drugs” and accordingly, analysis of DRL has been done. The option to discontinue the research at any stage and licensing of the drug was not considered, in the study. The abandonment option may result in increase in the value of real options. For example, a multi-million dollar licensing deal has been announced by DRL, for an anti-diabetes molecule with Swiss multinational Novartis AG. Payments, amounting to $55 million, are to be received by DRL, over a period of time, during the process of research. This study has come to the conclusion that, the underlying value of R&D investments, is best recognised by option pricing model. The traditional NPV method fails to capture the underlying value, due to deterministic approach followed and constant cash flows taken. Other significant finding, coming out from this study, reveals that the present value of R&D, depends significantly on the expectation of achieving a critical mass in terms of global market share. R&D efforts, always, have been costly research decisions, while, the Indian market, for any high investment research drug, is comparatively smaller. Hence, it can be concluded that the
success of a drug, completely driven by R&D, depends on its ability to capture global market. This is purely reason behind most of the Indian pharmaceutical companies, not having completed the research and preferred to sell the same at molecule stage. Considering the reality, there are different stages of R&D investments. Hence, according to Geske, 1979, compound option model is ideal for capturing the value of R&D investments of a pharmaceutical company. Feature of compound options, has not been considered by the present study. It has been rightly identified that application of any real options model requires more detailed information and assumptions. Availability of more information, may improve the results of the present study. It should be noted that the value of options has been reduced by the regulations in drug discovery process. Finally, a word of caution is necessary. Finally, it has been observed that if the underlying assumptions are not meticulously designed, decisions taken, on the basis of real option analysis, may be wrong. Word of caution, specifies that, model risk is very high.

The input variables required for valuing options premium of DRF 1042 and DRF 1644 are:

**Underlying Asset Value**

Continuously traded underlying assets (e.g., shares), are considered by Black Scholes Model, for which continuous time series data are available. It is observed that value of this traded variable, can easily be derived. An arbitrage free evaluation is carried out for the trading of an underlying asset, which is important, in options pricing theory. But, it is practically impossible to build a duplicate portfolio, to determine the option value (Trigeorgis, 1993), if the underlying asset is not traded in the market. Market value cannot be determined, for R&D investments, as the underlying investment, is not traded in the market. Future cash flows of the R&D project, are taken, as the proxy for the underlying asset, according to most of the studies (e.g., Kellogg and Charnes, 2000, Perlitz, Peske and Schrank, 1999). Probability of success of the drug in the market, would determine the future cash flows, appropriately. A successfully tested drug may or may not be successful in the market. According to studies undertaken by Myers and Howe (1997), a drug reaching the market, may be part of one of five quality categories: (a) dog; (b) below average; (c) average; (d) above average, or (e) breakthrough. The revenues
associated with each quality category are highly skewed and the variance can be as high as 95 per cent (between breakthrough and dog qualities). It can be concluded that estimating the underlying asset value for a researched drug, could be very complex.

**Exercise Price**

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

**Time to Expiration**

The time to expiration can either be known or unknown, like exercise price. Time to maturity, may be delayed by regulations, while, competition, may force early investments. Generally, stock options have comparatively, shorter time to maturity. But, real options have a longer maturity period. It is believed that DRL would get FDA approval for 20 years patent period, as it has already applied for patent registration. Clinical trials may take 6-8 years and hence, the time to expiration could be safely, taken as, minimum of 6-8 years. Further, after the products are launched, DRL will get only 12-14 years of patent life. It is assumed that DRL will be ready to launch molecule, after successful completion of Phase III.

**Volatility (Risk)**

Volatility of an R&D investment project is difficult to measure as it is quite cumbersome to get historical volatility data. Two compounds of DRL, namely, DRF 1042 and DRF 1644, may contain features, which are not present in its existing anti-cancer drugs. According to Nichols, 1994, US based, Merck & Company, uses historical volatility of a bio-technology index of related stocks, which are traded at NASDAQ. Ideally, desired database in this study, would have been historical data of research companies, focusing only on anti-cancer drugs, to compute volatility. According to Damodaran, 2000, in the absence of such information, volatility of stock prices of pharmaceutical companies may be used as a weak surrogate. Some of the conservative estimates of volatility for the R&D
projects, ranged between 40 per cent to 60 per cent (Nichols, 1994); 26 per cent (Kellogg and Charnes, 2000) and 25 per cent (Perlitz, Peske and Schrank, 1999). Volatility (variance) of 35 per cent has been assumed, nearer to observed volatility. In fact, the observed annualized volatility (standard deviation) on the basis of 60 monthly returns of DRL’s shares in the BSE comes out to be around 6 per cent, which is equivalent to a variance of around 36 per cent.

Convenience Yield

For a traded underlying asset, convenience yield is the annual dividend yield on traded asset (e.g., shares). 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 (Perlitz, Peske and Schrank, 1999). For a pharmaceutical company evaluating an R&D project, convenience yield should indicate the estimated net revenue (net of expenses) 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 and 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 (Damodaran, 2000). One crude way to estimate such cost of delay could be the reciprocal of unexpired patent period, i.e., 1/20 (first year), 1/19 (second year), etc. This method is based on the assumption that cash flows are evenly distributed over the patent period. But, as this is not the case in most of the situations, this method of estimating convenience yield has not been used in the present study. In case of DRL, the current cash operating margin is 25 per cent. If the expected future margin from patented two compounds is 30 per cent per annum (based on the author’s assumption that DRL earns a cash operating margin of 30 per cent on oncology products), the excess return that DRL may lose in the clinical phase will be the difference between expected operating margin and current operating margin. This method would give us a cost of delay (or convenience yield) of 5 per cent per annum for DRL. [6]
In recent years, practitioners and academicians have made the argument that traditional cash flow models do a poor job of capturing the value of the options embedded in many corporate actions. They have noted that these options need to be not only considered explicitly and valued, but the value of these options can be substantial. In fact, many investments and acquisitions, that, would not be justifiable otherwise, will be value enhancing, if the options embedded in them, are considered. This paper examines the merit of this argument. Series of examples have to be developed, where an attempt has been made to value these options and consider the effect on investment, financing and valuation decisions.

In recent years, this framework has come under some fire, for failing to consider the options that are embedded in each of these actions. For instance, the net present value of a project does not capture the values of the options to delay, expand or abandon a project. When comparing across investments, the traditional approach of picking the model with the highest return or net present value may shortchange investments that offer a firm more flexibility in operations and investing. A financing model that focuses on minimizing the current cost of capital does not consider the value of financial flexibility that comes from having excess debt capacity. In a similar vein, firms that hold back on returning cash to their stockholders and accumulate large cash balances might also be guided by the desire for financing flexibility. The value of equity, obtained from a discounted cash flow valuation model, does not measure the option to control, and if necessary, liquidate the firm that equity investors possess. Also, it does not take into account, other options that might be owned by the firm, including patents, licenses and rights to natural reserves. In acquisition valuation, the strategic options that might be opened up for the acquiring firm, as a result of the transaction, are often not considered in valuation. For these options that seem to be everywhere, there are some theorists and many practitioners, who believe that these options should be considered, while analyzing corporate decisions. Some top managers and consultants would like to use real options as a rhetorical tool that can be used to justify investment, financing and acquisition decisions; they feel that while there are embedded options in most decisions, they cannot be valued with any precision. There are others who argue that we should try to
quantitatively estimate the value of these options and build them into the decision process.

Three options have been considered, embedded in investment projects - the option to expand a project, the option to abandon a project and product patents as options. In all these cases, the underlying asset was the project and the options added value to the project. The argument carried forward was that equity could be viewed as a call option on the firm, and that this would suggest that equity would have value even when the firm value was less than the outstanding claims on it. Furthermore, viewing equity as an option allowed to consider the conflict between stockholders and bondholders much more clearly and provided with insights on why conglomerates may make stockholders worse off, while making bondholders better off. [7]

This paper presents survey of some results regarding standard discounted cash flow analysis, economic value added and real options. Since Standard literature ignores the role of market frictions and the effect of incomplete information, Merton’s (1987) model of capital market equilibrium with incomplete information has been taken to introduce information costs in the pricing of real assets. Using this model instead of standard CAPM allows a new definition of the weighted average cost of capital and offers some new tools to compute the value of the firm and its assets in the presence of information uncertainty. New results have been proposed by extending the standard models to account for shadow costs of incomplete information. The extended models can be used for the valuation of R & D projects as well as projects with several stages like joint ventures.

Section 1 presents a simple framework for the valuation of the firm and its assets, in the presence of information costs. Using Merton’s (1987) model of capital market equilibrium with incomplete information, it was made possible to extend the analysis in Modigliani-Miller (1958, 1963), to account for the effects of incomplete information in the computation of the firm value. This setting, allows to extend the concepts of economic value added and standard DCF analysis, to account for information costs. An application is proposed for the valuation of a biotechnology firm. Section 2 uses the main
results in the real option literature to make the standard analogy between financial and real options. This allows the presentation of the main applications of the real option pricing theory. It presents some simple examples and proposes the main results in the literature regarding the analysis and the valuation of real options. Section 3 develops a simple context for the pricing of real options in a continuous time setting. We develop some simple analytic formulas for the pricing of standard and complex European and American commodity options in the presence of information costs. Then, we extend the results in some real option pricing models to account for information costs. This allows us to study the investment timing and the pricing of real assets using standard and complex options. Results are extended in Lint and Pennings (1998) for the pricing of the option on market introduction.

Section 4 develops some simple models for the pricing of real options in a discrete time setting by accounting for the role of shadow costs of incomplete information. Extension of Cox, Ross and Rubinstein (1979) model was done to account for information costs in the valuation of managerial flexibility and the option to abandon. Further, the generalization in Trigeorgis (1990) was used for the pricing of several complex investment opportunities with embedded real options to account for the effects of information costs. Most of the models presented in this paper can be applied to the valuation of biotechnology projects and investments with several stages.

