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INVESTMENT TIMING IN AFRICAN PRIVATE EQUITY: A REAL OPTIONS ANALYSIS

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Declaration of Authorship

I declare that this proposal titled **Investment Timing in African Private Equity: A Real Options Analysis** is a record of the dissertation work carried out by me and submitted to Strathmore University in fulfilment of the requirement for the Bachelor of Business Science in Finance Undergraduate Degree program. I grant Strathmore University permission to reproduce and distribute copies of this proposal document completely or in part.

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Linda Yunia Achacha — Student — 24th July 2020

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ABBREVIATIONS

AVCA – Africa Venture Capital Association

EBITDA – Earnings Before Interest Tax Depreciation & Amortization

EY – Ernst & Young

GDP – Gross Domestic Product

ABSTRACT

This paper modifies the standard binomial option pricing approach to real options analysis so as to incorporate exogenous volatility. Real options allow a manager to gather information about a potential investment payoff prior to investment occurring . The focal point of this paper is to uncover the value that deferral options have in regard to investment decisions and to determine the optimal investment timing given macroeconomic conditions. The results show that enhanced value is yielded by deferral options in instances of higher exogenous volatility and that the most optimal investment outcomes are achievable when there is higher volatility which is proven by the complete elimination of downward movement investment loss.

CHAPTER 1: INTRODUCTION

1.1 Background to The Study

Uncertainty and irreversibility are key elements in the investment world (Arrow & Fisher, 1974). This uncertainty is compounded in private equity funds as they face a number of risks that they attempt to hedge with their investment criteria. The risks arising include currency risks, liquidity risks that arise at the time of exit and the risk of undervalued stock at the time of entry into an investment. Since the market for private equity is illiquid, it is necessary for deep analysis of the nature of the stock to occur. The stock is unlisted and therefore, the price at time 0 does not reveal the true value of the stock in most cases. This becomes an issue of concern due to the possibility of purchasing an overvalued stock that may be difficult to exit at the end of the target investment horizon period for a firm.

Irreversibility of investment can become a point of detriment for an investor if they fail to understand stock characteristics on an intrinsic level, especially in an illiquid asset market. It is key for players in this field to understand how the risks occurring evolve with time and for them to spend time gathering strategic information. The presence of strategic information can be derived from taking a deferral option in a stock and can enhance value for an investor. This value occurs from upside risks and the flexibility that real options exhibit hence addressing the key points of concern that are uncertainty and irreversibility.

The idea of the time curve then arises as the stock value growth is time dependent. It is necessary for private equity funds to inject money in a company that will be 'exitable' (the EBITDA value at the time of exit is favourable to allow the profitable sale of their stake) when the time horizon ends to avoid a scenario whereby a fund has to hold on to portfolio company shares longer than it has to. This is achievable if at investment, the company is on a growth time curve such that its value at the time of exit attracts buyers. The growth time curve is influenced by exogenous uncertainty which presents itself in the form of macroeconomic risks. The option to delay investment can give a company sufficient time to gather information and gives a firm the flexibility of choice of exercise due to the irreversible nature of investments.

The core concept of this study is to apply real options to uncover value in the choice to exercise an option to delay the investment decisions of a firm. Real options focus on illiquid assets which are the main assets of trade for private equity investors. I shall incorporate into this study, the time horizon investment criteria which is the period in which a firm holds shares in an unlisted private company before selling them off in an exit. The real options approach shall be applied to test the application of real options to the investment decision making process and to the address various challenges that occur in exiting private equity investments. Key challenges include finding a buyer and share valuation as there exists no 'organized market' in private equity due to the unlisted nature of shares. Examination of the real options approach and testing how much value can be derived from its use is the main point of interest. This investigation aims to uncover the drivers of value such as economic factors and market information.

1.2 Problem Statement

According to a research done by Ernst & Young in 2013, there was a decline in the number of private equity realizations in Africa despite the efforts to diversify exit means from trade sales to buyouts, initial public offers, and sale to private companies. Where there is a decline in realizations, private equity funds will have to hold on to their stake in the portfolio company until a point where it is favourable to sell. In a 2018 study by Africa Venture Capital Association, the average holding period in 2015-2017 were all above 5.0 years with 2016 having an average holding period of 7.7 years which is higher than the average target investment horizon that is 4 – 5 years. This can be a point of concern especially due to fund investment horizons as investors expect a return at a pre-specified date. The concept of real options to delay can be applied in this case such that a fund manager is able to correctly time when to buy stock in a certain company. This decision is influenced by macroeconomic & microeconomic factors, which when favourable, lead to a high Earnings Before Interest Tax Depreciation and Amortization at the time of exit. According to Southern Africa Venture Capital Association in 2018, the market for exits is quite illiquid but there are always buyers for quality & fairly priced assets.

