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Introduction

Real options are "investment decisions characterized by uncertainty, the provision of future managerial discretion to exercise at the appropriate time and irreversibility" (Kogut & Kulatilaka, 2001). Using real options, a company can incorporate the risk and alternative courses of action in a project with high investment value and high levels of risk. In the real world, managers have to choose which projects to pursue and when to pursue those projects to determine the fair risk-adjusted value of these investments.

Research shows that real- options are conceptualized in two ways: firstly, as a managerial perspective that sees real options as a strategic way of analysing projects, and secondly, as a valuation tool to determine the actual value of uncertainty associated with all relevant options, derived from the first (Hartmann & Hassan, 2006). With real-options analysis, companies can consider strategic options and their potential outcomes, assess the value of each alternative, and choose the most favourable course of action.

There are four major types of real options: options to expand, contract, delay, and abandon a project or investment opportunity. The option to expand allows firms to scale up operations if demand exceeds expectations or if there is an expectation of an increase in future returns. The option to contract enables the firm to downsize or divest assets if market conditions deteriorate. With the option to delay, a company can postpone an investment until the uncertainty is resolved and market conditions become favourable. Lastly, the option to abandon gives the firm the right to minimize losses by discontinuing current investment opportunities.

Real Options Theory and Valuation Methods

The real-options theory offers a robust framework for evaluating investment opportunities, enabling firms to make more informed decisions. Organizations can strategically assess investments by incorporating the value of flexibility and the potential for future adaptations, leading to better outcomes and enhanced long-term competitiveness. The real-options theory is grounded in the principle that investments are not irreversible in that they are embedded with the option to adapt, expand, delay, or abandon them based on how the future unfolds. Like financial options, which give the holder the right but not the obligation to buy or sell an asset at a

predetermined price, real options provide managers with the flexibility to respond to changing market conditions.

Faced with uncertainty, the inherent asymmetry of options where the holder can act on discretion based on the potential outcomes of these decisions inevitably results in an asymmetry of outcomes (Trigeorgis & Reuer, 2017). In this sense, the real value of these options comes from capitalizing on the potential upside gains of exercising them at the right time while also limiting any downsides in the event of an investment going bad forcing companies to thereby abandon a project (Van Putten & MacMillan, 2004).

Real options analysis as a valuation tool to assess the value of an investment or a project is well documented (Perlitz et al., 1999; Kellogg & Charnes, 2000; Boer, 2000; Trigeorgis, 2005; Fernandes et al., 2011). Two popular valuation methods have been discussed in theory: The Black-Scholes-Merton model and the binomial model. The Black-Scholes Options Pricing (BSOP) model, mostly used for estimating the value of financial options that generally have an underlying asset, is formulaic and consists of five variables. The traditional discounted cash flow models cannot fully capture the optionality embedded within real options, and therefore come short. The BSOP model provides the scientific basis for estimating the value of optionality and thus contributes to determining the actual value of a project or an investment opportunity.

In the case of non-financial options, investment opportunities can be treated as a call option and these variables can be mapped, as shown by Lehrman (1998). Table 1 below describes the variables used in the BSOP model.

Call options	**BSOP Model Variables**	**Investment Opportunity (Mapping, adapted from Leurhman (1998)**
Stock Price	Underlying Asset Value (P_a)	PV of future cash flows (S)
Amount paid or received at the exercise of Call or a Put Option	Exercise Price (P_e)	Outlays to acquire assets or opportunity (X)
Return on Government T-bills	Risk-free Rate of Return (r_f)	Time value of money (r_f)
Variance of stock returns, measured by standard deviation.	Volatility (s)	Riskiness of project's assets (σ^2)
Time to expiration	Time (t)	Time until the decision may be deferred

Table 1 - Options-Pricing Model (BSOP)

The BSOP model, despite its wide popularity, has several flaws. For instance, real options, unlike financial options, are tied to managerial choices which a variable-based model like BSOP cannot fully capture (Copeland & Tufano, 2004). Moreover, unlike financial options, estimating volatility in projects or investment opportunities would be difficult owing to the lack of historical data (ACCA, 2022). An alternative, less popular, but equally relevant model is the binomial model which estimates the value of an option and the underlying asset by modelling prices in each period along two possible movement directions, i.e. the price can either go up or down. Binomial models can be customized to incorporate changes in risk and decision pathways (Copeland & Tufano, 2004). Instead of guessing the expected returns on an investment opportunity, managers can estimate the relative probabilities of upward or downward movement of returns.