General context is proposed for the valuation of real options and the pricing of real assets in a discrete-time setting. Salkin (1991) shows, how to apply the Cox, Ross and Rubinstein (1979) model for the valuation of complex capital budgeting decisions. The methodology is applied to a hypothetical case of a marginal natural resource project. The real benefit of this technique arises in its ability to value more realistically, situations in which traditional techniques attributed little or no worth. Following the analysis in Salkin (1991), simple context is developed for the valuation of real options using option pricing techniques in the presence of information costs. Then, using the Trigeorgis (1991) general Log-transformed binomial model for the pricing of complex investment opportunities, a context is provided for the valuation of these options under incomplete information. Trigeorgis (1991) proposed a Log-transformed binomial model for the
pricing of several complex real options. That generalization is used to account for information costs in the pricing of complex investment opportunities. [8]

The paper is divided into three sections. The first uses interviews and some of the historical literature on adult literacy in Bangladesh to attempt to pick out the critical moments and changes in the development of the literacy movement. That includes a discussion of teaching methodology, and the emergence of patterns and policies of delivery. The second part brings the paper more up to date. It describes recent changes and debates in the policy context and a number of recent innovations in literacy teaching and learning. The paper then concludes in the final lesson by returning to the questions posed in the terms of reference, and suggesting some future directions for policy and practice.

It has been seen that over time the people’s understanding and expectation of ‘adult literacy’ has developed in an institutional sense, both in terms of establishing the ‘literacy group’ as a legitimate and important social institution, and in terms of the mechanisms and norms guiding the delivery and management of adult literacy programmes at a national level. Change also has been in the roles of government and the NGO sector with a greater degree of standardisation and regulation from government. With this standardization, greater numbers of people were able to access adult literacy classes, but the standardisation and mechanistic approach to training and delivery may have also contributed to a reduction in the scope for new innovation, and perhaps also resulted in groups with particular needs and interests – for example ethnic minorities and the chronically poor, who are not such active and organised members of NGOs being excluded. Over the years, the government of Bangladesh has taken a significant role in supporting adult literacy programmes. In terms of integrating literacy initiatives into wider policy reduction strategies there remains a lot of work to be done, particularly since the benefits of adult literacy learning and use may be hard to research. This is a particular consideration for women, the poorest groups, and ethnic minorities, who may be reluctant to express their needs, or to discuss the impact and uses of literacy in a public context.
This suggests that new systems of monitoring and evaluation should be developed that are more sensitive to such factors. [9]

Objective of this paper is to contrast discounted cash flow and real option valuation methodologies in the context of strategic capital budgeting decisions like remote sensing technologies. Application of remote sensing technologies in agriculture is a very sound business proposition. However, it should be clear that such high technologies are characterized as: i) involving large research investments in research and development, ii) some sunk costs that cannot be recovered if the project is abandoned (irreversibility), iii) a high degree of uncertainty in the returns to these investments (risk), iv) significant time lags between investing and realization of a return, v) some leeway in the timing of the investment (i.e. atleast some of the investment may be deferred until more information is available).

The essential question is what valuation analysis tool to use in order i) to evaluate such a highly uncertain investment (but highly profitable if successful) and ii) to communicate this value to investors in a disciplined and unbeatable way. The latter proposition is particularly important for high technology companies because due to their high investment costs, they have to approach capital markets several times during their early growth phase.

NPV is necessary a more powerful valuation tool. Particularly for certain industries such as biotechnology, high tech, etc. no one believes that NPV and other DCF based valuation methodologies work. In the real world strategic projects often fail internal DCF based financial tests. Analysts, to justify their “gut feel”, tend to manipulate the valuation process raising cash flows forecasts to unlikely levels (Amram), or they use the “hurdle rate” rule, which requires an investment, to not merely have a positive NPV, but to have a sufficient positive NPV -usually put in the form of an Internal Rate of Return, exceeding the current market rate of interest by an additional amount, say 3%. Strategic investments present two major components that NPV ignores: a) the decision making process includes contingent decisions (the possibility to delay an investment), and b) option valuation must be aligned with financial market valuations. The following example will show that
the first component can be partially taken into account when a more complex tree
decision analysis (still DCF-based valuation) is used. However, the second component is
still ignored.

The key to valuing an investment opportunity as an option is the ability to make a
correspondence between project characteristics and financial option characteristics. The
potential investment corresponds to an option’s exercise price. The operating assets the
firm would own, if the investment were made, equal the stock, one would own, after
exercising a call option (stock price). The length of time the company can wait before it
has to decide is similar to a call option’s time to expiration. Uncertainty about the future
value of operating assets is captured by the variance of returns on them; this is analogous
to the variance of stock returns for call options. Finally, the time value of money will be
the risk-free rate of return instead of the WACC used in DCF method. Like in the DCF
framework, in an option pricing approach, cash flow, time and risk all still matters, but
they enter the analysis in two ways. Two cash flows matter: cash from the business and
cash required to enter it. Time: the timing of the eventual cash flows and how long the
decision to invest may be deferred. Risk: the riskiness of the business and the risk
circumstances will change before you have to decide. Even simple option-pricing models
must contain at least five or six variables to capture information about cash, time, and
risk. [10]

It is examined whether the value of an undeveloped oilfield is affected by using real
option valuation. Applying the two-factor model dependent on the spot price of Brent and
the convenience yield implies a premium over the certainty equivalent method, ranging
from 20-1000% for reasonable spot prices. However, premium over the risk-adjusted
method can be negligible since they are dependent on the spot price forecasts of
managers. This does not mean that the option criterion should be neglected, considering
its implication, for the strategic decision, of when to optimally invest. This risk-adjusted
approach suggests that investment is optimal whenever oil prices surpass $15.69 per
barrel. Whereas the real option analysis suggests production at prices above $26.72.
Moreover, positive market price is found of convenience yield risk on the IPE, strongly
disagreeing with economic theory.
Option to delay investment is used, assuming that model uncertainty is inherent from the spot price of Brent and the convenience yield. Findings indicate an option value of $56.720 million, implying a premium over the certainty equivalent value of approximately 37%. Although performing an additional risk-adjusted valuation indicates a more modest premium of 10%. Emphasizing the need to complement the real option method with a DCF valuation expressing the managers believes of future oil prices. In general, the real option premium varies considerably and ranges from 20-1000%, for reasonable values of the spot price and the convenience yield. However, it is impossible to draw any general conclusions about the premium over a risk-adjusted method, since this method is entirely dependent on the manager’s outlook for future spot prices. Nevertheless, a substantial premium definitely exists for pessimistic price predictions, implying that information costs incurred applying option methods are negligible in relation to the discovered hidden values. Acknowledging that the DCF method presents similar values to the option approach for high spot prices does not mean that the option criterion can be neglected, bearing in mind that, it also has implications for the strategic decision of, when to optimally invest. The risk adjusted approach suggests that investment is optimal, whenever, oil prices surpass $ 15.69, whereas the real option analysis suggests production at prices above $ 26.72 per barrel. Reasonable values of the spot rate and the convenience yield imply an optimal investment price range of 25-27 dollars per barrel. Accounting for the option to delay has considerable implications for both valuation and strategy. The two cash flow methods suggest that investment should be undertaken on Jan.1, 2001, while the real option approach indicates that development should be delayed further. The main reason for not using the real option method is the complexity and the trouble of describing results to clients. Limitations of the real option framework are also inherent in the parameter estimation and the simplified view of reality. For example, petroleum properties are generally leased by several operators who have to agree on various decisions. In addition, the decision to invest can be influenced by the state of the firms other assets, in case the company is experiencing a shortage of funds. Moreover, geological conditions can also play an important part in investment decisions. [11]
This study is an attempt towards examining, whether decision makers, applying real options in capital budgeting, have lesser chances, to raise commitment, for a failing course of action, as compared to decision makers, who use discounted cash flow techniques, like net present value alone. According to Staw, 1997, Escalation of commitment happens in case of decision makers, who wish to continue to commit resources to a project, after receiving negative feedback about the effects of prior resource commitments. It has been observed that finding about decision makers escalate commitment to failing courses of action, is robust across various settings and conditions, including capital investment decisions. According to Graham and Harvey, 2001, although the application of such techniques is common in the business world, participants, in this research, have not been allowed or required to calculate value of capital budgeting projects, using techniques like net present value or internal rate of return, as observed in prior research conducted on the escalation of commitment phenomenon. Incorporation of real options into capital budgeting techniques, is mainly of interest in this study.

The techniques, which are developed to value financial options, are taken by real option analysts and applied for the valuation of other endeavors, involving uncertainty as a factor, such as business ventures, product lines or entire firms. Value of managerial flexibility, has to be considered over the period of happening of a project, explicitly, in case of real options in capital budgeting. Such flexibility has been seen in cases, when management has the right to terminate a project early, expand a project after an initial toehold investment, or extend a product line to better utilize technology investments. Decision makers are able to add the value of management's options to the discounted cash flow value of a project, by considering real options in the capital budgeting decision process. According to Teach, 2003; Copeland and Antikarov, 2001; Coy, 1999; Ross, 1995, supporters of the real options approach to capital budgeting claim that it results in decisions superior to those made using discounted cash flow techniques alone. It is a fact that including the value of real options, increases the quality of information, available to managers, which is also a base, for many arguments. As informational advantage has been addressed by copious amount of research, according to Newton et al. 2004; Teach 2003, Copeland and Antikarov 2001; it has not been tested in this study. Decision
maker's behavior, can be affected by use of different techniques, otherwise, it can be due
to differences in information quality.
HI: Decision makers will be less likely to escalate commitment to a failing project, when
real options are explicitly considered in the planning phase of a capital budgeting project
than when discounted cash flow techniques alone are used.
H2: The cognitive accessibility of the possibility of project abandonment mediates the
relationship between the capital budgeting technique a decision maker uses and that
decision maker's escalation of commitment to a failing project.