There exists an opportunity cost in holding a share for a longer period of time than the company specific investment horizon. A longer holding period might facilitate unwanted risk exposure as it may not be aligned with fund investment criteria. Delays can lead to shorter investment periods which enhance diversification of risks such as currency risk which has been the largest risk in African Private Equity according to a 2017 survey by Africa Venture Capital Association. Furthermore, volatility increases over a longer period of time. Although research in this area that has not been vastly explored by researchers, I aim to uncover how the Real Option to delay can be implemented to enhance value for the participants of Private equity investment: Private Equity Fund managers and Investors specifically within the African region that has been growing over time.

1.3 Research Objectives

The objective of this research is to be able to quantify the value addition that real options to delay have on an investment.

This will be done by comparison of the Net Present Value in the case whereby an option is available to an investor and an option free scenario. I shall then go a step further in my analysis and attempt to isolate the drivers of this value such as information on industry risk factors of the investee company and various general macroeconomic factors that influence the EBITDA performance of an investee company. Therefore, there shall be a quantitative analysis to be able to further understand the drivers of value in a real options to delay framework and possibly determine an optimal time of investment.

The key research questions are:

1. Under what conditions are deferral options value adding and what drivers facilitate this value addition?
2. What is the optimal investment timing given macroeconomic conditions in the framework of deferral options?

The motivation of this research is to measure the benefits of taking real options in the Private Equity sector in Africa to weigh the feasibility of their incorporation into the investment decision making process.

1.4 Significance of the Research

The research is of value to Private Equity investors. This sector exhibits elements such as illiquidity of assets, uncertainty, irreversibility of investment, underperformance of assets and various risks as currency risk, macroeconomic factors, and other systematic risks. Through deeper understanding of the drivers of real option to delay value it can be easier to incorporate those factors into their decision-making process. For instance, closer focus on risks arising in investment and a more rigorous due diligence process to ensure that there is ample information in support of the investment choice. Hence the reason for specific focus on the real option to delay as employment of a 'wait and see' approach can be value adding to decision makers in the Private Equity space. Guthrie (2009) states that a wait and see approach can enhance value if a decision maker waits for a period of time before expansion. This research aims to test for this value and uncover the delay period as well through specific projection of certain systematic risks.

CHAPTER 2: LITERATURE REVIEW

2.1 Theoretical Framework

2.1.1 Introduction to Real Options

Myers (1997) coined the term, 'Real Options' to refer to the use of option pricing to arrive at the value of real assets (Li. Et al, 2007). A real option is a choice made available to decision makers that have the capacity to enhance flexibility or potential value of an investment decision. There are various features in a real option that exhibit similarity to a finance option such as the exercise price and the expiration date. Regarding market entry, there are two types of options that are of interest, growth options and deferral options. Value creation is attributable to time dependency, uncertainty as well as discretion (Kogut & Kulatilaka, 1994). Discretion points to the freedom to exercise the option hence flexibility. It becomes valuable as investments are usually irreversible due to the incurrence of sunk costs.

2.1.2 The Option to delay & Uncertainty

The deferral option (also, option to delay) entails postponement of an investment, without completely missing out on the potential benefits that the venture can avail to decision makers. A deferral option enhances the possibility of making the right choice on a crucial decision thus forming its value proposition. A venture may have a negative net valuation today but still be valuable.

The ultimate factor that enhances value for real options is uncertainty which exists in two forms namely; exogenous uncertainty and endogenous uncertainty (Folta and O'Brien, 2004; Kogut and Kulatilaka,1994). Sears (2019) recognizes the value creation that each type of uncertainty creates and propounds that endogenous uncertainty creates value in the case of a growth option whereas exogenous uncertainty unearths value in the framework of a delay option.

2.1.3 Real Options & Decision Making

Amram, Li & Perkins (2006) identified that the following strategies can lead to the successful application of real options for corporate decision makers, using Kimberly Clark as their company of reference. Kimberly Clark is a leading consumer products manufacturer that was focused on consumer products and business to business at the time of study.

Quantification of upside risk value is scarcely possible with traditional valuation techniques such as discounted cashflow valuation. This enables a company to deeper understand the intrinsic value of a risky venture, achieved by real option valuation. This quantification can be further enhanced through information gathering made possible by the deferral option. Real options can as well be adapted to specific business needs and applied to ventures of different risk. Customization allows individual risks that affect certain ventures to be deeper understood instead of using a single, rigid valuation technique. The real options framework of analysis as well allows for screening of different venture prior to a formal analysis. This allows for isolation of high potential deals for a firm hence the more lucrative areas of venture are focal.

The real options approach allows identification of information and using it for learning for the purposes of enhanced investment value. This approach can be paired with the concept of learning options that can be used to derive value from investment uncertainty (Guthrie, 2011) For this specific study, Kimberly Clark applies the real options approach in early product testing and incorporates the information learnt to enhance value. Companies that do not have the tools to address uncertainty apply real options to their simple decision trees (Amram, Li & Perkins, 2006).

