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Traditional DCF versus Real Option for Strategic Investment Decisions Valuation

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Abstract:

In an economic environment characterized by rapid change and great uncertainty the static nature of the conventional net present value and discounted cash flow (DCF) method becomes inadequate to set up an effective investment strategy. This Paper tries to introduce the Real Options Approach as a novel means of evaluating investment decision and provides a good solution on the uncertain problems. Real options assume a dynamic series of future decisions where management has the flexibility to adapt given changes in the business. However, the complexity of the real option models makes them difficult to apply in real world.

Keywords: Net Present Value, Real Options, Uncertainty, Flexibility, Investment valuation.
Jel Classification Codes:

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1. INTRODUCTION

Business conditions are fraught with uncertainty and risks. These uncertainties hold with them valuable information that could vary the future outcome dramatically. When uncertainty becomes resolved through the passage of time, managers can make the appropriate mid-course corrections through a change in business decisions and strategies. Real options incorporate this learning model, akin to having a strategic road map, therefore, providing the flexibility in management for decision makers. Unfortunately, the value of flexibility of the project cannot be measured by using the traditional discounted cash flow (DCF) analysis. This is because a traditional DCF analysis cannot fully account for active project management. It does not properly value management's ability to wait or to revise the initial strategy when future events turn out to be different than expected. Also, management is not obligated to revising the firm's strategy or to undertaking any future discretionary opportunities. Thus the right to do so is an option – a real option. In practice, managers decide on capital investments by evaluating, on an on-going basis, their available options to invest in real assets and either exercising them, deferring them, or allowing them to expire. Uncertainties in forecasting variables could vary the future outcome dramatically. As a result, various strategies are usually needed to properly respond to the effect of uncertainty. Providing the flexibility in management for decision makers is valuable. Unfortunately, the value of flexibility of the project cannot be measured by using standard Net Present Value (NPV). This is because NPV is not considered uncertainties in the evaluation process. Therefore, the questions that could be asked is:

How can real options be superior to the traditional NPV method in valuing Investment decision?

The paper is trying to answer the above question by introducing the basic of net present value model, explaining the inadequacy of traditional methods for risk management in valuing risky projects. The paper then, focuses on the analogy between real options and financial options as well

as some typical types of real options and the difficulties in implementing this approach. Finally, the paper presents, how real options are superior in dealing with risk and providing an insight of real option valuation in real world.

2. DCF Valuation:

2.1 Basic NPV model: Investment decisions are often made with reference to standard discounted cash flow techniques, (*DCF* analysis). The most common capital budgeting model used by corporations is the Net Present Value. The NPV of an investment is the sum of the present values of the expected benefits, generally in the form of cash flows, from which the present values of all expected cash outlays are subtracted. If I_0 is defined as the initial outlay of an investment, CF_t as the cash flow at period t, and k as the rate of return that can be earned on an alternative investment, the NPV is: (Roger, 2002, p. 44) .

$$NPV = \frac{CF_1}{(1+k)^1} + \frac{CF_2}{(1+k)^2} + \ldots + \frac{CF_n}{(1+k)^n} - I_0$$

$$= \sum_{t=1}^{n} \frac{CF_t}{(1+k)^t} - I_0$$

The net present value rule is to accept investments that have positive net present values, that is, when the present value of the investment's cash inflows are at least as large as the present value of the cost outlays.

The discounted cash flow method has its advantages (Mum, 2002, p. 58)**.**

- Clear, consistent decision criteria for all projects.
- Same results regardless of risk preferences of investors.
- Quantitative, decent level of precision, and economically rational.
- Not as vulnerable to accounting conventions (depreciation, inventory valuation, etc.).
- Factors in the time value of money and risk structures.
- Relatively simple, widely taught, widely accepted.
- Simple to explain to management: "If benefits outweigh the costs, do it!"

In reality, there are several issues that an analyst should be aware of prior to using discounted cash flows models, as shown in table (1).

