MANAGERIAL FLEXIBILITY USING ROV: A SURVEY OF TOP 40 JSE LISTED COMPANIES

By

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Declaration

I, the undersigned, hereby declare that the work contained in this assignment is my original work and that I have not previously in its entirety or in part submitted it at any university for a degree.

Signature……

Date:……..

Abstract

For the last 40 years, academics advocated the use of the traditional Discounted Cash Flow (DCF) techniques but these suggestions were ignored by practitioners for a long time. The Net Present Value (NPV), Internal Rate of Return (IRR) and Present Value Payback Period (PVPP) are now some of the more widely used traditional DCF-based techniques, especially among large firms. However, academics are now criticising these techniques as they are based on rigid assumptions that ignore the management of flexibility in projects. The Real Option Valuation (ROV) is suggested as an alternative technique because it implicitly incorporates this flexibility in project valuation. With ROV, opportunities in projects are treated as real options and are therefore valued using financial option principles. Real options give the firm the opportunity to act on an investment project (invest, abandon, rescale) at a later date, when more information is available.

As with the traditional DCF-based techniques in the past, few firms seem to have adopted ROV despite academics' recommendations. This study is thus aimed at determining through a survey, whether the largest firms in South Africa, specifically those included in the JSE/FTSE Top 40 index, are using ROV. Based on the results of the survey, it is concluded that firms generally do not use ROV as only nine percent of the respondents were found to be using it. This is largely attributed to managers being unaware of the technique, and to some extent, to the technique's complexity. On the other hand, managers were generally found to recognise the flexibility despite not using ROV, although it was not confirmed whether they quantify this flexibility.

Opsomming

Gurende die afgelope 40 jaar het akademici die tradisionele Verdiskonteerde Kontantvloei-tegnieke (Discount Cash Flow, DCF techniques) aanbeveel en gebruik maar hierdie aanbevelings is grootliks deur die sakelui geignoreer. Die Netto Huidige Waarde (Net Present Value, NPV), Interne Rentabiliteit (Internal Rate of Return, IRR), en die Huidige Waarde Terugbetalingsperiode (Present Value Payback Period, PVPP) is sommige van die tradisionele tegnieke wat nou wyd veral deur die groot maatskappye gebruik word. Academici kritiseer egter nou hierdie tegnieke omdat hulle te rigied is die en nie die behoefte vir bestuur van buigsaamheid in projekte in agneem nie. Reële Opsie Waardasie (ROW) (Real Option Valuation, ROV) word voorgestel as ’n alternatiewe tegniek aangesien dit buigsaamheid inkorporeer in projekbeoordeling. Met ROV word geleenthede in projekte aan die hand van reële opsies hanteer en word dus evalueer volgens die beginsels van finansiële opsies. Reële opsies gee aan die maatskappy die geleentheid om op ‘n latere stadium, as meer inligting beskikbaar is, in die beleggingsprojek te belê, of om dit af te skaal of selfs heeltemal ter syde te stel.

Soos wat die geval was met Verdiskonteerde Kontantvloeitegnieke in die verlede, word ROW tans deur min maatskappye gebruik ten spyte van die aanbevelings van akademici. Daar is dus in hierdie studie gepoog om vas te stel of die grootste maatskappye in Suid Afrika, veral dié in die JSE-FTSE Top 40 indeks, huidiglik gebruik. Die bevindings van die studie toon dat dat slegs nege persent van die maatskappye dit wel doen. Dit word grootliks daaraan toegeskryf dat die bestuurders onbewus is van die tegniek en ook ten dele omdat die tegniek gekompliseerd is. Aan die ander kant is daar bevind dat bestuurders die nooligheid vir buigsaamheid insien alhoewel hulle nie van hierdie tegniek gebruik maak nie. Daar is egter nie bevestig of hulle die buigsaamheid kwantifiseer nie.