A third, and more balanced approach is to combine the traditional approaches such as NPV and real options analysis to incorporate the value of options within NPV calculations (Kellogg & Charnes, 2000; Van Putten & MacMillan, 2004). The value of the option is calculated using real options models and added to the base value of a project calculated by discounted cash flow methods. As Leuhrman (1998) shows, options value and NPV are essentially the same at the expiration date. For instance, at $t = 0$, an option's value is only affected by the PV of future cash flows (S) and the total outlay under consideration (X). Thus, the option's value would be S - X. In cases where the exercise of an option or decision to invest can be deferred, the value of the option is added to the base NPV of the project. The traditional methods cannot be relied upon in what Van Putten & MacMillan (2004) have referred to as the 'Options Zone', where managers can use the calculated value of an option to confirm or reject DCF-based decisions.

Positives of Real Options

The traditional discounted cash flow (DCF) methods cannot fully capture the risk associated with uncertainty and managerial flexibility. Options-based valuation approaches address these problems by incorporating the value of an option in the calculation of the project or investment's total value. For this reason, the discussion on the positives of real options also includes the weaknesses of the traditional investment appraisal methods in getting the value of an investment right.

Firstly, real options recognize that market conditions do not always remain constant, nor do managerial responses to these changes. The traditional approaches such as the NPV assume that the cash flows can be accurately predicted. As these cash flows are based on projections, traditional methods discount these cash flows at higher rates to account for the possibility of cash flow overestimation. But what happens when the actual returns are higher than the predicted returns? Real options analysis accounts for both the upside and the downside associated with uncertainty (Van Putten & MacMillan, 2004).

Secondly, the real-options analysis takes into account the discretion that is available to managers to strategize in real-time. The presumed value of an option is in this flexibility. For instance, a pharmaceutical company that has invested $ 70 million in R&D for a new drug can abandon the project if it does not successfully pass the testing phase. Similarly, positive feedback in the trial stage may convince managers to invest more.

Thirdly, in the real-options approach, cash flows are thought of as real options with multiple decision outcomes attached to them. For instance, a company can decide to continue with a product launch only if the first-year sales reach a certain threshold and abandon the product if that threshold is not met. Conversely, in the NPV method, cash flows are seen as fixed probabilities that have to be discounted as well (ACCA, 2022).

Fourthly, with the real-options approach, once the initial investment has been made, any further outlays can be entirely avoided if managers feel that the expected returns do not match with the level of risk the company is taking, a possibility traditional cash flow-based models do not afford. Once an investment is made, managers have to rely on risk and return estimates made at the start of the project. In options-based analysis, contingencies are also taken into account in the sense that a bad investment may provide future opportunities that can be exploited even if the current investment does not match return expectations.

Moreover, the real-options analysis, when seen from a management perspective and not as a valuation tool, can allow managers to conceive investment choices as strategic choices and not just one-off project investments based on a forecasted number such as the NPV method does. Therefore, the managers can make informed decisions that align with the company's long-term vision and coveted strategic and competitive positioning.

With DCF approaches, there is a risk of overvaluation. For instance, in these traditional methods, both the investment and the cash flows are discounted at the same weighted average

cost of capital (WACC), even when both have different risks. This over-discounting of future expenditure, as Mun (2006) argues, leads to a higher estimate of NPV.

Lastly, as Luehrman (1998) argues, the real-options approach can quantify the value associated with the deferral of an investment opportunity. When the outlays can be delayed, the project's value goes up for two reasons. Firstly, deferring the expenditure can result in the interest earned on the money not being used. Secondly, the value of the underlying asset can change. In case of upward and downward movements in the underlying asset's value, the company can exercise the option (in case of any increases in the value) or choose not to exercise the option to protect against any decreases in the value of the asset. The ability to incorporate these new sources of value and estimate the resulting additional value makes the options-based approach superior to traditional cash flow-based models.

Critique of Real Options

Although the traditional discounted cash flow-based models have some flaws, the Net Present Value (NPV) approach is still widely used for valuing investments (Van Putten & MacMillan, 2004; Hartmann & Hassan, 2006). According to a survey of Fortune 1000 companies, only 13.45% of the respondents reported using the real-options approach (Block, 2007). Similarly, a Bain & Company survey of 451 senior executives found that the real-options analysis was among the least used tools (Bain & Company, 2001). While the options-based approach does overcome the obvious disadvantages of traditional valuation methods, it has also faced criticism for several reasons:

Real-options theory assumes that managerial decision-making is rational in that the managers would always act to maximize shareholders' wealth and minimize risks. The theory allows for flexibility in choosing the right time to exercise an option, but if managers fail to predict the right time, it can result in a loss of value. Copeland & Tufano (2004) showed that the suboptimal exercise of options may lead to a loss of around 91% of their value in highly volatile markets. For example, if a company buys a piece of land with the option to sell it in three years, but the land price increases more than expected (as real estate is considered a volatile market), the company must sell the land at the right time, or the price increase will not translate into value.