Table (1) Disadvantages of DCF: Assumptions versus Realities

DCF Assumptions	Realities
Decisions are made now, and cash flow streams are fixed for the future	Uncertainty and variability in future outcomes. Not all decisions are made to days, as some way be deferred to the future, when uncertainty becomes resolved.
Projects are "mini firms", and they are interchangeable with whole firms.	With the inclusion of network effects, diversification, interdependences, and synergy, firms are portfolios of projects and their resulting cash flows. Sometimes projects cannot be evaluated as stand-alone cash flow.
Once launched, all projects are passively managed.	Projects are usually actively managed through project life cycle, including checkpoints, decision options, budget constraints, and so forth.

Future free cash flow streams are all highly predictable and deterministic.	It may be difficult to estimate future cash flows as they are usually stochastic and risky in nature.
Project discount rate used is the opportunity cost of capital, which is proportional to non-diversifiable risk.	There are multiple sources of business risks with different characteristics, and some are diversifiable across projects or time.
All risks are completely accounted for by the discount rate.	Firms and project risk can change during the course of a project.
All factors that could affect the outcome of the project and value to the investors are reflected in the DCF model through the NPV or IRR.	Because of project complexity and so-called externalities, it may be difficult or impossible to quantify all factors in terms of incremental cash flows. Distributes, unplanned outcomes (e.g., strategic vision and entrepreneurial activity) can be significant and strategically important.
Unknown, intangible, or immeasurable factors are valued at zero.	Many of the important benefits are intangible assets or qualitative strategic positions.

Source: Johnathan Mun,(2002) Real Options Analysis: Tools and Techniques for Valuing Strategic Investments and Decisions, John Wiley & Sons, Inc. New Jersey, p59.

2.2 Net Present Value and Risk Management

The above observations may lead us to ask about how management, in using NPV model, deals with risk? For management, the risk of a project is the synthesis of the uncertainty that it may face in the future, and the means available to deal with the effects of this uncertainty. Uncertainty for a corporate investment comes from a variety of sources-the overall economy, technology, changes in regulations, natural phenomena and a competitor's actions, to name a few. All of these 'uncertainty factors' can affect significantly either the operations, or the results from the operations and thus change the value of the investment. In observing and trying to predict those factors, management deals with uncertainty in two stages (Keenan T. E., 1998, p. 49) .

- project selection- management considers alternative projects and selects only the ones that promise, on average, to provide abnormal returns compared with similar projects; and project management- once a project is selected and implementation is commenced, management takes appropriate.
- actions either to curb the negative effect of the uncertainty factors on the value of the project, or to take advantage of them and enhance their positive effect.

The net present value methodology acknowledges that, in the future, the value of the corporate investment may follow different paths depending on what uncertainty factors are at play. Unfortunately, it implies no active risk management once the project starts. The method aggregates all possible scenarios into a single, expected future cash flow scenario. In practice, because the expectations are formed line-by-line along the free cash flow models, no contingent future decisions are incorporated into the analysis. The most obvious example is the duration of a project. A net

present value model usually has a time horizon of between five and 10 years, which shows the expected results from operations if the project endures. At the same time, it is understood by management that the project could be cancelled much earlier if it turns out to be a value destroying operation with no positive prospects (Keenan T. E., 1998, p. 49) .

The net present value method is designed to help management only with the first part of dealing with risk-the project selection process. The net present value approach is not concerned with active risk management and, because of this, the only uncertainty it considers is the one correlated with the overall market. This uncertainty is reflected in the weighted average cost of capital used to discount the expected cash flow. To use the standard terminology, projects with very different idiosyncratic risk are considered risk-equivalent as long as their market related risks are the same. In the same limiting perspective, the net present value approach does not take into account the different level of flexibility that alternative projects provide to management in order to deal with future uncertainties. Frequently, a flexible, but more expensive, technology displays a lower net present value than a cheaper but rigid alternative. The irony of all this is that, by ignoring the project management and thus failing to account for all future uncertainty and the management's flexibility, the net present value analysis fails to provide optimal choices for the project selection.