2.2 Empirical work

Guthrie (2011) employs a case study approach that examines real options from a learning options perspective. He builds binomial trees in two contrasting scenarios: first in the case where rapid learning is available and second the scenario that does not exhibit any learning option. There is alteration of the binomial tree periods and this is to factor in the element of volatility. Unlike the standard binomial trees, the time periods are not uniform, rather they are manipulated to be longer or shorter depending on volatility. The inverse relationship between volatility and time is considered in this study. The process of information gathering, and learning is modelled and tied to real options. The presence of information reshapes the forecast of observations and the increase in information is inferred to be able to alleviate uncertainty.

Therefore, according to him, the complete presence of information is directly connected to the complete absence of uncertainty. Guthrie (2011) states that since learning has a negative relationship with uncertainty. When incorporating this information into the real options approach, it is notable that there are shorter periods in the rapid learning tree whereas the no learning binomial tree exhibits even periods of time. This study also accounts for the fact that information gathering can be faster and more effective in one period and slower in another.

A key inference is that the choice to delay only becomes feasible when a manager is able to gather specific details that can enhance investment. Therefore, the optimal point of investment occurs at a later period (time 2) whereas in the no learning binomial tree, optimal investment period begins at time 0 due to the fact that there is no possibility of gathering information that can possibly enhance the project. The paper is therefore able to isolate the value of the delay option to the gathering of information. However, the assumption that uncertainty can completely be eliminated is too optimistic. A more realistic assumption would be that information can be utilized advantageously to gain value from upside risk.

Sears (2019) uses a case study of a developing country vis a vis a well-developed country and attempts to arrive at the net option value of an investment based on exogenous and endogenous uncertainty. The paper takes into account the element of competition and the availability of scarce resources. It also builds on the duelling options model by Folta and O'Brien (2004) and addresses uncertainty by enhancing the values of both the growth and deferral options.

The inferences are such that for the deferral option, value appears to decrease as expiration date draws near more so for the developing country case as compared to the advanced country case. The real option value also varies with the point that these options are introduced as there is a less steep curve in the case of the later stage. This study is in the context of market entry and the concept of a time curve is integrated into this analysis.

Decamps (2003), in accordance with the standard real options framework models investment decisions using optimal stopping time. The paper employs a case study methodology design with a decision maker who has the choice to make an irreversible investment incurring a sunk cost greater than 0 and this process follows a Standard Brownian motion process with a constant uncertain drift and a variance whose value is known and a contrasted instance of an unknown drift. The drift can assume any value but for enhanced simplicity this paper has the drift fall within the bounds of 0 and 1. The decision maker considered in the case study is risk neutral and the discount rate that is applied is constant and greater than 0. Risk neutrality is preferred for this study as a risk neutral decision maker has little to no relationship with risk and uncertainty.

Decamps (2003) concludes that the decision maker benefits from the drift uncertainty of the non-constant process. The methodology veers from the standard real options framework in that the option value in the case of investment is not at all levels increasing with respect to the volatility of the value process. This was according to the uncertainty that was modelled by a complete space of probability.

2.3 Research Gaps

Previous papers in this research topic have covered study areas such as real options paired with different features such as learning options, volatility, and uncertainty.

Decamps (2003) argues that in the presence of sunk costs there ought to be flexibility to allow for time that is allocated towards the gathering of information. The main analytical result of the paper is that the optimal investment region is characterized by a continuous and non-decreasing boundary in the value/belief state space. Thus, in contrast with standard real options models, the optimal decision rule is not described by a simple threshold for the current value of the investment, above which it becomes optimal to invest no matter the past evolution of the value. The value process follows a Brownian motion, and the model is in continuous time.

His study deviates from the standard real options model and applies the Markov framework of optimal stopping time. The concept of optimal stopping time has been a recurring area of research. An optimal investment region is therefore yielded based on information fed into the model as the data is continuous. In contrast, I will use discrete data to come up with optimal investment time as the real-life data is discrete.

Fontes (2004) uses the methodology of Markov jump processes to uncover an optimal investment as well as stopping time. The possibility of getting a higher expected return if one invests today is considered and is used as an alternative only in the case that the expected return if the investment is executed today is higher than if the investment is executed after a period of 1 unit time. The study attempts to discover the optimal time to invest as well as the optimal waiting time although there is a pre-emptive assumption made about an infinite investment horizon that I shall be tackling. The assumption is that there exist no time horizon constraints. The consideration of time constraints through the incorporation of a finite time horizon presents a more realistic approach to real options analysis and this shall be my approach to this study area.