The foundational basis for real options valuation comes from the Black-Scholes Option Pricing (BSOP) model. As the model is based on financial options where the relative availability

of historical data can allow for some accurate estimation of the project's volatility, in real options, access to such historical data is not always possible. For instance, under binomial models, the value of the underlying asset has to be forecasted across a range of possible values. Additionally, real-options analysis does not take into account external factors like market forces, changes in demand, and legal and political climates that can impact the projected value of an investment.

Moreover, as Copeland & Tufano (2004) argue, the real options approach is valuable where projects can be mapped as options. For instance, the option to abandon a project can only be used once the managers know that the investment would result in losses or when the returns are lower than expected. However, in projects where managers are not afforded that possibility and where huge amounts have to be invested without knowing if the investment will pay off, such as building a new factory or erecting a plant to expand current capacity, the real options approach would not work.

Furthermore, in the real options approach, the uncertainty around a project is directly proportional to its value. However, this approach fails to consider the risks associated with the costs of a project, focusing solely on the variability of revenues. As a result, a project where expenditures cannot be accurately predicted will have more value than a project with similar variance of returns but lower volatility around costs. This approach does not account for the fact that cost overruns are more likely than cost overestimation in projects with high volatility around expenditures (Van Putten & MacMillan, 2004).

Lastly, the real options analysis may not provide an accurate estimate of the value of a project in situations where the outlays are being made in areas outside the core operations of the company. In such cases, the benefits of the investment may be difficult to quantify, such as when a company invests in socially responsible projects. Such investments may result in demand from socially conscious consumers, which can increase the demand for the company's new product launches. However, the value of these interactive effects would not be added to the estimates of the value of the product launch, making it difficult to estimate the true value of the project.

Real Options Analysis in Pharmaceutical Industry

Marcus et al. (2006) conducted a study on the application of real options in the pharmaceutical industry. The researchers collected data on the use of real options between February and October

2004. They surveyed two sections, the pharmaceutical section and the capital markets section, to capture both the internal and external view of R&D investments in the industry. The purpose of the study was to explore the use of real options in the pharmaceutical industry and analyze the data collected.

The authors collected 28 responses in the pharmaceutical section and 27 responses in the capital markets section. The authors grouped the various methods used in these companies into four major categories. Table 2 below shows these four categories along with the criteria used by the authors to evaluate them. Table 3 outlines the major areas about which respondents were asked.

Criterion for Categorization	Valuation Methods - Categories
If usage > 50%	Main Methods
If usage between 26% and 50%	Auxiliary Methods 1
If usage between 11% and 26%	Auxiliary Methods 2
If usage is negligible	Niche Methods

Table 2 - Categorization of Valuation Methods

Research Areas	Survey Questions
Valuation Methods	• Which valuation methods are used? • Which stage of R&D uses which particular method?
Personalized Medicine	• Will the influx of personalized medicine give way to new valuation techniques?
Knowledge about ROA and mode of usage	• Are you familiar with real-options approach? • What is the level of familiarity? • If No, which valuation methods are you aware of? • If yes, How and why do you use the ROA approach
Obstacles to use of real-options approach	• What are the reasons the ROA's limited usage?
Comparison between NPV and ROA	• Which method do you prefer? • What are the reasons for this preference? • Which method works better?
Real Options Pricing	• Which valuation method is used more? • How are forecasts made? • What kinds of tools are used and preferred for forecasting?

` Table 3 - Research Areas and Survey Questions

Key Findings - Hartmann & Hassan (2006)

The survey results of the six categories of research areas, identified in Table 3, are outlined below:

1. The study revealed that despite the buzz around the real options approach, it has not penetrated pharmaceutical R&D. The dominant approach to value investments in pharma R&D is net present value (NPV) in both the pharmaceutical and capital markets sections. Real options analysis was only used in the clinical phase, with 26% of respondents reporting its usage. As a valuation method, real options analysis has negligible usage in research and market phases and has an overall status of Auxiliary Method II.
2. Real options analysis is mostly used in the pharmaceutical section. However, the authors predict that this approach will become the standard valuation technique in 2010 in the capital markets section. Any increase in the adoption rates of the real-options approach would not impact the dominance of discounted cash flow-based methods such as NPV. When asked about the possible adoption of new techniques such as the ROA with the influx of personalized medicine, 67% of the respondents in the capital markets section rejected the hypothesis.
3. Real options analysis, when seen as a new perspective in innovation management and not as a valuation tool, has gained traction in pharmaceutical R&D as it offers a way to incorporate ROA within the existing valuation methods and provides a holistic way of looking at projects.
4. The pharmaceutical section has a higher familiarity level with the real options approach as compared to the capital markets section. However, for both sections, this familiarity has not translated into the application of ROA in the industry. Many of the respondents cited organizational obstacles to implementing real options analysis such as lack of acceptance by decision-makers. The authors point out that lack of familiarity with less complicated tools such as binomial models for pharmaceutical R&D (Kellog & Charnes, 2000).
5. In the capital markets section, binomial models are preferred for their ability to account for the technical risks associated with an R&D project. However, the Black-Scholes model enjoys wider usage.