The theory of the DCF method excludes management from making decisions and capitalizing on emerging opportunities during the lifetime of the project. However, in practice those decisions are madeand change the project's cash flow structure and the discount factor that should be applied for the project valuation. Unfortunately, neither the DCF approach nor any other traditional approach of capital budgeting is apt to integrate these changes and capture the asymmetric information embedded in these investment opportunities. To quote Dixit and Pindyck : *The simple NPV rule is not just wrong; it is often very wrong* (Dixit, 1994, p. 136)

3. Real options valuation:

3.1: Real options are analogous to financial options: As a direct outgrowth of finance, the real options approach uses techniques and methodologies which prevail in that field. However, finance is mostly preoccupied with evaluating and pricing financial instruments, put and call options among them. As the real options approach percolates into various areas of management and decision making, there is a shift of emphasis from pure evaluation to decision analysis and optimization ((Boyer, 2003, p. 13))**.**

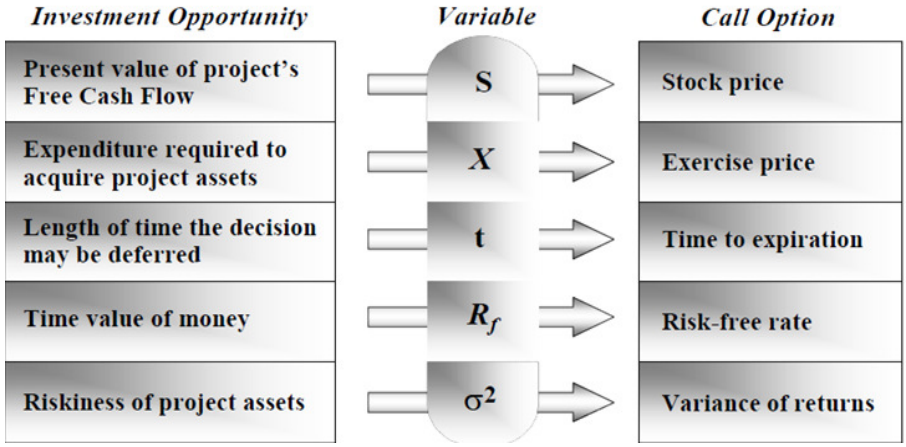
Myers was among the first to publish in the academic literature the notion that financial option pricing theory could be applied to strategic issues concerning real assets rather than just financial assets. In fact, the option pricing theory provides a framework for valuing strategic investments. The methods of valuing real options are the same as the financial options, although it is difficult to identify the values of certain inputs in case of real options (Mbolo, 2008, p. 9).

Trigeorgis defined real options as follow: "Similar to options on financial securities, real options involve discretionary decisions or rights, with no obligation, to acquire or exchange an asset for a specified alternative price" (Lenos, 1996, p. 10) **.** Real options analysis is based on the observation, that a company evaluating an existing asset or potential investment is in much the same position as the holder of a financial option, such as those written on stocks or commodity prices. Like financial options, if the expected outcome generated by a real option is estimated as being not favourable, the real option is not exercised. The holder of a financial put option on, say, the price of oil can exercise that option if the price rises above a pre-agreed level, but doesn't have to if the price falls. Similarly, the owner of a marginally profitable oil field has the right to exploit if the price of oil rises, but is not obliged to do so if it doesn't. That observation leads to the assumption that the

future value of such an investment can be best valued in a similar way to financial options, rather than by simply discounting the cash flows expected from it in future. In particular, option valuation takes into account the risks and rewards of future uncertainty, or volatility, which traditional cash flow (DCF) models do not (Boyer, 2003, p. 22).