Schwartz (2006) studies optimal portfolio allocation in the case of a liquid asset and an illiquid asset. For the illiquid asset, no trading is allowed until a time, T which is the exit point. This exit point is determined when the EBITDA of the company invested in attracts a return on exit. Focus is on the correlation of the illiquid asset and the market and the possibility of hedging the risks associated with both assets. In the case of partial correlation, the stochastic optimization problem is involved with the constraint of no borrowing with the aim of reaching non-negative liquid wealth which cannot occur before time, T i.e at $t < T$. The study is largely concerned with portfolio optimization and there is focus on risk and liquidity such that the desired state is a point of total liquidity for the portfolio owner. My study will focus on time delay. Although it can be insightful to understand the correlation of the asset to the market to predict EBITDA movement, my approach is focused on investment timing rather than market predictability. The aspect of correlation is tied to the information gathering aspect of my research model.

Wong (2007) uses a canonical real options model to study the effect of uncertainty on investment. He first uncovers the trigger of optimal investment and studies it for the uncertainty relationship. The optimal investment trigger which is known as the critical point follows a U-shaped curve and this is due to two countervailing factors in effect. When the volatility of the project goes up, the risk factor enhances the value of the investment option and thus makes waiting more beneficial. This lifts up the exercise trigger. On the other hand, the return factor arising from the upward adjustment of the discount rate makes waiting more costly. This pushes down the exercise trigger. The study therefore examines the two aspects that cause the shape of the critical point line. There is, however, no examination of the time aspect in the unearthing of the critical point.

Guthrie (2011) focuses on information gathering as well as learning options and recognizes that information can be gathered before investment as well as during the life of the investment. He states that with the complete availability of information, uncertainty can be completely eliminated. Uncertainty and volatility are studied separately and within the real options model, periods of high volatility are countered by shorter time frames such that the expected value is not largely impacted by periods of high volatility. Rapid leaning yields more favourable outcomes compared to an instance where information is not gathered during the life of the investment. The core focus of my research is how returns can be enhanced through delayed investment and information acquisition. I shall advance this study by examining the effects of uncertainty on value. The reason behind this approach is the inability to completely eliminate uncertainty in the real world. Through the acquisition of information however, a decision maker can be able to enhance returns through upside risk focus rather than complete elimination of uncertainty. The latter is the approach Guthrie (2011) used.

Guthrie (2011) also infers that the optimal investment policy is to wait as long as the investment payoff is greater than the value of waiting. This is a profound theory although, my research incorporates investment horizons that funds implement within investment criteria so my focus will be on what would be the optimal number of jumps before S>K such that the element of time horizon constraints are taken into consideration.

This research area has also been explored from the aspect of investment signalling whereby a smaller player follows the lead of a larger player who bears more information on investment potential. Watanabe (2012) covers this from the point of view of two competitors: an incumbent and an entrant. The research is structured in a monopoly framework such that an entrant would threaten the possible profitability of the incumbent and that the incumbent will only reveal information truthfully in the case that there is a possibility of a large payoff with a duopolistic framework in place. They delve into investment timing and take into consideration that the actions of competitors might not contain complete information on the market and that it could be a strategy by the incumbent to mislead followers (entrants). This is significant although the research involves a lot of pre-emptive assumptions that cannot necessarily apply in a research on African private equity. This is because my research will take into consideration the various investment criteria of individual firms therefore the aspect of competition will not be as relevant as the aspect of high returns given company investment criteria.