Testing of the hypothesis was done by an experiment, having 2 x 2 between-subjects and
two things, that were varied, were the capital budgeting method used by participants and
the order, in which participants performed tasks. Measurements were taken for
recommendations to continue the project and construct accessibility of the possibility of
abandonment. Forty-five students of Masters of Business Administration and Masters of
Accounting, were participants, in the experiment. Average age of these students were
26.33 years old, along with 3.1 years of work experience and 48.8 percent of these
students were females. Reasons for choosing this population, was due to the familiarity of
the participants with capital budgeting scenarios and the similarity of the participants to
the population of interest, i.e. real-time business managers. Random assignment was
given to the participants in terms of two conditions; in one of them, they played the role
of a controller at an electronics firm, that, either used net present value analysis alone or
incorporated real options into the analysis, depending on prevailing conditions.
Participants were informed that their responsibilities included performing financial
analysis for capital budgeting projects and presenting recommendations, related to
accepting or rejecting of such projects. They were also provided with instructions
regarding the application of technique to perform analysis and were informed regarding
the capital budgeting technique, used by their firm. An illustration problem was given to
them, related to the firm's capital budgeting technique and instructed that they could refer
to the illustration, in case of any problem, at any time, while, performing their own
calculations. Information regarding the project, was provided to the participants, related
to the development of an all-in-one cell phone, organiser and MP3 player.
Further, information regarding the project life, its cash flows and its probability of success, was provided to the participants. Calculations were performed, regarding the value of the project using the firm's capital budgeting technique, by the participants and also, indications were generated, regarding the likelihood that project could be funded, on a 101-point scale ranging from 0 (not at all likely) to 100 (extremely likely). Small justifications could be given in the form of statements by the participants, if they wanted to defend their choices. Objective was to arrive at an unambiguous choice, using the available information, to undertake the project, as the net present value of the project is $30,960,000 and the value of the project including application of real options is $39,864,000. As both these values are positive, it was obvious that unanimous decision would be made to fund the development of the device. If any of the answers are below 50 indicating neutral, it represents lack of understanding of capital budgeting techniques, or possibility of an error in performing capital budgeting analysis; actually, four of the participants had responses below 50 and one of them, failed to respond to the question; these responses were excluded from all analyses. Two aims were satisfied by the decision made at this stage. One was to find out, whether advantage in terms of different manner of project acceptance had occurred due to application of real options into the analysis and to pinpoint personal responsibilities on the participants for the project, where decision is to be made. According to Schoorman and Holahan 1996, Goltz 1993; above two advantages, assume importance, although it is not necessary that they are antecedent condition for escalation of commitment to occur, in the future. [12]

Objectives of phase I of Clinical Trials, is to determine the metabolic and pharmacological actions and the maximally tolerated dose. Factors to be identified are bioavailability, bioequivalence, proportionality of dose, metabolism, pharmacodynamics and pharmacokinetics. Data focus is on vital signs, plasma and serum levels and adverse events. Design features are unblinded and uncontrolled single, ascending dose tiers. Population consists of healthy volunteers or individuals with the target disease i.e. Cancer or HIV. Sample size is 20 to 80, with duration of 1 month. Example is study of a single dose of drug X for normal subjects. [13]
Real option valuation methods can assess the value assigned by investors to biotech companies. Value of the company is derived from the expected profits of the company’s products and their potential for growth of the company as one with many profitable drugs. Real option valuation methods, can be applied to assess the value of projects individually, but, the challenge here, is to use real option models, to assess value of a company, having portfolio of projects.

Decision tree and binomial lattice methods have been used to compute the value of a biotechnology company, Agouron Pharmaceuticals, seen as sum total of value of its current projects. Computed values of Agouron Pharmaceuticals, after calculations, are compared with actual market values at selected points in time, during the development of Viracept, a drug for treating HIV-positive patients. It is illustrated as to how real option models can be utilised for financial analysis. This analysis uses data, based on research from prior studies and hence, results come with an assumption that situation of the company matches with that of a typical research intensive pharmaceutical company in the 1980s and early 1990s. Methods presented in this paper, provide stock analysts with means to value biotechnology companies, not having current revenues.

It is believed that investors were making different assumptions. Firstly, there was tremendous political pressure on FDA to approve drugs for HIV-positive patients. Hence, investors assumed that this drug would need less than eight years from beginning of phase II to launch. In fact, it took slightly less than two years. Secondly, probability distribution of revenue stream has been assumed 80% probability has been taken for revenues to be under $ 100 million a year at peak. Sales of Viracept were more than $ 400 million during 1998 in its first full year of sales and were expected to be between $ 430 and $ 440 million in fiscal year 1999. Market would have assumed different probability distribution for revenue. Finally, market is likely to have assumed probability of approval for Viracept, greater than that of a typical NME. [14]

Real-options pricing techniques can help assess the value investors place on biotech firms. The valuation of the firm is derived from the expected profits of the firm’s products and the potential for growth of the firm into one with many profitable drugs. The real-options valuation model, will help to determine the worth of individual projects,
but the question here is, can real-options valuation models be used to assess a portfolio of projects (i.e., the firm)? In this paper we compute the value of a biotechnology firm, Agouron Pharmaceuticals, Inc., as the sum of the values of its current projects. Each project's value is found using the decision tree and binomial-lattice methods. An influence diagram method is also used and discussed. The decision tree and influence diagram methods yield identical results, but the influence diagram method has advantages as the decision trees become more complex. We compare our computed values of Agouron to actual market values at selected points in time during the development of Viracept®, a drug used to treat HIV-positive patients. The approach and results are of interest to stock analysts because it provides a means to value biotechnology companies that have no current revenue. Financial analysts in pharmaceutical companies can use these methods to value projects and compare their relative worth for capital budgeting purposes. Executive management of pharmaceutical firms can use these methods to better understand the value of their projects and convey it to investors. Finally, for academic people, this is an interesting case study that provides empirical evidence of the usefulness of real options valuation methodologies. [15]

The emergence of a new technology or product of uncertain profitability endows each potential producer with a real option on the future net revenues accruing to that technology or product. If the number of potential producers is finite but greater than one, so that potential competition in providing this product is neither perfectly competitive nor a monopoly, this real option has a value that depends on the exercise strategies of the producers, as well as the volatility of the flow of future revenue. Moreover, the equilibrium in the timing and magnitude of investment will endogenously determine the nature of competition in the ensuing market for sales of the new product. This paper considers the advent of technology allowing the provision of banking services on the Internet as an example of the general phenomenon of real option exercise in the adoption of new technologies and the provision of new products. Potential providers of such Internet banking services, within a regional market defined by existing banking relationships, hold an option to invest ‘early’ in a transactional Internet banking site or to
delay such investment until more is known about the extent of demand for Internet banking services and the profitability of such an investment.

Theoretical predictions have been shown about the timing of investment in Internet banking technology as a function of both relative firm size and the degree of uncertainty over the profitability of providing such services in a regional market. These predictions have been tested on a sample of data from 1,618 commercial banks from the Tenth Federal Reserve District. Specifically, we test two predictions. First, that the concentration of a bank’s rivals in its market should have a negative effect on the probability of investment in a transactional Internet banking site. Second, by reducing uncertainty over the volatility of demand for Internet banking services, favorable economic characteristics, such as low variation in income per person around its trend, should also have a positive effect on the probability of such investment. Using Logit regression techniques, we find results consistent with both predictions. [16]

This paper introduces influence diagrams as an alternative capital budgeting decision-making framework and compares & contrasts decision tree models, binomial models along with influence diagram models. Influence diagram models represent decision problems in more descriptive, intuitive and compact manner as compared to decision tree and binomial models. Further, influence diagram models and decision tree models are mathematically equivalent and for modeling & valuing investment opportunities having real options and under certain conditions, influence diagram models and binomial models give same valuation and optimal strategies.

In decision problem, basic similarities and differences of the various decisionmaking frameworks, can be observed:

1. The decision tree and binomial tree are structurally the same when there is one 2-state uncertainty and the decision alternatives are explicitly included in the model. Both of these models grow exponentially as variable and time periods are added to the model. Therefore, they are unsuited for modeling large problems.
2. The solved decision tree and the solved binomial tree yield different valuations due to the different asset pricing models assumed and, accordingly, the different probabilities and discount rates used in valuing the investment opportunity.

3. Even with different resulting values, the optimal strategies (initial and follow-on actions) are not necessarily different for the two models.

4. Depending on the inputs, an influence diagram model can emulate either a decision tree model or a binomial option-based model and can be an alternative decision-making framework for investment opportunities having real options.

5. Influence diagrams are superior in how they graphically represent and present decision problems. They are more descriptive of the decision problem, better illustrate the relationships between and among the decision problem’s variables, and grow linearly as time periods and variables are added to the model.

This decision problem illustrates that an influence diagram model is more easily implemented for real options analyses and can readily be used by corporate managers to value investment opportunities having real options. Practically, therefore, this research may provide a means for bringing real options analyses into the applied arena. [18]

There are two important driving variables in a real options analysis: volatility (total risk of spot price) and convenience yield (expected growth rate of the spot price relative to the cost of capital). It can be seen that there is a tradeoff between volatility and convenience yield. Volatility pushes for delayed development and convenience yield pushes for early development.

In summary, the useful market data are: current futures and futures options prices for petroleum commodities (especially crude and natural gas) plus gold futures (to infer the riskless rate of interest for commodity traders). Limitation of these data are that they reflect short term horizons, rather than long-term futures. These can be extended to longer terms by using:

1. Long term bond yields and forward interest rates implied by them.

2. The corporate cost of capital.
3. The corporate forecast of the nominal escalation rate of petroleum spot prices. [21]