Figure (1), shows the link between real options and financial option, in the case of the option to defer, as proposed by Smit and Trigeorgis. Deferment options are particularly important, when making an irreversible investment decision under uncertainty. Invested money can rarely be taken back in real life! With this example, Smit and Trigeorgis illustrate the fact that the opportunity to invest in a project is like having a financial call option. In the real options case, the underlying asset is the present value of the cash flows from the completed operating project, S, While the exercise price is the necessary investment outlay (at time t), X. Depending on market evolution, if later the situation becomes favourable and S > X management can exercise the option by investing and project net present value becomes positive. In the opposite case where market development would be unfavourable, management will decide not to invest to cut further loss, thus losing only the amount spent to get the option.

Figure (1) The link between Investments and Black-Scholes Inputs



Source: Timothy Luehrman, (1988) Investment Opportunities as Real Options, Harvard Business Review, July-August, p 33.

3.2. Types of real options: When valuing potential investment opportunities, managers would like to know what types of real options are associated with a particular investment/project. The numerous types of real options can be classified into three main categories (Tank, 2004, p. 8): learning options, growth options and insurance options. Within these categories, we distinguish several options types.

The following table depicts an overview of these real options types along with the equivalent financial options.

Table (2) Real option types and their financial equivalent

Category	Option type	Equivalent financial option
Learning options	Option to defer Time-to-build option	Call option Compound call option
Growth options	Option to expand Option to innovate	Call option Call option
Insurance options	Option to contract Option to shut down and restart	Put option Call option

	Option to switch Option to abandon	Combined call / put option Put option

Source: Stephan Schmidt Tank (2004) Valuing Joint Ventures Using Real Options. ESCP-EAP Working Paper No 7 September, p8.

a. Learning options offer management the opportunity to react to changes in the environment and to adapt investment strategies to new information that they may acquire at a future point of time. An option to defer allows management to wait to invest into a project and gather more information on the project; oil leases are an example for defer options. Time-to-build options exist when investments are staged, i.e., the firm can stop an investment project before making all the investments; research and development efforts are usually staged investments.

b. Growth options let the firm react to positive market or project developments, management may be able to expand their business activities in a market or their commitment to a project by making additional investments (option to expand). Firms can also acquire new knowledge or skills through investment projects, generating opportunities for follow-up projects based on three skills, i.e. options to innovate.

c. Insurance options can be found whenever a firm is able to react to (negative) changes in the market environment by adapting an existing investment project or abandoning it altogether. An option to contract lets management reduce the firms' activities once market conditions deteriorate. An option to shut down and restart represents a special case of an option to contract, allowing the firm to completely shut down operations for a certain period and restart them as soon as the market environment improves. If management can put the firm's assets to another, more profitable use, it has an option to switch, i.e. exchange one investment project for another. Finally, a firm can leave the market altogether and shut down operations permanently in exchange for the salvage value (option to abandon).

Real options are not mutually exclusive; investment projects can create types of options at the same time.

3.3 Real Options and risk management: Real options do not replace traditional DCF based methods but they augment them, in other words, it is important to stress that real options represent an extension, not an overthrow, of NPV. Real options accept the essential NPV insight – that value equals the sum of discounted future payoffs – but argue that the standard NPV framework is unable to correctly make this calculation when projects offer future managerial flexibility (Faulker, 1996, p. 50)**.** With existing of uncertainties, the flexibility in management is valuable. Real Option Analysis (ROA) can be used to examine the value of flexibility when the project subjected to uncertainty (Pichayapan, 2003, p. 315). In all real options valuations, the start point is the NPV analysis of a project. Real options valuations are most important in situations of high uncertainty where management can respond flexibly to new information. NPV is treated as the "value without managerial flexibility". The total value of a project that owns one or more options is given by Trigeorgis (Lenos, 1995, p. 55)

Expanded (Strategic) NPV = Static (Passive) NPV + Value of Options from Active Management