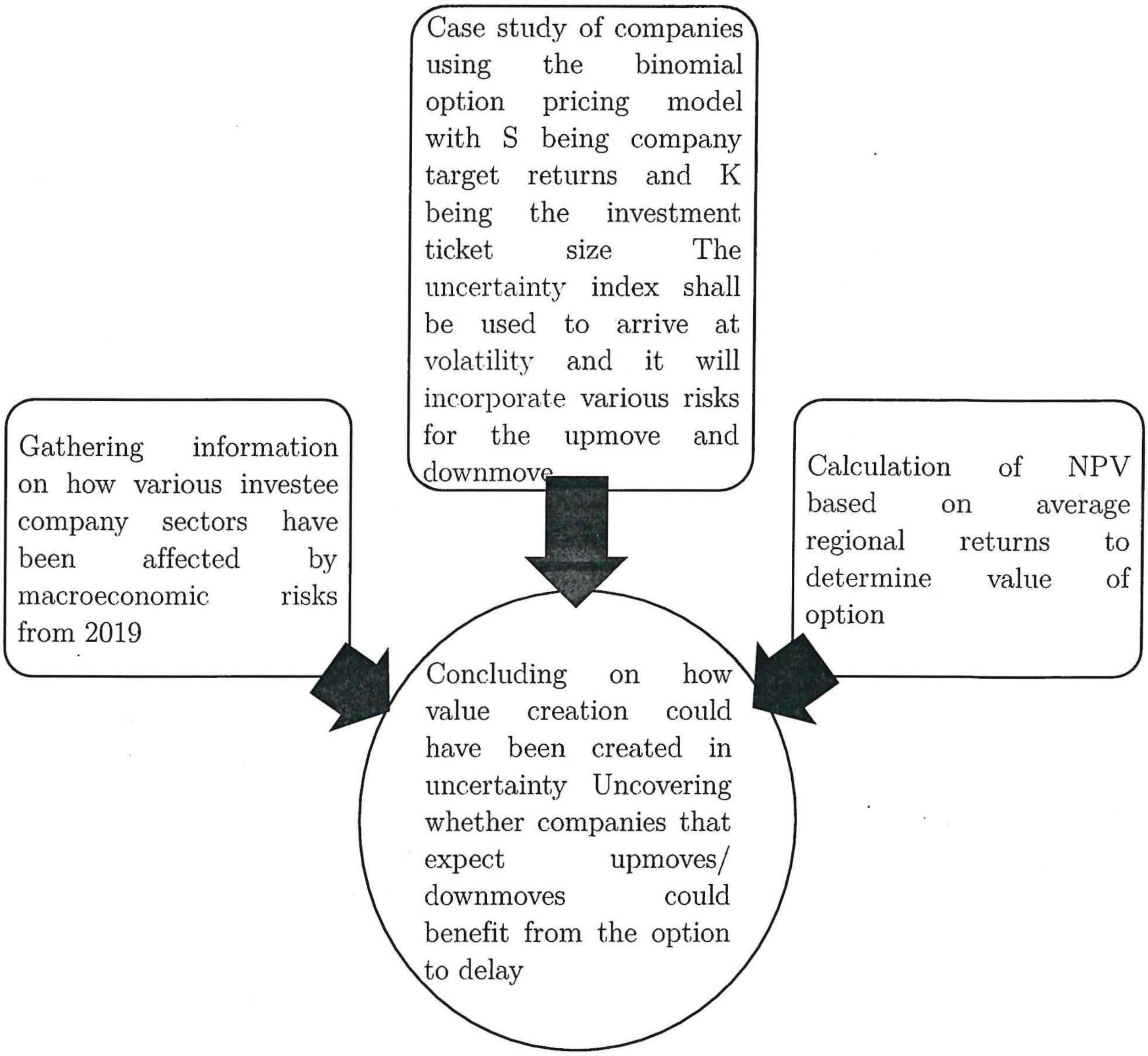
2.4 Links between the studies

The link between the above studies is through deferral options, uncertainty, and investment timing. Just like Sears (2019) employed a contrast approach involving an advanced and a developing firm, I shall look into different sectors and the various uncertainties that can enhance value or prove detrimental to decision makers in Private Equity funds. I shall advance his approach through sector specific analysis of uncertainty and volatility to isolate the net option value of investing.

Similar to Guthrie (2011), this paper shall attempt to uncover the value of delay options and whether they can be valuable in the face of uncertainty. I expect a similar outcome although I shall use an uncertainty index and bundle up the different risks that affect various sectors and attempt to arrive at the value that an option to delay would have created for PE firms that made investments in various sectors from 2019 onwards.

This study therefore becomes of relevance due to the incorporation of various operational risks that have presented themselves within the time period of interest such as COVID-19. It contributes to study in this area through the use of a unique dataset, the incorporation of more recent exogenous uncertainties as well as a new measure of data analysis and customization that is achieved by the uncertainty index.

2.5 Conceptual Framework



CHAPTER 3: METHODOLOGY

3.1 Nature of the Study & Research Design

This paper shall employ a case study research design. According to Summers (2008), a case study design is best for the analysis of a phenomenon, the generation of a certain hypothesis or the validation of a method. This paper aims to analyse and validate the concept of value creation by real options, specifically the deferral option for private equity investors. A case study design allows for such analysis by focusing on specific parties of interest in order to make informed data driven inferences.

3.2 Population & Sampling

The population of interest for this paper comprises of investee companies that are seeking investment from Private Equity Fund managers and analysis shall be done with the investor in mind. There shall be a sector-based selection to capture the effects of macroeconomic risks on various sectors of investment. Different sectors shall be considered in order to contrast the possible benefits of the application of real options in this framework of decision-making. The sample shall comprise of pre-money private equity deals in Sub-Saharan Africa from 2019 onwards and an uncertainty index shall be formulated based on the various risks affecting the sectors of investment to be considered.

3.3 Data Collection

3.3.1 Type of data

Secondary Data on the various variables of interest shall be used. Some variables however, such as the up-moves and down-moves shall be generated for use in this paper.

3.3.2 Sources of data

The data will be sourced from the financials of the two different case studies: Caplora Academy and Get Gas. The macroeconomic variable data for the exogenous volatility and discount factors shall be sourced from the Economic Intelligence Unit and from Aswath Damodaran's datasets.

3.3.3 Data Collection instruments

Quantitative data that shall enhance results will be collected from statistical databases and reports done in the field of interest.

3.4 Data Analysis

3.4.1 Tools of Data Analysis

The data shall be analysed on R and this is to enhance the visualization of the binomial trees that will be used to derive option value.