Various extensions have been considered, to the standard investment problem under uncertainty. The standard NPV rule is typically applied to one-stage investment problems (e.g., building a plant or commercializing a new product), taken immediately or never, without any strategic considerations. The early real options literature (e.g., McDonald & Siegel, 1986) highlighted the value of the option to “wait and see” under demand uncertainty, justifying deferral of even positive-NPV projects. A part of the strategy literature instead focused on the benefits of investing early, e.g., by preempting competitive entry (Dixit, 1979, 1980) or generating learning experience cost effects through cumulative production (Majd and Pindyck, 1993). An alternative way to lower future production costs is to invest in R&D to develop a more cost-efficient production process. The R&D investment problem involves a two- (or multi-) stage analysis, with the first stage (research) effectively being a (compound) option on the latter stage (commercialization); the latter stage is discretionary and must be valued as an option since management would proceed (and pay the commercialization cost) only if the first stage is successful, but not otherwise. This growth option value can justify taking negative-NPV investments. (The firm may even choose the optimal timing of investing in R&D, trading off the benefits of future cost savings against the option value of waiting under demand uncertainty.) But more importantly, there is a strategic benefit to early investment commitment in terms of improving a firm’s relative competitive position (e.g., via a cost advantage) and influencing the competitor’s behavior. The problem then involves a tradeoff between the option value of waiting and the strategic benefits of early commitment --even from the perspective of a single firm (Baldwin, 1987). The value of these strategic benefits may depend on whether the firm can keep them proprietary or whether they are diffused to the industry (Kester, 1984). But in a dynamic environment, the competitor is probably faced with a similar opportunity, to make an R&D investment early or wait, taking each other’s behavior into account. Further, each firm can decide to invest in R&D independently (i.e., compete in R&D), or both firms may do so jointly (collaborate via a joint research venture). An R&D investment may generally involve the
resolution of multiple sources of uncertainty. Besides the market demand uncertainty, there may be technical uncertainty, concerning the outcome of each firm’s R&D effort, that, also may influence the investment decision of two competing firms. Each firm’s decision would then depend on whether it has complete or incomplete information about the resolution of the other’s technical R&D uncertainty (success); in case of asymmetric information, each firm also faces a decision of whether to signal truthful information or not. This paper combines the real options framework with game-theoretic industrial organization principles to model the above complexities and derive economic implications that may help explain strategic investment behavior under uncertainty. Basic model examines a two-stage game, where the option value of R&D depends on endogenous competitive reactions. Further, a sequence of investment decisions by a pioneer firm involving a first-stage strategic (R&D) investment commitment that can influence its strategic position (relative future production costs) vis-à-vis its competitor in the second stage and subsequent productive investment (commercialization) decisions by either competitor. The model illustrates the tradeoff between flexibility value of waiting and the strategic commitment value of R&D that interacts with market structure via altering the competitor's equilibrium quantity or changing the market structure altogether (e.g., from Cournot Nash equilibrium to Stackelberg leadership or monopoly). Basic model is extended by developing various competitive strategies depending on uncertainty in market demand and a stochastic outcome of the R&D effort, on proprietary or shared benefits of R&D, imperfect or asymmetric information with signaling, learning or experience cost effects, and R&D competition versus cooperation via a joint research venture. [23]

Managers and designers for technological systems face a common difficulty, new projects or products are inherently risky, both, technologically and financially, especially given the rate of change in the high technology, deregulated economy. Consequently, they need solid methods for valuing prospective investments, so that they can justify their development strategies. Their fundamental problem is compounded by two methodological difficulties: traditional net present value evaluations are inadequate for
Real Options: Valuation and Applications (Case Studies of Indian Projects)

many risky projects and the available methods for valuing these projects are limited and often impractical. This paper identifies practical solutions to this problem. Conceptually, it is crucial to focus on dynamic strategies of development, rather than on specific projects or products. Planners need to understand that they are consciously managing risk and will do so most effectively by developing options they can exploit or abandon depending on future events. Methodologically, it is useful to combine best of the alternative approaches to valuing risky projects, to achieve practical and effective means of valuation. [27]

Real options have a fundamental effect on the normative value of capital investments. A number of studies (such as Brennan and Schwartz, 1985 a; Paddock et al., 1988; Ingersoll and Ross, 1992) have demonstrated that when an irreversible investment is contemplated in the face of uncertainty, the option to postpone the investment can be highly valuable. Other studies have suggested that the option to grow or develop explains a large component of a firm’s market value (Kester 1984, pp 154-155). There is also evidence that having the option to abandon a project can be an important influence on the decision to adopt the project in the first place (Grinyer and Daing, 1993). The normative theory in this field, however, is complicated and conceptually difficult. This makes it impractical as a general decision-making aid for most business managers. A natural step is therefore to assess the decision-making process in business, for its recognition of the presence of options and to determine, how far this process is at least qualitatively consistent with the theory.

This paper describes an exploratory survey of senior finance officers in the largest U. K. firms, assessing how, in the absence of an easily implementable normative model, firms think about real options during investment appraisal. The purpose of this survey was therefore to make an initial attempt to answer these questions. As an exploratory piece of work, the aim was to develop insights rather than test firm hypotheses.

In summary, we found that real options often occur and are generally significant in determining, how decision-makers regarded an investment proposal, but that there was a wide variation between individual decision-makers in attitude to real options and wide
variation in the frequency of occurrence of different types of option. Most respondents could recall at least one case of a real option, with which they had to deal and in about half the cases, the option in question had been necessary for the associated investment proposal to be sanctioned. A few firms have procedures to assess options in advance, although these normally help identify the conditions in which options are needed rather than make an explicit evaluation of the options that may be present. Real options are not, however, always seen as being beneficial, since they reduce organizational commitment to a planned outcome or event; furthermore they may often be unavailable as a result of legislation, regulation or commercial commitments. Very few decision-makers seemed to be aware of the research in the field of real options but, mostly, their intuitions agree with the qualitative prescriptions of such work. [29]

This paper shows a contrast between traditional valuation methods and new generation of strategic decision analytic method namely real options with Monte Carlo simulation, stochastic forecasting and optimisation. Readers should understand that the new methods do not completely replace the traditional approaches; rather, they complement and build upon the traditional approaches. Traditional approaches are not incorrect, but simply incomplete, when modeled under business conditions of uncertainty and risk. There are two major takeaways from this paper. First, is the fact, that, real option analysis is not an equation or set of equations. It is both an analytic process as well as decision analysis thought process. This brings to second takeaway that 50% of the value of real options is simply thinking about it Another 25% comes from generating the models and getting the right numbers and remaining 25% of the value of real options is explaining the results and insights to senior management, to people with you or yourself, so that optimal decisions can and would be made, when it is most appropriate to do so. [31]

It suggests use of contingent claim analysis, which is another version of Black & Scholes. It is applicable, when risk can be spanned by existing assets in financial markets. Market is in equilibrium stage for above method, with no chances of arbitrage. Other method
suggested is dynamic programming, which has to assume a discount rate and it is applicable to many environmental problems. Such methods are applicable in resource extraction, development and management; species preservation; global warning and abatement investment under different policies. Key results can be achieved in applied welfare analysis.

In a typical study, how much is the amount to be paid for preserving a park, if the person is uncertain about the value of the park or substitutes/complements and expects that he/she can learn about the value. If the person has some willingness to wait and expects the cost of reversing the action of buying or selling, then he/she may choose to wait for more information before making a decision. [32]

A decision to invest in the development of an oil reserve, requires an in-depth analysis, of several uncertainty factors. Such factors may involve either technical uncertainties related to the size and economic quality of the reserve, or market uncertainties (e.g., oil price). Considering that the technical uncertainties are known, the analysis of market uncertainties will help decision-making with regard to investing in a field immediately or waiting until market conditions are more favorable. When a great number of investment alternatives are involved, the task of selecting the best alternative or a decision rule is very important and also quite complicated due to the considerable number of possibilities and parameters that must be taken into account.

This paper presents a Genetic Algorithm (GA) for obtaining the optimal investment decision rule for the development of an oil reserve under market uncertainty, particularly with regard to the price of oil. This optimal decision rule is formed by three mutually exclusive alternatives which describe three exercise regions along time, up to the expiration of the concession of the field. The Monte Carlo simulation is employed within the genetic algorithm for the purpose of simulating the possible paths of oil prices up to the expiration date, and it is assumed that oil prices follow a Geometric Brownian Motion (GBM). Section 2 describes the problem of the optimal exercise of the development option. Section 3 describes how the problem was modeled with the use of a GA with the Monte Carlo simulation and the Real Options theory, and also the way, how,
chromosomes were represented and evaluated. Section 4 presents the results obtained with the proposed model. [33]

Real Options would not have been so much popular, if so called ‘irrational exuberance’ for the new economy had not occurred in world markets, particularly in US markets, in late 1990s. Price multiples and market valuations of new economy stocks were so high that conventional approaches like discounted cash flow analysis were simply inadequate in explaining market prices. Employment of real options has filled in the gap between valuation and market prices by taking into account hidden or embedded options pertaining to flexibility possessed by firms. Copeland et al. (1990) has outlined that these options comprise abandonment option, options to defer investment, option to expand, option to contract and switching options of prospective or ongoing projects that can be exercised at various stages throughout the project lifecycle. The right to exercise such option as new information arrives, leads to better informed decisions and hence, such options become valuable for the firm. Copeland (2000) argues that for emerging companies, which are small, high-growth businesses that have yet to establish a track record of profitability but are highly flexible and may have investment or growth opportunities that could greatly increase their cash flows, these opportunities have an option value that often represents a significant portion of the firm’s total value. In these cases, it is more appropriate to use a real options valuation technique. [34]

Two important features of R & D projects are that such projects take time to complete and outcome of such a project is uncertain. Analysis of R & D projects is surely one of the most difficult problems of investment under uncertainty, according to Schwartz and Moon (2000). Aim of this paper is to provide analytical results regarding incentives for R & D investments of firms dealing with competition. After starting with studying the monopoly benchmark case, a duopoly framework is considered. Section 3 considers the monopoly case, while effects of a duopoly framework are talked about in Section 4. It is concluded that using the real options method of assessment of R&D investment, allows the firm to undertake larger investment projects, when the variance s large. This
supports the argument of Dixit and Pindyck (1995) about the value of exploratory investment as an "option creator" for the firm. Also the real option criterion creates more complex strategic interactions between the competing agents in a duopoly. These interactions allow us to model more realistically, the R&D investment and production behavior of firms under technological uncertainty. It is observed in the model that if the R&D is profitable for both agents, they will end up in a Cournot competition with symmetric market shares. But the technological uncertainty together strategic interaction between two agents can lead to the outcome when it is profitable for one agent to invest in R&D only if another does not. The "technological leader" in this case obtains larger market share and is actually capable of conducting the R&D investment in volumes, which are not profitable under regular symmetric conditions or in cases, when the first-stage exploratory R&D was not successful. Moreover, if the unit production costs gain is substantial, it is more likely, that the "inferior" firm will leave the market and the "leader" will find himself in a monopolist position. [35]

It is undeniable that U.S. government and businesses have recognized the potential of fuel cells and established plans to pursue their commercialization. However, much still needs to be done, and continuous financial support from the government and businesses is imperative to see progress in the technologies. Department of Energy (DOE) has actively involved in fuel cell R&D, and spent $240 million for hydrogen-related initiatives in 2004, but the DOE spending on fuel cell only accounted for 0.5% of the agency’s annual budget. In addition, the $240 million spending was only 10% of federal government subsidies paid that year to U.S sugar producers, direct economic aid to the Jordanian government, or one-half day’s expenditure on the occupation and reconstruction of Iraq (Eisenmann and Willis, 2004, p. 8).