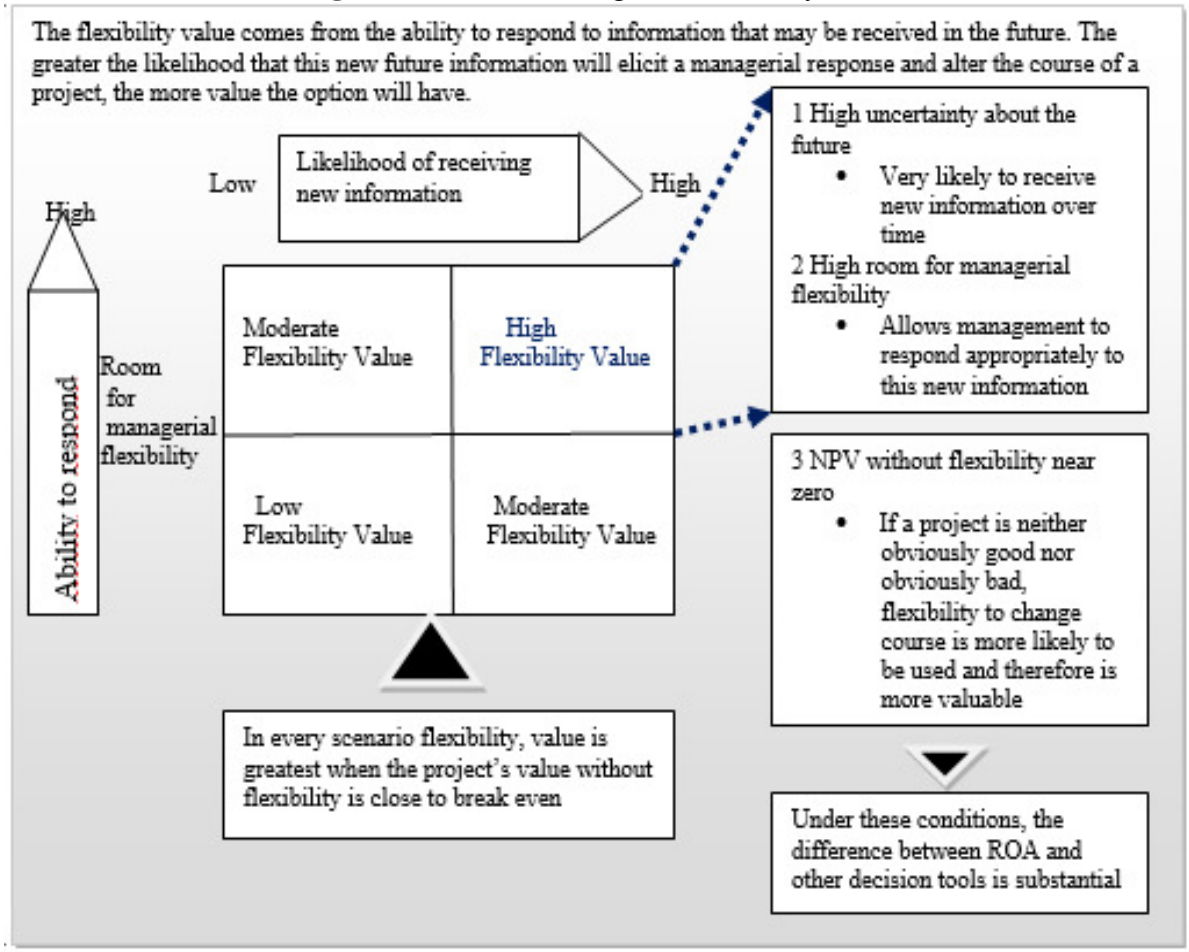
or

Value of project = Value of project without flexibility + Value of flexibility

The flexibility value named as option premium is the difference between the NPV value of the project as estimated by the Static or Passive Net Present value method and the Strategic or expanded NPV value estimated by the Real Options method. The higher the level of uncertainty, the higher the option value because the flexibility allows for gains in the upside and minimizes the downside potential.