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List of Abbreviations

CFO – Chief Financial Officer

CIF – Cash Inflows

COF – Cash Outflows

DCF – Discounted Cash Flows

ENPV – Expanded Net Present Value

FDA – Food and Drug Administration

FMA – First Mover Advantage

FTSE – Financial Times Stock Exchange

HEX – Helsinki Exchange

IRR – Internal Rate of Return

IT – Information Technology

JSE – Johannesburg Stock Exchange

MIRR – Modified Internal Rate of Return

NCF – Net Cash Flow

NPV – Net Present Value

OTC – Over the Counter

PI – Profitability Index

PP – Payback Period

PVCOF – Present Value Cash Outflows

PVPP – Present Value Payback Period

R&D – Research and Development

ROI – Return on Investment

ROV – Real Option Value

SMA – Second Mover Advantage

TV – Terminal Value

UK – United Kingdom

US – United States

Chapter 1

Introduction

1.1 Background of the Study

A lot has been written about the capital budgeting process in finance publications as there seems to be a gap between theory and practice. Interest in this topic is understandable given the impact that capital budgeting decisions have on a firm's return on investments and ultimately, on firm value. For a while, it seemed in practice and academically, as though the traditional discounted cash flow (DCF) techniques were sufficient tools on which capital budgeting decisions could be based. Practitioners had ignored these techniques for a long time, but they have of late, become very popular with firms. Recent studies suggest that DCF techniques such as the net present value (NPV) and payback period (PP) are now being used by most organisations (Nyberg in 2002, Ryan and Ryan in 2002 and Synergy Partners in 2004).

However, academics point out that a conflict exists between strategic planning and financial evaluation when evaluating a project. Based on financial criterion such as the NPV, a project may be rejected even if the investment makes strategic sense. This is particularly prevalent in Research and Development (R&D) intensive industries such as pharmaceutical and information technology industries. Most R&D investments are likely to yield quite negligible NPVs at best. However, such projects have proven to be the backbone on which these industries are built. R&D projects tend to pave the way for future entry into new markets and can at times enable a firm to make follow-on investments in more lucrative and larger scale projects (Herath and Park, 1999: 1).

The traditional DCF-based techniques are based on static assumptions, and therefore ignore management's flexibility in projects. In reality though, it may be possible for a firm to delay investment in some large scale projects until a later date by obtaining or creating such an opportunity. Strategic planning recognises such opportunities as well as

the potential optionality in projects that may initially appear to be unviable. The optionality in projects is seen as managerial flexibility because it gives managers the opportunity to plan for the most profitable decisions in a highly uncertain environment. Mauboussin (1999: 5) defines flexibility as the ability to delay, abandon, contract, or expand an investment project.

Traditional DCF-based techniques do not account for or recognise this flexibility. Under these techniques, only the project's foreseeable viability determines whether it is selected or not, while the less obvious potential profitability of the project is ignored. Flexibility in projects can lead to a preservation of resources and create a greater future profit potential. Does this then mean that all projects with optionality should be pursued or even that all options in projects are valuable and justify delaying the investment decision? More importantly, how does the manager then account for flexibility in projects? How does he/she determine how long to defer an investment, when to abandon, contract, or expand? According to Kemna (1993: 259), real option valuation (ROV) can be used to plan investments with optionality because it quantifies flexibility in strategic capital projects. This entails treating opportunities in capital projects as real options.

A real option is similar to a financial option in that it gives the holder the right but not the obligation to act on an underlying asset for a certain cost at or within a given time. The relevant project is the underlying asset on which the option is based. ROV involves managing the flexibility of investment projects to derive the highest possible economic value with a minimum level of risk. Yet, despite its supposed superiority over traditional DCF-based techniques, it seems most managers are still not using ROV to plan their investments (Lewis, Enke and Spurlock, 2004: 37). According to Dias (2004) a survey conducted in 2003 revealed that around 27% of companies surveyed in the US and Canada were using ROV. A study by Collan and Långström (2002) in Finland found none of the Finnish listed firms to be using the technique.

1.2 Statement of the Problem

Collan and Långström conclude that while many of the companies do engage in projects with inherent optionality, few actually have an established program of identifying and exploiting real options. The study also suggests that managers' feelings about the different types of flexibility in investments are mixed. Given these findings, what is the case in South Africa? Furthermore, why do managers use or not use ROV?