3.4.2 Technique of Analysis

Table of Variables

Variable Symbol	Description	How the variable shall be arrived at
S	Value of returns/ inflows from investment at a specific point in time	This shall be derived from the target return for the companies that are likely to attain them and the relative regional return shall be used for the contrast company
X	Sunk cost of the investment at the time of deal sealing	This value will be derived from the values reported in journal articles of various closed deals in private equity from the year 2019. This variable remains constant throughout the period of analysis. The up-move and down-move factors are not applied to this variable
p	Probability of an up-move	This is the probability of a favourable outcome in the next period. It is arrived at from the following equation; $p = (1 + r) - d / u - d$
u	The up-move variable	This is the up-move factor that is applied to S to get

		the upper up-move node at each point in time
q	Probability of a down-move	This is the probability of a non-favourable outcome in the next period. It is arrived at from the following equation; $q = u - (1 + r) / u - d$
d	The down-move variable	This is the down-move factor that is applied to S to get the lower down-move node at each point in time
r	The discount factor	This will be based on the target cost of capital for the investor company. It shall be derived by getting the target rate of return for the specific company being analysed at a time
σ	Volatility	This is a key variable of interest as it determines the probabilities of motion in the next period. I shall develop this by calculating sector-based risks that have presented themselves on a semi-annual basis since the time of investment and using this for projection into the near future based on company-specific investment horizons.

t	Time period: The jump	This variable signifies the length of the jump from node to node

The Choice of Model

The paper shall use the Binomial Options Pricing model to carry out analysis as opposed to the Black Scholes Model. This is because the model follows an iterative process and allows for isolation of certain points in time between the option valuation date and its expiration date. This is key for this analysis because the aspect of time is necessary in this paper. Another reason for the choice of this model is that it is path-dependent hence one is able to analyse the effect of uncertainty and volatility on the up-moves and down-moves as well as understand the value at each node.

The Binomial Options Pricing Model

The following is the model that is used to calculate the value of an option at time 0 that has two probabilities in the next period; probability of an up-move and that of a down-move.

The probability of an up-move, p = (1 + r) – d / u – d and that of a down-move,

q = u – (1 + r) / u – d.

$$C_n(\omega_1, \cdots, \omega)n) = \frac{1}{1+r}[\tilde{p}C_{n+1}(\omega_1, \cdots, \omega_n; H) + \tilde{q}C_{n+1}(\omega_1, \cdots, \omega_n; T)]$$

This iterative process occurs from the expiration date node up to the time 0 node such that it is possible to derive option value at each node. The option shall only be exercised if it fits within its call criteria i.e Max {0, S-K}. K representing the sunk costs of investment and S representing the value of inflows at a point in time.

The Real Option to Delay

The payoff of an option to delay resembles that of a call option therefore its value at a specific point in time is;

Max {0, S-K} this makes the assumption that the parties of interest will take a long position in this option.

For n periods of observation, the following formula shall be of interest

$$C = \frac{1}{R_f^n}\left[\sum_{j=0}^{n}\left(\frac{n!}{j!(n-j)!}\right)p^j(1-p)^{n-j}max[0, u^j d^{n-j}S - K]\right]$$

We then introduce a minimum integer, a that determines if the option will expire in the money. Such that for all j > a, the option expires in the money.

$$max\left[0, u^j d^{n-j}S - K\right] = u^j d^{n-j}S - K$$

This is required to determine the minimum number of jumps required for S to exceed K.

Comparison of Value of investment with the presence of the option and without the presence of the option

This comparison will be key for the quantification of option value and shall be determined by comparing net option value of investment and net value of investment.

Determination of optimal delay period (Best timing practice)

This shall be determined using the concept of minimum jumps and the 'a' integer to be able to determine what minimum integer is ideal for the option to expire in the money.

CHAPTER 4. RESULTS

4.1 Analysis Findings

4.1.1 Volatility and Deferral Option Value

The first step was to incorporate the aspect of macroeconomic factors affecting investment prior to the COVID-19 pandemic and during the period through volatility. Aswath Damodaran (2020) was able to incorporate macroeconomic risks into one sector-specific volatility figure prior to the pandemic and after the pandemic. The two case studies, Caplora Academy & Get Gas are in the Education and Oil/Gas Distribution sectors respectively hence exhibited varied volatility measures.

The differences in volatility influenced the up-move and down-move in the model and notably the volatility as expected was higher during the period compounded with macroeconomic uncertainty.