By applying option valuation methods, real option valuation is a useful tool for company managers. The fact that managers can decide which action to take at different points during the life of the project has proven to be quite valuable. The value of these options can be such that makes the difference between entering or not in an investment. Options create value when the future is uncertain and they support management to draw the highest possible value from an investment. Hence, an accurate project valuation is crucial for the survival of companies. The use of two different valuation methods provides two different option values, which shows the importance of choosing a correct valuation method. The Real Option Approach attempts to value projects by considering the value of being able to decide among several strategic options. Especially when the value of a project is highly dependent on the level of flexibility that it allows, the real option methodology should be used. Otherwise, the valuation is not accurate because the project is undervalued.

Figure 2 Value of managerial flexibility



source: Tom Copeland. Cutting Edge Topics in Finance: Real options available on www.asabv.org/../Real_Options_Case_Study_Val

The motivation for using option pricing in capital budgeting arises from its potential to enable managers to quantify properly the option premium or flexibility component of value. The options-based approach is superior to decision tree analysis and NPV, since it combines the best features of these approaches without their drawbacks (Pandy, 2006, p. 277)**.**

Unlike NPV Approach the real options analysis approach focuses both on the current project selection decision and on the active project management in the future. Instead of working with an aggregate scenario of the future, the real options analysis starts by trying to capture, in sufficient detail, all possible future trajectories that the project's value may take without active management. Already, at this stage, by not forcing managers to work with a single expected scenario, the real options analysis approach provides the motivation to explore and forecast the possible effects of the major uncertainty factors on the project, and to understand its uncertainty profile. As a result, management can observe how projects with similar net present values could have very different displays of possible future value trajectories. Now, these projects no longer look similar.

After the risk profile of a project has been understood and the possible paths of its value in the future identified, the next step is to identify the major future decisions (real options), which will provide the flexibility for active project management (Keenan T. C., 1998, p. 50) For each real option, the following factors need to be determined:

- ✓ when and for how long the option is available;

- ✓ how the option will have a positive effect on the project's value and what this effect would be;
- ✓ what investment is needed to execute the option;
- ✓ whether any additional investment is needed now to make the option available;
- ✓ whether there are any preceding options that need to be executed to make this option available; and
- ✓ whether the execution of this option makes follow-up options available.

The option identification and qualification process presents a tremendous learning opportunity. Here, rather than disregarding the future flexibility as part of the project's financial analysis and valuation, management has to focus on it explicitly and in a rigorous manner. Now, projects appear very different, not only because of their net present value, but for the future opportunities they provide for expansion in the same related markets, for the flexibility to switch between types of resources and levels of operations and for the ease or difficulty to slow down or stop further expenditure and exit.

The power of the real options analysis is that it values the project's flexibility in the context of the uncertainty it is likely to face. The more volatile the future environment, the more valuable the real options to protect and expand the project's value.

To estimate the net present value of a project with flexibility, real options analysis has to identify when and under what conditions each real option should be executed optimally. In addition to a more correct valuation to support the current project selection, management is provided with an optimal contingency plan for each of its major future decisions. In this way, real options analysis supports the entire process of project risk.

Ultimately, then, the option valuation recognizes the value of learning. This is important, because strategic decisions are rarely one-time events, particularly in investment-intensive industrial sectors. NPV, which does not properly recognize often inadequate (Michael, 1997, p. 11).

3.4 Models of real option valuations barriers to their use According to Mun (2002), before starting the analysis of real options, analysts should be aware of several constraints. Firstly, there are the following five requirements must be met before it is conducted:

a. there must be a financial model. The analysis of real options requires the use of an existing model of discounted cash flows. If there is no such model, it means that strategic decisions have already been made and no financial justification is required,

b. there must be uncertainty. Otherwise an option is worthless. If we know everything 'upfront', in this case the model of discounted cash flows is sufficient,

c. uncertainty must affect decisions made by a company during the realization of a venture as well as it must affect the results of the financial model. The appearing uncertainties will become risk then and real options may be used to secure the risk of failure,

d. the manager must have the possibility of flexible decision making or the possibility of implementing changes during the active realization of the project. You cannot use the concept of real options in case there are no options or flexibility in managing the value,

e. the decision-maker must be predicting and credible enough to realize an option at the optimal moment. In other words, all existing options are useful when they are realized in proper time and in appropriate conditions.