This thesis applies a 3-step approach to value the fuel cell R&D program as a real option. Fuel cell vehicles’ high-fuel economy and CAFE benefit would allow GM to market and sell greater volume of high-profit, low-fuel economy vehicles that are previously restricted by the CAFÉ constraint. The value of the R&D program should not be evaluated by itself, which is predicted to be negative; rather, the value and the payoff of
the R&D program are positively correlated to the incremental value of the fleet brought about by selling fuel cell vehicles in the product mix of the fleet. The approach identifies the best commercializing time between 2010 and 2015 in all scenarios; the analysis result is the optimal value of the fuel cell R&D as uncertainties are proactively quantified and managerial flexibility is exercised based on a profit-maximizing principle.

The choice of underlying in real option valuation has generated many debates due to the difficulty in finding a replicating portfolio. In this case, the underlying is the NPV without fuel cell vehicles. NPV can be used as an underlying in this case because (1) the objective of the analysis is to observe how the fleet NPV behaves after the commercialization of fuel cell vehicles, (2) NPV before launching fuel cell vehicles has similar risk profile with that of after the launch. After all, fuel cell vehicles are selling only as much as 2% of the total light passenger sales, and (3) GM is a publicly traded company and when the unit of evaluation is entire fleet, it is relatively easy to calculate the volatility of the project. The stock market has determined the volatility through the fluctuation of GM share price. It is not to say that the practitioners should always use NPV as the underlying regardless of the case to be evaluated. Practitioners should carefully evaluate, based on their understanding of their specific problem, what underlying best describes the risk and payoff structure of the option. After all, the choice of underlying is not only difficult but contentious; it seems that none of the choices of underlying are completely justifiable. For example, practitioners have used Gold price or electricity price as the underlying for a Gold mine or a large dam. However, can the price of Gold and the price of electricity be a representative indication of the risk level of these projects? Gold price and electricity price are readily observable, but they do not seem to represent the many technical and organizational risks involved in mining or infrastructure projects. [36]

“The value of R&D is almost all option value” postulated Myers in 1984 who, bristly, recognized the analogy between inimical options and real world investments. For this relationship, he coined the expression “real option”. This term describes the cognition that, based on the resemblance mentioned above (R&D) investments can be valued
similar to financial options. The scientific basis for this task is provided by the research of Black/Scholes and Merton, who were awarded the Nobel Prize in 1997. Real options account for management flexibility, which delivers a significant value contribution in the presence of uncertainty. Therefore, real options analysis (ROA) was recommended several times to be more adequate than traditional Net Present Value (NPV) for judging R&D projects (e.g. Newton et al., 2004). In addition, following a real option’s perspective on R&D projects, in R&D-intensive companies has a positive impact on both their R&D performance and their financial performance (Kumaraswamy, 1998). These notable statements raise the question of the actual level of usage of ROA for valuation tasks inside the affected companies. However, due to the exclusive inter-sectoral nature of the surveys conducted so far, there is no exact picture available that tracks the concrete situation in one particular real option branch. This paper aims at investigating the application of real options analysis in the pharmaceutical industry. Thereby, R&D projects as well as the assessment of whole companies are focused. The study considers every R&D stage and the different project valuation methods applied there. The current and the expected usage of real options analysis are determined. The data collection is performed using a survey based on a written questionnaire. The main international pharmaceutical companies as well as the health care departments of financial service companies have been addressed.

The current article, presents the first detailed empirical data of real options analysis for pharmaceutical R&D and comprises the following sections: it begins with a short introduction on the current situation of the pharmaceutical industry and the particular features of the R&D process in this sector (Section 2). An overview of real options analysis is given in Section 3. The results from other surveys regarding real options usage are presented in Section 4. Subsequently, the concept of the actual survey is explicated (Section 5), accompanied by the respective outcomes (Section 6). Finally, a critical discussion is undertaken in Section 7. [38]

Security challenges have always been accompanying the process of externalizing company’s operations and a variety of coordination and security mechanisms have been
designed to help organizations cope with these challenges. Resolving these challenges in a systematic way requires information security risk be managed based on five cornerstones: an information security organization, IT asset risk inventory, information security policies, including those based on a common policy structure such as ISO 17799, information security architecture, and a business resiliency program. Real options thinking appears to be well suited to assist in predicting what composes a security strategy and how much of it should be present in a cross-organizational setting: it focuses explicitly on flexibility under uncertainty and makes it feasible to link likely changes to be accommodated by inter-organizational and intra-organizational architectures to value creation. The key merit of our approach is in that it recognizes that the ability to postpone, size up, size down, and outsource types of security and aspects of security of certain types is valuable at both the levels of the business network and the partner companies, when there is flexibility associated with security decision making. Moreover, such an approach seems to reflect well the opposing forces of agility and discipline in today’s dynamic business networks: agility implies maintaining the flexibility to change direction quickly, whereas discipline and focus imply the opposite digging in, reinforcing, and securing a space and refusing to budge or give it up until all the benefits have been reaped. The tension between agility on the one hand and discipline and focus on the other has to be managed creatively and the real options concept brings the vehicle that security decision-makers need to do this.

This paper contributes to the application of quantitative approaches to assessing risks, costs and benefits associated with the various components making up the security strategy of a company participating in value networks. A risk-based approach is adopted for determining what types of security, a strategy should include and how much of each type is enough. We adopt a real-options-based perspective of security and make a proposal to value the extent to which alternative components in a security strategy contribute to organizational resiliency and protect key information assets from being impeded, disrupted, or destroyed. [39]
The goal of this paper is to show how real options theory and game theory can be merged to enrich the theory of R&D investment valuation with a dynamic and strategic competitive perspective, to apply this theory for analyzing models of duopoly competition vs. joint R&D cooperation and to highlight possible further applications and research topics.

The integrated options-and-games perspective of this paper is particularly relevant for oligopolistic and innovative industries like consumer electronics, pharmaceuticals/biotech or telecommunications which face high R&D investment costs over several stages in a technologically uncertain and competitive setting (Smit and Trigeorgis, 2006). As Smit and Trigeorgis (2004b) point out, companies in these sectors have to make prior investments in R&D, to improve their competitive position and their ability to better capture growth opportunities in the industry later on. As stated by Bowman and Moskowitz (2001), an R&D investment program can therefore be seen as a two-stage process, where the program usually makes a small initial investment (purchasing the option) and a larger later investment (exercising the option). In fact, the value of these R&D investments does not derive so much from the expected cash inflows of the investment opportunity but rather from the option to invest in future commercial exploitation. [41]

There is a large body of research on Information Systems (IS) Risk Management; however it falls of demonstrating that it meets practical needs. An Extensive analysis of IS risk management literature reveals an area rich in terms of approaches (e.g. Casestudies, surveys) and theoretical foundations (e.g. structural contingency theory, prospect theory) (Roponnen 1999). Yet, this research has two gaps that are of concern in this study. First, it focuses mainly on the discovery of risk factors affecting information technology projects and of risk countermeasures for controlling risks but without empirically studying the connections between the two (Roponnen 1999). Second, it does not offer adequate ways to quantify risk and risk countermeasure as well as their consequence on the cost and risk of an IT investment. Due to these gaps it is impossible
to know whether any specific combination of risk countermeasures used for a target IT investment is optimal or even adds value from an economic perspective. Some IT research suggests using real options theory to address these gaps. Initial work sought to establish the importance of flexibility in risky IT investments. When deciding, for example, on whether to accept an IT investment (Taudes et al. 2000) or on the timing of an investment (Benaroch and Kauffman 2000), it is suggested to conceptualise and value different forms of flexibility as real options (defer, pilot, stage and so on). Although this early work has no direct link with IT risk investment, it explicitly recognises that the value of flexibility afforded by options is driven by the presence of risk. Later work has looked at the link between flexibility, real options and IT risk management. Flexibility is a crucial success factor in IS development (Evans 1991), as it enables deployment of risk countermeasures contingent on the materialization of risk (Avison et al. 1995). On this ground, real options theory was used to justify certain IT project management practices related to risk (Kumar 2002, Kim and Saunders 2002). Further, it was argued that since flexibility is not inherent in any investment, proactively embedding options (flexibility) in risky IT investments can add value (Benaroch 2002).

This paper uses the real option valuation method to assess impact of a construction guarantee on equity values of two copper projects. Real option method has been noted for its ability to determine value of management flexibility and to provide valuations that differentiate projects by risk and uncertainty. Real options, also has been used to assess the impact of the interaction between project participants on the value of each participant’s claim to project cash flows. This paper, considers the effect of construction guarantees on the value of a project owner’s claim to project cash flows, when there is mineral price and FOREX rate uncertainty. These guarantees may be used by project financiers and host governments to ensure that a project is developed. Construction guarantees can restrict a project owner’s ability to manage the development phase of a mine by forcing development in adverse business conditions. Such restrictions may lead to a significant reduction in the equity value of a project.
Two mining projects, Long Life mine and Short Life Mine, were valued using real options to assess the impact of a construction guarantee, when an early closure option exists and projects are exposed to reverting mineral price and FOREX rate uncertainty. [43]

As energy markets are competitive; government regulations, development of technologies, along with uncertainty in terms of energy prices and CO prices, are highest risks, in path of assured recovery of energy sector investments. While, evaluating projects, for the purpose of making investments, traditional techniques like DCF, are not capable of fully quantifying these risks and uncertainties faced. ROA offers a newer type of approach, towards strategic investment and it considers the value of the options for decision-makers, working under budgets. Uncertainty can exist over real assets like project investment capital, while, examining optimisation of available options, in terms of real option problem. ROA, as a technique, helps in analysis of different risk factors, in the energy and environment sectors, favouring a direct comparison of CO price uncertainty with other risks.