CAPLORA ACADEMY (CASE STUDY 1 – EDUCATION SECTOR)	
Volatility prior to enhanced macroeconomic risks (COVID-19)	0.3481
Up-move prior to enhanced macroeconomic risks (COVID-19)	1.461374
Down-move prior to enhanced macroeconomic risks (COVID-19)	0.7060283
Volatility during enhanced macroeconomic risks (COVID-19)	0.4715
Up-move during enhanced macroeconomic risks (COVID-19)	1.602396
Down-move during enhanced macroeconomic risks (COVID-19)	0.6240655

GET GAS (CASE STUDY 2 – OIL/GAS DISTRIBUTION SECTOR)	
Volatility prior to enhanced macroeconomic risks (COVID-19)	0.2122
Up-move prior to enhanced macroeconomic risks (COVID-19)	1.236395
Down-move prior to enhanced macroeconomic risks (COVID-19)	0.8088029
Volatility during enhanced macroeconomic risks (COVID-19)	0.2374
Up-move during enhanced macroeconomic risks (COVID-19)	1.267948
Down-move during enhanced macroeconomic risks (COVID-19)	0.6240655

The next step was to calculate the parameters for the binomial model on a case-by-case basis.

Caplora Academy

Variable Symbol	Value
S	328,666.5
X	368,138.7
r	0.1784
t	1
n	4 years

The Net Present Value of investment without the deferral option was calculated to be

– 39,472.15.

Generating the binomial tree to derive the option value in both instances brought about the following results.

In the current macroeconomic climate – Volatility (0.4715) :

```
         [,1]      [,2]     [,3]     [,4]     [,5]
[1,] 56234.73 101758.51 178910.3 301649.0 475769.4
[2,]     0.00  16770.32  35458.3  74971.2 158515.2
[3,]     0.00      0.00      0.0      0.0      0.0
[4,]     0.00      0.00      0.0      0.0      0.0
[5,]     0.00      0.00      0.0      0.0      0.0
```

The deferral option has a value of **56,234.73** hence the Net Present Value of investment with the incorporation of the deferral option is **16,762.58.**

In the period prior to the current macroenvironment – Volatility (0.3481) :

```
         [,1]     [,2]      [,3]      [,4]      [,5]
[1,] 41788.95 71379.69 118907.66 191182.57 291204.13
[2,]     0.00 12606.63  24920.11  49260.74  97375.99
[3,]     0.00     0.00      0.00      0.00      0.00
[4,]     0.00     0.00      0.00      0.00      0.00
[5,]     0.00     0.00      0.00      0.00      0.00
```

The deferral option has a value of **41,788.95** hence the Net Present Value of investment with the incorporation of the deferral option is **2316.8.**

Get Gas

Variable Symbol	Value
S	1,086,662
X	1,179,869
r	0.1784
t	1
n	3 years

The Net Present Value of investment without the deferral option was calculated to be

– 93,206.15.

Generating the binomial tree to derive the option value in both instances brought about the following results.

In the current macroeconomic climate – Volatility (0.2374) :

```
        [,1]      [,2]      [,3]      [,4]
[1,] 102340 170106.04 280752.85 459481.48
[2,]      0  20463.63  36868.62  66424.94
[3,]      0      0.00      0.00      0.00
[4,]      0      0.00      0.00      0.00
```

The deferral option has a value of **102,340** hence the Net Present Value of investment with the incorporation of the deferral option is **9,133.85.**

In the period prior to the current macroenvironment – Volatility (0.2122) :

```
         [,1]      [,2]      [,3]     [,4]
[1,] 90617.91 148079.20 240817.00 389466.8
[2,]     0.00  15861.68  27714.25  48423.6
[3,]     0.00      0.00      0.00      0.0
[4,]     0.00      0.00      0.00      0.0
```

The deferral option has a value of **90,617.91** hence the Net Present Value of investment with the incorporation of the deferral option is **– 2,588.24.**

4.1.2 Optimal Investment Timing

Caplora Academy

Analysis of the Binomial Tree valuation of Caplora Academy suggests that the shaded period would be the optimal investment region.

	[,1]	[,2]	[,3]	[,4]	[,5]
[1,]	56234.73	101758.51	178910.3	301649.0	475769.4
[2,]	0.00	16770.32	35458.3	74971.2	158515.2
[3,]	0.00	0.00	0.0	0.0	0.0
[4,]	0.00	0.00	0.0	0.0	0.0
[5,]	0.00	0.00	0.0	0.0	0.0

Consistent with Guthrie (2011), this indicates that there is room for more strategic information to be gathered about this investment and the deferral option allows for that therefore the optimal investment period would be as from the start of 2022 and this is due to the probabilities available that leave little room for investment losses as all downward movements within the period are higher than **56,234.73**. This is if the binomial tree period began in 2020 on the onset of elevated macroeconomic risks.

Get Gas

Analysis of the Binomial Tree valuation of Get Gas suggests that the shaded period would be the optimal investment region.

	[,1]	[,2]	[,3]	[,4]
[1,]	102340	170106.04	280752.85	459481.48
[2,]	0	20463.63	36868.62	66424.94
[3,]	0	0.00	0.00	0.00
[4,]	0	0.00	0.00	0.00

Consistent with Guthrie (2011), this indicates that there is room for more strategic information to be gathered about this investment and the deferral option allows for that therefore the optimal investment period would be as from the start of 2021 and this is due to the higher down-move probabilities available in the future however the deferral option in this case of lower volatility does not completely alleviate downward loss as the downward figures are less than **102,340**. This is if the binomial tree period began in 2020 on the onset of elevated macroeconomic risks.