There is widely held belief that the methodology used for calculations is hard to verify. Indeed, it is sometimes the case. In the assessment of real option valuation, we use two basic methods: The

Black Scholes model and the binomial model based on the decision tree analysis. The former method is a theoretical foundation for other methods, whereas its application in valuation is restricted to only a few cases.

4. Real Options in Practice

Despite a large body of literature on the topic, empirical tests of real option models are scarce due to the complexity of real options models makes them difficult to apply on real world situation. Therefore, in the managerial decision making more widely used versions of the real option model are those based on the simplified approach of Cox, Ross and Rubinstein.

Based on the responses of 392 CFOs, Graham and Harvey (2001) find that real options rank eighth among 12 capital budgeting techniques considered in their study with almost 27% of respondents indicating using this technique always or almost always. In a study of 313 European CFOs, Brounen et al. (2004) find almost identical results as Graham and Harvey regarding the ranking and use of real options. In a survey of 205 Fortune 1000 CFOs, Ryan and Ryan (2002) find that real options rank last in a field of 13 supplementary capital budgeting tools with a utilization rate of 11.4%. Teach (2003) reports the results of a Bain and Company survey conducted in 2000 of 451 senior executives from 30 industries about their views of management techniques and finds only 9% using real options. In these surveys, the authors limit their analysis of real options to identifying the relative use of real options compared with other capital budgeting techniques. Block (2007) focuses exclusively on real options and capital budgeting. In his survey of Fortune 1000 companies, Block receives 279 responses but finds that only 40 (14.3%) of the responding managers use real options. The 40 users come mainly from industries where sophisticated analysis is the norm, such as technology, energy, and utilities. Further, he finds that industry classification has a significant relationship to the use of real options but does not have a significant relationship to the techniques used. Respondents report using real options for new product introduction (36.2%), research and development (27.8%), mergers and acquisitions (22.1%), foreign investment (9.6%), and other (4.3%). Block finds that the most common 8 techniques for using real options are binomial lattices, risk-adjusted decision trees, and Monte Carlo simulation. The primary reasons that managers give for not using real options are a lack of top management support (42.7%); discounted cash flow is already a proven method (25.6%); real options require too much sophistication (19.5%); and real options encourage excessive risk taking (12.2%). Commenting on the current status of real options, Triantis (2005 p8) states that "the extent of acceptance and application of real options today has probably not lived up to the expectations created in the mid- to late-1990s." In a similar vein, Teach (2003) notes that while real options may not be poised to conquer the corporate world in the short run, perhaps they will prove their value in the long run. In support of this notion, Block (2007) reports that 43.5% of the nonusers indicate there is a good chance they will consider using real options in the future. In summary, survey evidence suggests that the use of real options analysis lags behind DCF analysis but is increasing, especially among large firms. According to McDonald (2006, p.37), "Despite survey evidence reporting that most managers do not claim to use real options methods when making capital budgeting decisions, academic studies generally find both managerial behavior and market pricing to be consistent with the predictions of real options models." Thus, DCF analysis and real options analysis can play a complementary role to each other. As (Guerrero, 2007) notes, real options are an important extension of DCF analysis.