During the past 30 years, ROA has emerged as a technique in favour of appraisal of project investments and emerging from financial economics theory. Different types of computer models, are observed towards using ROA in the quantitative analysis of energy and environmental investment; at the same time, very few models apply ROA, to quantify the impacts of climate change policy and uncertain energy & carbon prices, on power sector investment. International Energy Agency (IEA) developed a model to address this lack of uncertainty regarding energy and carbon prices, which was inspired by the Electric Power Research Institute's (EPRI's) first Greenhouse Gas Emissions Reduction, Cost Analysis Model (GHG-CAM) model. The IEA model adds several new features, including an ability to model carbon price jumps and a new plant’s construction and development, under multiple uncertain factors, at the same time and expands menu of options, presented in this paper. Due to the international climate change regime and government climate change policy, nowadays, it is discussed that carbon prices would likely jump at the end of the first ‘commitment period’ of the Kyoto Protocol. Decisions
of power investors, would be considerably affected, by carbon price jumps. Impact of carbon price jump on power sector investment, needs to be evaluated, on an urgent basis. According to extensive literature reviews, no modeling research or study has been undertaken, to analyse the impact of carbon price jump on investors’ decisions. IEA’s modeling technique, provides one more significant contribution to the ROA literature. Application of ROA modeling has been limited up till now, to one-stage investment and mostly has relied on one stochastic variable, as observed in literature reviews. In contrast, the IEA’s approach is centered towards modeling of construction or development of a new power plant from a green field, considering multiple stage investments, using stochastic variables simultaneously, with uncertainties of energy price and carbon price. Article, here, presents the IEA modeling methodology, presents it's supporting database, states the assumptions in the model with clarity, describes the issues that the model can look at and demonstrates the applications for the model, to be used in future projects. Entire methodological framework of IEA’s modeling can be sub-divided into four major modules. Module 1 is a database of sorted primary data, such as energy prices, carbon prices and power production technologies. Module 2, permits the development of scenarios and the processing of relevant data. After treatment is performed, these data and scenarios constructed, enter Module 3’s traditional discounted cash flow analysis and Module 4’s real options analysis. The detailed mathematical equations used in the computer model, have been illustrated, in this paper. These equations, include those of deterministic method, dynamic & stochastic analysis method and real option optimization method, developed in an MS-Excel environment and supported by commercial software named Real Option Calculator. The IEA’s model, provides a wide range of applications: (1) a model, without considering options, to estimate the risk premiums of the project; (2) a base option model to simulate the project from one baseline scenario to a single post-exercise scenario; (3) a multiple options model, accounting for many risks; (4) a multiple options model, with assigned probabilities, to indicate a probability distribution, for showing the likelihood of each of the target scenarios; and (5) a nested (compound options model), to create a model for a series of investments over time. [44]
In spite of the aggregate level of the analysis it is obvious from the case study that flexibility and its value can be of substantial value in ongoing and future offshore development projects. While previous contributions to a large degree have neglected the operator’s flexibility during the operating phase, this flexibility can play a major role to the overall value of the project. Particularly, this is true, when the uncertainty surrounding the reservoir is high, as is the common situation at early stages of the development. Future assessments of offshore oil field development projects should therefore give due attention to the operator’s decision making freedom in the project’s different phases. The reported results help to explain the reluctance of Norwegian oil companies to accept analyses based on option pricing theory, which typically emphasise the value of waiting. A decision to “wait”, instead of immediate development, has been, and is, considered counterintuitive. If the cost structure of the case is mirrored by previous field developments, the initiation flexibility has most likely been worthless in the majority of projects considered the last 10 - 15 years (given the oil price level for the same period). The error made by the companies by neglecting this opportunity is thus believed to be minor. A similar conclusion is also obtained if the price is assumed to follow a mean reverting pattern. However, one should note that these results are not general. Different assumptions and, in particular, reduced oil prices may alter the picture and give substantial value to the option to wait. [45]

Procedure to value real options proposed by Copeland and Antikarov introduce significant upward biases in the estimation of volatility. Due to importance of volatility in option analysis, it can be expected that such biases would lead to over-valuation of investment projects and over-investment. The application of real options analysis to the valuation of real-life projects presents some serious difficulties. A general approach proposed by Copeland and Antikarov (2001) seems to make the practical application of real options analysis much more accessible. However, this general approach has some important weaknesses. One of these weaknesses lies in the procedure for volatility estimation. This paper shows that both the procedure originally proposed by Copeland and Antikarov and another procedure used by Herath and Park (2002) and Cobb and
Charnes (2004) introduce significant upward biases in the estimates of volatility. Given the importance of this parameter in option analysis, it can be expected that such biases will sometimes lead to the overvaluation of investment projects, and to over-investment. It may also happen that projects are excessively delayed due to over-valuation of deferment options. This paper proposes alternative procedures that will lead to better estimates of project volatility, thus allowing more accurate valuations. Some other weaknesses of the approach have not been addressed by this paper. [47]

This paper reviews some of the path-breaking studies on valuation of medicinal plants for drugs and pharmaceutical purposes. In the last 17 years (1985–2002), numerous studies on this theme have been carried out. A few representative studies have been reviewed and the emerging policy issues mapped out. A careful analysis of these studies also provides an indication of the direction in which the valuation of medicinal plants is progressing and the emerging research agenda in this particular area in the coming years. Valuation studies done so far fall into three categories, viz. gross estimation, net estimation and estimation of lead for drug industry.

Alyward estimates the return to different factor inputs in the R&D process of the pharmaceutical industry. Based on the data primarily in three studies and other contract agreements (e.g. Merck-INBio), return for each factor input, can be calculated. Alyward explicitly discerns the cost factors like biodiversity protection, biotic samples extraction and other R&D costs (from sample extraction to regulatory approval). He adopts two different models to capture the return: (i) cost (private and social) model, and (ii) prospecting royalty’s model. For estimation of net returns across different factors of prospecting, in each model the expected net return to each factor is assumed equal to its proportional share in the total cost of the prospecting process. In another model of royalty, Alyward estimates the net returns from prospecting royalty. Here the gross revenue comprises sales net of distribution costs up to patent expiration. After making the adjustment in the species success rate and the number of samples used per species, he computes the gross royalty on the biotic samples.
Economic valuation of medicinal plants has proved to be one of the major economic benefits of bio-diversity. This in no way reduces the significance of other benefits of biodiversity, for example, functioning and dependence of various ecosystems. By and large all studies are discussing the medicinal plants derived from the forest ecosystem. Medicinal plants of other ecosystems like marine ecosystem and animal species have not been considered. [48]

The thesis is split up in three major parts. The first part describes the real options analysis for valuing capital investment projects and introduces the different types of managerial flexibility as proposed by Trigeorgis (1996). The second part reviews real options in theory and practice and analyzes, whether theory meets practice. Firstly, the real options literature database, which has been created, within the scope of this thesis, is presented. Based on the academic literature collected in the database, an extensive review of the application areas of the ROA in theory is provided. Afterwards, academic literature is studied to find out, how often each real option type, each industry and both in combination, are discussed. Furthermore it is examined, whether there is a link between the type of the real option and a specific industry. To assess the application of the ROA in practice, an exploratory survey on the largest US companies has been conducted. Finally, 852 executives and 103 investor relations have been invited to fill in the online questionnaire but only 17 complete responses were received. As this response rate is not sufficient for an evaluation, the occurrence of managerial flexibility, within Swiss firms, is analyzed with recent field research data from Scalding (2007). The analysis explores how frequently managerial flexibility occurs in Swiss practice and whether certain types of managerial flexibility occur particularly often in certain industries. To find out whether theory meets practice, the findings from academic literature are compared to the evidence found in Swiss practice. In particular, it will be investigated, whether some types of managerial flexibility occur in certain industries but have only been insufficiently discussed by academia. By assuming that managerial flexibility, that occurs, is wished to be quantified by practitioners, these findings will indicate gaps between theory and practice. These gaps need to be diminished by academia to more widely diffuse the
application of the real options approach in practice. In the last part, the real options framework developed by Luehrman (1998) is introduced and provides managers with an applicable and understandable tool to easily use option-pricing on their own projects. By the means of a small case study, it is finally illustrated how an R&D project at Merck & Co. Inc. could be implemented in the framework. [50]

This technical note shows how designers of infrastructure systems can evaluate flexibility in engineering systems in fairly simple ways. Model avoids complex financial procedures, which are both inappropriate for most design issues and constitute barriers to understanding and thus substantially improving the performance that real options enable. The spreadsheet approach uses standard procedures, is based on data available in practice and provides graphics that explains the result intuitively. It thus should be readily accessible to practicing professionals responsible for engineering design and management. A practical application to design of a parking garage demonstrates the ease of use and presentation of results of this approach.

The spreadsheet approach was applied to the design of a parking garage, inspired and extrapolated from the Bluewater development in England (http://www.bluewater.co.uk/). This example shows the ease of use and transparency of the approach, particularly when contrasted with financial methods for dealing with the same issue (see Zhao and Tseng, 2003).

Case study talks about a multi-level car park for a commercial center in a region, that is growing, based on the expansion of population. Basic data is as follows:

• The deterministic point forecast is that demand on opening day is taken as 750 spaces and is expected to rise exponentially at the rate of 750 spaces per decade;
• Average annual revenue, for every part of the space used is $10,000 and average annual operating cost for unit space available, is $ 2,000;
• Land on Lease, is costing $ 3.6 million annually;
• Construction is attached with cost of $16,000 per space for pre-cast type, with 10% increase, for every level, above the ground level;
• Site is quite large enough to accommodate 200 cars per level; and
The discount rate, has been taken as 12%. Further, economic analysis should recognize that actual demand is uncertain, considering the long time horizon. This case, has an assumption that future demand could be 50% away from the projections, in either direction and the annual volatility for growth, is 15% of the long-term average.

**Flexibility:** The owners have planned to design the footings and columns of the original building, so that, addition of levels of parking can be done easily, as illustrated in case of the Bluewater development. This study assumes that action, according to plan, as above, would add 5% to the total initial construction cost. This premium is the price to get the real option for future expansion, which is the right but not the obligation to do so. [51]

Real Options Analysis (ROA) has been proposed as an alternative methodology to evaluate capital investments such as R&D projects or new product decisions. The advantage of ROA is that unlike the Net Present Value (NPV) methodology used in capital budgeting, ROA treats a given investment opportunity as a single option or series of compound options, and thus captures asymmetric upside potentials embedded in the project. Well known texts like Trigeorgis (1996) and Dixit and Pindyck (1995) suggest that neither the discounted cash flow (DCF) approach nor the NPV framework can value correctly operational flexibility and other strategic aspects of investment projects because these rules make the false assumption that the investment is either irreversible or that it cannot be delayed. Similarly, Smith and Mccardle (1999) criticize the cost-of-capital based discounting rule as the riskiness of the project in some cases may be significantly different than the firm’s own risk structure.