6. In pharmaceutical R&D, the use of ROA may increase only in clinical phases. In both sections, respondents have not shown the inclination to expand the usage of ROA as a valuation method.

Conclusion

Real options theory provides a rigid framework for navigating investment decisions amidst uncertainty and managerial decision. By incorporating flexibility and adaptability into the evaluation process, real options analysis offers a nuanced approach to assessing the value of projects and investments. Unlike traditional discounted cash flow methods, real options recognize the dynamic nature of market conditions allowing for more strategic decision-making.

However, despite the theoretical advantages of real options analysis, its adoption remains limited in practice. Empirical evidence, particularly in industries like pharmaceuticals, suggests that traditional valuation methods such as net present value (NPV) still dominate decision-making processes. Organizational barriers, lack of familiarity, and challenges in applying real options analysis to complex investment scenarios have constrained its widespread use.

Nevertheless, there are opportunities for growth and development in the application of real options theory. Integrating real options analysis within existing valuation methods and leveraging its strategic suggestions in innovation management could enhance decision-making capabilities. As industries grapple with increasing levels of uncertainty and volatility, real options analysis may become increasingly relevant in helping firms navigate complex investment landscapes.

While real options theory offers a promising approach to investment valuation, its practical implementation requires overcoming various challenges. By addressing these obstacles and capitalizing on its potential benefits, organizations can improve their ability to make informed and strategic investment decisions in today's dynamic business environment.

Work Cited

- ACCA (2022) Investment appraisal and real options. *ACCA Global*. Available from: https://www.accaglobal.com/us/en/student/exam-support-resources/professional-exams-study-resources/p4/technical-articles/investment-appraisal.html [Accessed 03 April 2024].
- Bain & Company (2001) Management tools 2001: Global results presentation (2001). *Bain & Company*. Available from: https://www.bain.com/insights/management-tools-2001-global-results-presentation/ [Accessed 02 April 2024].
- Block, S. (2007) Are "Real Options" Actually Used in the Real World?. *The Engineering Economist* 52(3): 255-267.
- Boer, F.P. (2000) Valuation of technology using "real options". *Research-Technology Management* 43(4): 26-30.
- Copeland, T., and Tufano, P. (2004) A Real-World Way to Manage Real Options. *Harvard Business Review* 82(3): 90-99.
- Fernandes, B., Cunha, J. and Ferreira, P. (2011) The use of real options approach in energy sector investments. *Renewable and Sustainable Energy Reviews* 15(9): 4491-4497.
- Graham, J.R. and Harvey, C.R. (2001) The Theory and Practice of Corporate Finance: Evidence from the Field. *Journal of Financial Economics* 60(2-3): 187-243.
- Hartmann, M. and Hassan, A. (2006) Application of real options analysis for pharmaceutical R&D project valuation—Empirical results from a survey. *Research Policy* 35(3): 343-354.
- Kellogg, D. and Charnes, J.M. (2000) Real-options valuation for a biotechnology company. *Financial Analysts Journal* 56(3): 76-84.
- Kogut B, Kulatilaka N. (2001) Capabilities as real options. *Organization Science* 12:744–58.
- Luehrman, T.A. (1998) Investment Opportunities as Real Options: Getting Started on the Numbers. *Harvard Business Review*. Available from: https://hbr.org/1998/07/investment-opportunities-as-real-options-getting-started-on-the-numbers [Accessed 04 April 2024].
- Mun, J. (2006) Real options and Monte Carlo simulation versus traditional DCF valuation in layman's terms. In *Managing Enterprise Risk*. Elsevier Science Ltd. 75-106.
- Perlitz, M., Peske, T. and Schrank, R. (1999) Real options valuation: the new frontier in R&D project evaluation?. *R&D Management* 29(3): 255-270.
- Poteshman, A.M. and Serbin, V. (2003) Clearly Irrational Financial Market Behavior: Evidence from the Early Exercise of Exchange Traded Stock Options. *The Journal of Finance* 58(1): 37-70.
- Sellers, L.J. (2004). Pharm Exec 50. *Pharmaceutical Executive* 24: 60–67.
- Sellers, L.J. (2003) Fourth annual Pharm Exec Top 50. *Pharmaceutical Executive* 23: 42–52.
- Trigeorgis, L. (2005) Making use of real options simple: An overview and applications in flexible/modular decision making. *The Engineering Economist* 50(1):.25-53.
- Trigeorgis, L. and Reuer, J.J. (2017) Real options theory in strategic management. *Strategic Management Journal* 38(1): 42-63.
- Van Putten, A.B. and MacMillan, I.C. (2004) Making real options really work. *Harvard Business Review* 82(12): 134-142.