5. Examples of industry leaders applying Real Option: Currently, Real option analysis is already accepted as an evaluation process for project under uncertainty in various fields some of which are:

5.1 Automobile and manufacturing industry: In automobile and manufacturing, General Motors (GM) applies real options to create *switching options* in producing its new series of autos. This is essentially the option to use the cheaper resource over a given period of time. GM holds excess raw materials and has multiple global vendors for similar materials with excess contractual obligations above what it projects as necessary. The excess contractual cost is outweighed by the significant savings of switching vendors, when a certain raw material becomes too expensive in a particular region of the world. By spending the additional money in contracting with vendors a meeting their minimum purchase requirements. GM has essentially paid the premium on purchasing a *switching option*. This is important especially when the price of raw materials fluctuate significantly in different regions around the world. Having an option here provides the holder a hedging vehicle against pricing risks.

5.2 Computer Industry: In the computer industry, HP-Compaq used to forecast sales in foreign countries months in advance. It then configured, assembled, and shipped the highly specific configuration printers to these countries. However, given that demand changes rapidly and forecast figures are seldom correct, the preconfigured printers usually suffer the higher inventory holding cost or the cost of technological obsolescence. HP-Compaq can create an *option to wait* and defer making any decisions too early through building assembly plants in these foreign countries. Parts can then be shipped and assembled in specific configuration when demand is known, possibly weeks in advance rather than months in advance. These parts can be shipped anywhere in the world and assembled in any configuration necessary, while excess parts are interchangeable across different countries. The premium paid on this option is building the assembly plants, and the upside potential is the savings in making wrong demand forecasts.

5.3 Airline Industry: In the airline industry, Boeing spends billions of dollars and several years to decide if a certain aircraft model should even be built. Should the wrong model be tested in this elaborate strategy, Boeing's competitors may gain a competitive advantage relatively quickly. Because there are so many technical, engineering, market, and financial uncertainties are involved in the decision making process, Boeing can conceivably create an *option to choose* through parallel development of multiple plane designs simultaneously, knowing very well the increasing development cost of developing multiple designs simultaneously with the sole purpose of eliminating all but one in the near future. The added cost is the premium paid on the option. However, Boeing will be able to decide which model to abandon or continue when these uncertainties and risks become known over time. Eventually, all the models will be eliminated save one. This way, the company can hedge itself against making the wrong initial decision, and benefit from the knowledge gained through parallel development initiatives.

5.4 Oil and Gas Industry: In the oil and gas industry, companies spend millions of dollars to refurbish their refineries and add new technology to create an *option to switch* their mix of outputs among heating oil, diesel, and other petrochemicals as a final product, using real options as a means of making capital and investment decisions. This option allows the refinery to switch its final output to one that is more profitable based on prevailing market prices, to capture the demand and price cyclicality in the market.

5.5 Telecommunications Industry: In the telecommunications industry, in the past, companies like Sprint and AT&T installed more fiber- optic cable and other telecommunications infrastructure than any other company in order to create a *growth option* in the future by providing a secure and extensive network, and to create a high barrier to entry, providing a first-to-market

advantage. Imagine having to justify to the Board of Directors the need to spend billions of dollars on infrastructure that will not be used for years to come. Without the use of real options, this would have been impossible to justify.

7.Conclusion

In the real world every business decision is coupled with uncertainty about the future that affects the present value of the projects in consideration. Thus, before making any investment decisions, managers use various approaches to determine whether the investment should be undertaken or not. Traditional approaches for valuing these investment opportunities do not take into account management flexibility to revise its decisions in the future, as well as the interdependence of the project with future investments. As a result, real option approach has been introduced. The Real Options Approach attempts to value projects by considering the value of being able to decide among several strategic options. Real options take into account management's ability to create, execute, and abandon strategic and flexible options. The problems encountered in real option valuation is the lack of ability to recognize them in reality. Other problems are related to the calculation procedure. It requires the use of complicated formulas which can be understood only by people with advanced mathematical knowledge and adoption of sometimes unclear and quite rigid assumptions. They demand that managers have specific mathematical skills without which they are unable to deal with them

and to use their full potential. A certain constraint in the use of the ROV concept is the need for very good historical data that generally only exist in financial markets for typical assets that are subject to systematic trading.

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