This paper suggests using influence diagrams as an effective tool to value real options. We use an influence diagram to compute the value of a biotechnology firm, Agouron Pharmaceuticals, Inc., as the sum of the values of its current projects. We estimate share prices for Agouron at selected points in time during the development of Viracept, a drug used to treat HIV positive patients. We then compare our computed values to actual market values as well as to the decision tree and binomial lattice estimates of Kellogg and Charnes (2000). The influence diagram yields better estimates of Agouron’s stock price.
on 4 out of the 5 selected dates. With the exception of October 1994, the influence diagram improves the estimates by at least 10% in the worst case and by 32% in the best case. [52]

Recent research efforts in option pricing have shown that real options approaches are more appropriate for R & D project valuation as they account for value of managerial flexibility to react to arising contingencies during R & D development. Strategic decision-making is allowed in context of hedging opportunities present in financial markets by tracking uncertainty in value of project in development through market-traded securities.

As an illustrative example of the OptFolio and MinRisk models, pharmaceutical company is taken, that has nine candidate drugs ready to begin Phase I clinical testing. The duration of each phase of clinical development is postulated as follows:

Phase I – one year, Phase II – one year, Phase III – two years, FDA approval – two years

Following a successful FDA approval phase, the product can be immediately commercialized under the assumption that capacity investments and production preparations were made during the two years spent awaiting FDA approval. In general, candidate products with high probabilities of technical success and high current value to future investment ratios are preferable. However, real options valuation may show that a riskier project (higher market volatility) can be more valuable because it has a larger upside while still maintaining a fixed, staged level of potential loss. Restricted by resource constraints, the pharmaceutical company must decide, which candidate projects to fund for further development during the upcoming year.

The probability distribution was approximately log-normal, which reflected the fact that most candidate drugs fail during R&D and experience fixed investment losses, but the few drugs may have high valuations. Approximately, 47% of the simulations resulted in a negative net ROV as candidate drugs failed during clinical testing, but the upside from successful commercial launches raised the average portfolio ROV to over $100 M. The Monte Carlo simulation allowed for input parameters to be regressed against resulting
ROV values, leading to a measurement of the sensitivity of ROV to different model parameters. In this example, the mean simulation-derived ROV was most sensitive to Phase III and FDA success probabilities because they contained the risk of large sunken investment costs, if these late-stage trials failed. [53]

The notion of viewing investment opportunities and managerial flexibility as options is a by-product of the research in pricing of financial options, as well as a pressing need for new perspectives on corporate capital budgeting. Thus it is clear that the value of real options thinking is both as a strategic tool and as a valuation technique. While, the latter is the primary focus of this paper, a good starting point on the more high-level issues is found in Faulkner (1996), but he also notes that “there is a tendency to use the term ‘options’ in a casual way to justify investments in a variety of projects without any substantive evaluation”, and goes on to emphasize that the numerical analysis is a necessary complement to the intuition. An excellent attempt to bridge the gap between the strategy-oriented discussions and the quantitative models is McGrath & Macmillan (2000), who present a framework for translating the verbal intuition into approximations of option values.

Models
Most obvious point of departure for those wishing to value growth options is to use the Black-Scholes (1973) option pricing model (BS-OPM) with the familiar five input variables. The literature is filled to the brim with applications of the clean-cut version of the model, and for illustrative purposes and a few real settings this is fine. There is a growing body of evidence, however, that the assumptions underlying the standard BS-OPM are either too simplistic, or downright false, when it comes to pricing options, on many real assets. Additionally, the estimation of several of the input parameters that are needed in the BS-OPM is a less than trivial exercise. [54]

The study has looked specifically for real options within small technology-based companies. The hypothesis that many applications for real options exist has been confirmed. The environment of those small companies is at least as uncertain as the
environment of large companies, and small companies have comparable flexibility to react to change as large firms. They also appear to possess growth options, timing options, learning options, and other types of operating options present in large firms. Only the exit option type was generally rejected by small companies because its execution would mean the shut-down of the entire company. It was observed that small companies are primarily interested in the real options approach as a way of thinking and not so much as an analytical tool for quantitative analysis. They appreciate that the real options approach provides a framework and a language that is able to model and to communicate important business issues. The interest in quantitative analysis concentrates mainly on occasions when a company licenses or sells a technology, because the options associated with that technology can be part of the deal.

Progress was also made in the methodology to identify option scenarios. The small companies that participated in the study had difficulties to relate to the popular option examples of large companies. They need to be offered examples of options that are closer to their own business. Scanning the company’s functional departments (e.g. production, R&D, distribution...) for choices to react upon uncertainty, has been a successful way to suggest, as well as, to identify option settings. The discovered option examples are sorted and presented according to the new functional classification for two reasons. Firstly, these examples show the relevance of the real options approach for small technology-based companies. Secondly, they can serve as templates that help other small companies to look for similar options in their own business. By employing this new and ‘user-oriented’ methodology, a major barrier to the wider adoption of the real options approach – the identification of options – can be overcome. [55]

It talks about the need for real options valuation. There are two dimensions to real options valuation: one is to discover uncertainties, options and flexibility and other is to value cash flows. Option pricing should be used to model market e.g. price risk. Decision analysis should be used to model private e.g. volume risk.

There is relatively unproven technology, from commercial standpoint. Technology is available from more than one source, with providers at differing points in development
and experience. Variation in technology performance and costs are anticipated, depending on provider. Questions arise in terms of whether a major commitment should be made for this technology, which commercial opportunities exist for application of this technology in long-term, which of commercial opportunities and technology providers should be focused in the short term, whether a portfolio can be made from commercial application of this technology. Areas of major uncertainty are technology effectiveness and cost for each provider, installation and operational costs for each provider and location, prices of inputs and end-products, potential for non-technical delays & contractual terms and taxes in various locations. 10 separate opportunities were modeled, three separate schedules were evaluated and it was treated as portfolio of opportunities. Significant emphasis was placed on learning from project to project within each schedule. Fully risked base case is technology provider A. Fully risked learning value with real options, ranged from 80 to 95 %, as compared to range of 15 to 25 %, without real options. Keeping more than one technology is often the best option. [56]

This thesis studies the Project A of Yalongjiang river basin development, to determine the most appropriate valuation method for this project, given the various uncertainties. The valuation methods studied include NPV, NPV with simulation, IRR, IRR with simulation, decision tree analysis and real options (using electricity price or project value as underlying). According to Baxter and Rennie, 1996, presence of Arbitrage, will enforce a price for the options. This price depends, neither on the expected value, nor on the particular distribution, exhibited by the underlying. Partial differential equation (PDE) such as the Black-Scholes formula, the dynamic programming such as the binomial tree and simulation are three categories of arbitrage-enforced valuation methods, existing in the market.

Due to the mathematical insights, PDE method, has become a standard and is widely used in academic discussions. Value of waiting to invest by PDEs., was examined in detail by McDonald and Siegel, in 1986. According to Siegel, Smith and Paddock [1987], offshore petroleum leases, have been valued, using PDE equations. Pindyck [1993], was instrumental in establishing PDEs, to model project cost uncertainties, both technical and in terms of input cost. Grenadier and Weiss [1997], have studied the options pricing, for
the purpose of undertaking investment in technological innovations. Simple representation of the evolution of the underlying asset’s value, is aptly demonstrated in binomial tree method. This method is powerful, but flexible enough to value real options. Luenberger [1998], have shown illustrations, using binomial trees, to value a real investment opportunity, in form of gold mine. Cox, Ross, and Rubinstein [1979], have been instrumental for developing this widely adopted method. Copeland and Antikarov [2001], have talked at length, on the use of binomial trees to value real projects and proved that this method, is equivalent to PDE solution, as well as, easy to use, without losing the insights of the PDE model. Big simulation programs, have been constructed to value options, that are very difficult to value, by solving equations or constructing binomial trees, due to development of computer technology. According to Nichols, 1994, in 1980s, Merck started using simulation, to value its R&D as real options. Tufano and Moel [2000], have exhibited an elegant way to use Crystal Ball to simulate the value of real options, inbuilt in a bidding case, for mining. Juan et al. [2002], recommended a simulation technique for calculating multiple interacting American options, for a harbor investment problem. [57]

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(Table I: Models and their applications) [57]
Real options analysis can provide useful insight into decision making, since it incorporates the uncertainty in the future – and uncertainty is inevitable. Real options, quantified via the Black-Scholes formula, provide a sound mathematical and financial basis for estimating the value of this uncertainty. There are some other observations that should be obvious by now. Firstly, research expenditures should have much higher option value in those industries or technologies, that are more volatile, since the variance in the future cash flows are much higher. For a National Energy Technology Laboratory (NETL) case, consider natural gas fired power generation versus coal fired power. Since natural gas prices are much more volatile than coal prices, the development of a better natural gas fired technology has greater option value than development of a coal fired technology, in general. Of course, this doesn’t imply that any natural gas fired technology is more valuable than a coal technology – the actual situation needs to be evaluated – but that companies can profit from the uncertainty in the natural gas industry. It does give the “edge” to natural gas fired power generation. Finally, the real options tool, like any other tool, must be used wisely. If used blindly, real options may be used to justify bad decisions. Real options are just another way of viewing and analyzing a decision. Real options can be used or abused just as any other analysis method can be. Ultimately, there is no replacement for common sense. [58]

DCF analysis, NPV rule and the maximisation of shareholder value tenet, are considered by most practitioners, to be axioms of finance, when in fact, they are actually results of theoretical economic constructions, which rely on several critical assumptions. The objective of this paper is to reveal these assumptions and to show that the valuation technique known as option pricing is built on the exact same economic foundation. The import of this is straightforward: if a manager is willing to make the assumptions necessary to apply the NPV rule to a potential investment, then the manager has already made all of the assumptions necessary to also price options on that project. In other words, real options analysis is perfectly valid in any situations where DCF/NPV is applied without further assumptions. A common objection to real option analysis is that option pricing models require certain assumptions that are not met in real asset markets.
For example, one often hears the ritual protest that options on real assets cannot be priced because the real asset is not traded and hence cannot be held in an arbitrage portfolio. This paper has shown that this objection is completely unfounded in any situation where DCF and the NPV rule can be applied: as long as you are willing to make the assumptions necessary for application of the NPV rule to an illiquid asset, you have made assumptions that are sufficiently strong for application of option pricing to value that asset—even though the asset is not traded. In other words, if real options analysis is rejected in a corporate setting due to the illiquidity of the project, DCF and NPV rule also must be rejected as well.