CHAPTER 5: CONCLUSION

5.1 Conclusion

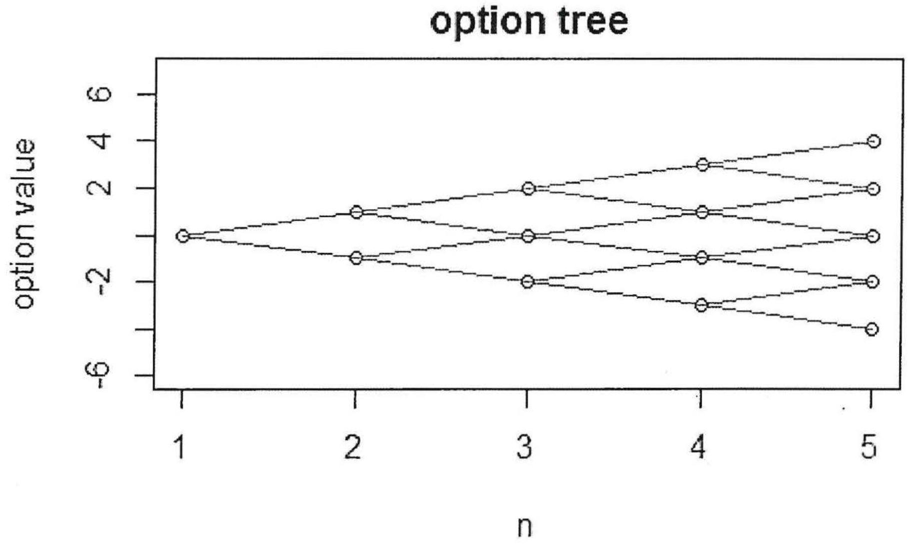
This paper modifies the standard binomial option pricing approach to real options analysis so that it can incorporate exogenous uncertainty. In the modified approach, volatility in the anticipated market value of the investment is the key driver behind the value addition that the real option to delay offers to decision makers.

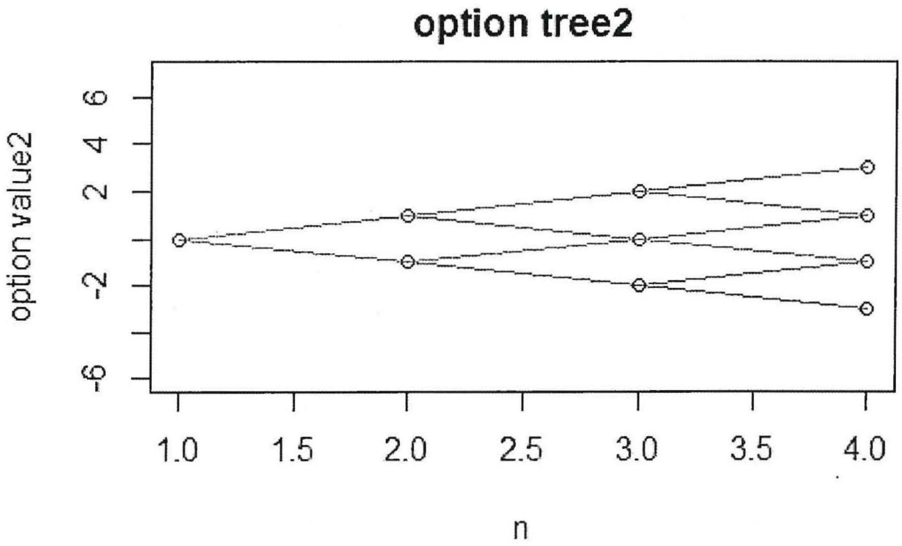
The findings of this study were consistent with Sears (2019) who was able to appreciate that deferral options are valuable in the presence of exogenous uncertainty. This was quantified through the sensitivity analysis of the option value vis a vis the volatility where is was notable that increased volatility and uncertainty increased the option's value for the same case study.

The results were therefore able to meet the research objective of deriving the drivers of value addition in the case of deferral options and the key driver is exogenous risk as the volatility used in the model was sector-based and derived from the macroeconomic factors present at a point in time. Moreover, they were able to quantify the value addition through derivation of the net present value of the investment with and without the deferral option.

Furthermore, in the case with the highest volatility (Caplora Academy) the optimal investment period is such that the net present value of the option is positive in both the upward and downward movements completely alleviating any possible investment loss thus deferral options are highly feasible and applicable to investment decision makers in cases where there is high exogenous volatility as compared to low volatility. In the case with the lower volatility, to completely eradicate the chance of a loss due do down-ward movements in the binomial tree, the investment would have to be made at a date beyond the period.

APPENDIX





DATA ANALYSIS

BOPM.Rmd

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