The point of valuation in corporate finance is to ascertain what value a new project would have, if it were currently available in the financial markets. Financial markets care about the timing and risk of the cash flows from the investment and if the corporate manager can ‘purchase’ those cash flows in the real asset market (by investing in a new project) more cheaply than investors could purchase those cash flows in the financial asset market, then the new project makes existing shareholders wealthier. This paper has shown that the common foundation of both the DCF/NPV model and the option pricing model is valuation by arbitrage. Both models use the prices of existing assets, which are determined in equilibrium, to value new assets. In either approach, the objective is to find an existing asset or portfolio that exactly mimics the ‘new’ item; since the new item can be replicated by the existing assets, the new item must have the same price as the reference asset or portfolio. This makes the common assumption of the two models transparent: both DCF/NPV and option pricing models (regardless of their application) rely critically on the assumption that any new proposals are really “old wine in new bottles” – their cash flows can be recreated in the financial markets. This is the assumption of complete markets. [59]

India is emerging as a global hub for clinical research. According to projections from Mckinsey & Company, Indian clinical research industry would attract US $ 1.5 bn. of revenue from US and European sponsors by 2010, creating a demand for more than 10,000 investigators trained in good clinical practices and supported by nearly 50,000
clinical research professionals. Most regulatory authorities accept India-specific clinical trial data when launching a product globally. Registration of new drugs for marketing in India requires submission of data generated on Indian patients. A 100 patient, noncomparative, open-label study on patients treated for the primary indication is sufficient. For drugs that treat rare conditions, a lower sample size is usually negotiable.

If India’s clinical trial business increases to 100% of the scope in US by 2015, industry would require 50,000 newly recruited people. India has a big pool of scientific, pharmaceutical and medical talent; supply of trained professionals in India is approximately one-tenth of its demand. Unless research training institutes are established, this huge gap between the demand and supply of trained personnel, would not be reduced. Most global pharmaceutical companies conducting multicenter studies in India, have smaller clinical research departments, handling regulatory and marketing support, local pharma co-vigilance reporting, conduct of local registration and post marketing surveillance studies. This team coordinates with its global project management or outsourcing partners to mentor, maintain timelines, ensure checks and maintains balance for regulatory compliance and collect quality data. The outsourcing decisions for these global studies are mostly done in the U.S. and Europe; however, as India becomes a major hub and contributes further to subject recruitment in clinical studies. Indians will have a bigger role to play in the outsourcing process. Career prospects with CROs and site management organizations (SMOs) in India are quite attractive, considering the number of clinical trials currently under way in India in diverse therapeutic areas.

Clinical Research industry is dependent on resources like investigators, with strong inclinations toward the conduct of ethical clinical research. This industry looks for experienced principal investigators, who have set up and conducted global clinical trials and have competent study staff at their sites. Ten years ago, it was very difficult to find a principal investigator who had worked on GCP trials. Recently, CROs and global pharmaceutical companies have started working with clinicians and physicians in different therapeutic fields, in an effort to familiarize these investigators with GCP and International Conference on Harmonization (ICH) E6 guidelines. [60]
The term “real option analysis” is loosely applied to three different things – framing in terms of identifying contingent opportunities, identifying learning events and time sequencing; Calculation tools in form of equations, decision tree, monte carlo simulation and dynamic programming and Market discipline in terms of price discovery, implied volatility, historical time series analysis & imperfect proxies. Black Scholes formula is just the expected value of a hockey stick pay-off with a particular probability curve. In other words, it is mathematically identical to a simple decision tree. This formula may still have many redeeming features as a framing tool and as a tool of market discipline.

Taking back of the envelope example, if, it requires $100 million investment in manufacturing plant, it is not known, how successful, it would be, most likely would be mediocre, generating $10 million per year, for 5 years, 10 % chance for a blockbuster, generating $100 million, per year. Remembering real options, $10 million, pilot plant, can be build, launched on a small scale, build the full size plant for $100 only, if it looks like a blockbuster, is this option worth $10 million? [61]

There is significant volatility in Certified Emissions Reduction (CER) prices today. This coupled with the option of retrofitting, enable firms to wait for the opportune moment to go for Carbon Capture and Storage (CCS). Since technology decisions create a lock-in for the plant-life, it is crucial for finance managers to appreciate and value these options. Unfortunately the traditional DCF models fail to take this into account and hence real options is the way forward. This article is prepared from the perspective of a firm deciding to invest in a new coal-fed power plant with 500 MW of generation capacity. A finance manager is faced with the following questions:

- Which technology to adopt?
- Should the plant be built capture-ready or retrofitted later?
- Is there an optimal time to retrofit?

A DCF model is developed for three contemporary technologies: Supercritical (SCPC), Ultra-Supercritical (USPC) and Integrated Gasification Combined Cycle (IGCC). Since
electricity tariffs are usually regulated and don't vary across technologies we mainly look at the present value of costs for evaluation. There are three scenarios before a power company mulling to build a power plant:

- Without capture facility and with no provisions for retrofitting/capturing CO₂ in future
- Capture ready plant
- Without capture facility and with provisions for retrofitting

Valuing costs under the last option, will capture the value of strategic opportunity, to defer CCS investments. until costs and CER prices make it economically justifiable.

Real options is used to evaluate the value of option to build a base case plant initially and then retrofit later, depending upon whether the present value of incremental cash flows from retrofitting exceeds expenditure incurred.

Conclusions, based on the study, are as follows:

- Value of option to build without capture plant now and retrofit later is positive for all technologies. Therefore it makes sense for the firm not to build capture ready plants
- Traditional technologies like SCPC are now becoming obsolete as they are neither cost efficient, nor amenable to be retrofitted at lower costs. It is losing out to technologies like USPC and IGCC
- USPC plants do best when, retrofitting or carbon capture is not taken into account
- IGCC is least costly, when option value, to defer retrofit investment is considered.

Though base case IGCC plant (without capture) is more costly and less efficient than USPC, it is more suited to CCS and hence becomes economical in a capture-ready scenario.

IGCC is much better in a CCS acknowledged scenario and the technology is expected to be adopted, at a much larger scale, in the near future. [62]
In this paper, recent developments were observed in real options theory and focus was on its applications in strategic management research. The current study, also identified several promising areas for future research, concerning investment decisions, governance choice and performance implications. While real options theory, has recently witnessed debates about the applicability, of option pricing models, for strategic decision-making and the complications, brought by organizational and psychological factors, that, influence managerial discretion in option creation and exercise, there are not significant challenges, concerning the validity of real options theory, as a sound conceptual lens, for explaining and predicting strategic decision-making, under uncertainty. Two decades ago, Myers (1984) proposed that real options theory as a unique perspective could be used to bridge financial theories with strategic management. This discussion shows, that, real options theory has provided substantial insights, into topics of central concern, to strategic management research, such as investment and exit decisions and the choice of investment modes. In addition, extant research studies have contributed significantly to our understanding of whether and under what conditions, organizations can benefit from real options embedded in projects, lines of business and firms. Future generations of research are required that would enhance the impact of real options as an emerging dominant conceptual lens in strategic management. [63]

2.2) BOOK REFERENCES

Book compares real options with financial options. It describes Discounted Cash Flow Model, Monte Carlo Simulation, Decision Tree analysis, Black Scholes Model etc. to value real options with calculated examples. It tries to find the right model to value real options, talking about cons and prons of each model. It says, why real options analysis is most valuable. It talks about types of risks associated with businesses and also different types of real options. It compares real options with discounted cash flow technique, decision tree analysis. Examples have compared black scholes method with binomial method and simulation. Details are provided regarding the meaning of volatility, along with the methods, which can reduce or control volatility of prices in various situations.
Real option has been identified as a six step process, where first step is framing the application, second step is identification of the input parameters, third step is calculation of the option parameters, fourth step is building of the binomial tree and calculation of asset values at each node of the tree, fifth step is calculation of option values at each node of the tree by backward induction method and sixth step is analysis of results.

Book has discussed different types of simple options like option to abandon, option to expand, option to contract, option to choose, option to wait and barrier options. Examples in all the above cases have been taken and explained as a six step process. It talks about advanced options like compound options (option to stage), which are sequential options, parallel options, rainbow options and options with changing volatility. Other advanced options are switching options, exit options and complex compound options.

Book has focused on a practitioner using real option analysis, in five steps. In the first step, estimate the baseline investment cost and present value of payoff or expected free cash flows of the project. In the second step, conduct an initial analysis, comparing the baseline project investment versus the present value of the payoff. In the third step, estimate the option value of the project using the binomial method. In the fourth step, analyse the option results to gain better insight into and better understanding of the project economics. In the fifth step, prepare the results for presentation to management in an easily understandable format.

Book talks about opportunities and challenges related to Growth of Indian Pharma Industry. It also talks about trends, SWOT analysis and value chain related to Growth of Indian Pharma Industry. Value chain of R & D process is described. It focuses at length on growth of biotech industry and strategies for growth of healthcare sector. It also talks about regulatory framework for Pharma Industry.

There is talk on strategies of drug discovery adopted by Indian Companies. Clinical Research has been discussed, where it has been divided into pre-clinical testing, clinical studies phase I, Clinical studies Phase II(A) and Phase II(B), Clinical studies Phase III and Clinical studies Phase IV. Ethical issues affecting clinical research, have been
discussed and regulatory aspects, which will have an impact on clinical research, have been talked about.

2.3) CHAPTER SUMMARY

Black Scholes Model is available for valuation of real options, along with Binomial method and Net Present Value Method. There is need for adjusting Black Scholes Model to account for the flexibility of the management to take decisions related to expansion, modernization or diversification of business etc. Pharmaceutical sector is witness to development of new drugs for curing of diseases and its success, depends on its development and its launch after number of years. Research gap is present in terms of identifying changes to be made in existing models to value real options, with different variables, pertaining to situations.