South Africa as an emerging market is attracting some attention as foreign investors can earn relatively high returns from such markets. However, emerging markets are usually associated with a high level of risk. And, according to Tóth and Zemčik (2006: 7), investors prefer to invest in firms with low non-systematic risk. Given that real options, like financial options, are used to mitigate downside risk while taking advantage of the upside potential, firms using ROV are expected to yield higher returns from their investments at a lower level of risk (Insead and Levinthal, 2004: 122). This study then investigates whether South Africa's Top 40 listed firms use ROV in their projects as well as the reasons for this use or non-use. The following research questions are addressed by the study:

- Do companies in the FTSE/JSE Top 40 use ROV?
- Do managers (CFOs) in these companies recognise and exploit flexibility in their investment projects?
- What factors influence these companies to use or not use ROV?

1.3 Objectives of the Study

The current study is largely inspired by Collan and Långström's study of Finnish companies (which in turn followed closely the study by Busby and Pitts of British companies in 1997) regarding their management of real options. The study attempts to replicate Collan and Långström's study in a South African context, with some adjustments though, to incorporate other factors. As a result, some of the objectives of

this study are in line with those of Collan and Långström's study. The main objectives of this study are then the following:

- To establish whether the Top 40 South African companies listed on the JSE make use of ROV in their capital budgeting processes,
- To determine the occurrence of flexibility in capital projects and whether managers recognise such flexibility,
- To determine possible factors that affect managers' use or non-use of ROV, and
- To discuss some of the more recent and relevant literature on the use of real options and to review some case studies in which ROV has been applied.

1.4 Research Methodology

The FTSE/JSE Top 40 firms are surveyed to address the research questions and objectives of the study discussed above. The study is based on observing through a survey, the capital budgeting practices of these firms, and how they deal with flexibility in their projects. A questionnaire is sent to the Chief Financial Officers (CFOs) and Finance Directors of respondent firms as they are expected to have a broader knowledge of their companies' capital budgeting processes. The two studies mentioned above also targeted the CFOs of respondent firms.

The full list of respondents is included in **Appendix A** of the paper. It should be noted that great care was taken not to reveal any details from the firms' responses that may in any way be used to identify any of the respondents. The survey questions closely follow the line of questioning used by Collan and Långström in their study. In addition, several other questions are included to address some of the factors that are expected to influence respondents' use or non-use of ROV. This was not a feature of the Finnish study.

1.5 Scope and Limitations of the study

One of the expected limitations of the study as is typical of a survey-based study was the possible unavailability of data. It was expected that some data would be unavailable or unusable due to possible non-responsiveness to questions or inconsistent responses to the questionnaire. However, great efforts were made to pursue a high response rate with reliable feedback. Another limitation of the study is the use of a relatively small number of respondents. As a result, any conclusions from the study are not used to generalise on the entire population of South African firms. There are two main reasons for using such a small sample size for the survey:

- The survey is constrained by limited resources which if otherwise, would allow for a larger scale survey.

Real options tend to be more valuable for capital intensive projects, most of which are undertaken by the larger companies. The Top 40 firms are some of the largest listed firms on the JSE and would be more likely to find ROV applicable in their investments. The study was then used to determine whether a larger scale study of the entire market was warranted.

Chapter 2

Literature Review

2.1 Capital Budgeting and DCF

2.1.1 DCF Techniques

In the recent past, the discounted cash flow (DCF) techniques have become popular with practitioners but less so with academics. In this paper, these techniques are referred to as traditional DCF-based techniques. According to Paddock, Siegel and Smith (2001: 775) and Dixit and Pindyck (1995: 106) the DCF techniques are popular because their decision rules and criteria are theoretically sound and easy to use. The decision criteria of these techniques are fairly straight-forward thereby making it easy to decide whether to accept or reject a proposed project. Brigham, Gapenski and Ehrhardt (1999: 426) suggest six of the more popular techniques. Five of these are DCF techniques:

a) Payback Period,
b) Present Value Payback Period,
c) Profitability Index,
d) Net Present Value,
e) Internal Rate of Return, and
f) Modified Internal Rate of Return.

a) Payback Period (PP)

The PP technique measures the amount of time in years it takes for a firm to recover the original investment amount in a project. According to Brigham, Gapenski and Ehrhardt (1999: 426) a project's payback period is determined by:

$$Payback = Year\ before\ full\ recovery + \frac{Unrecovered\ cost\ at\ start\ of\ year}{Cash\ flow\ during\ year} \quad \text{..... (1)}$$

Let us assume an investment, Project ABC with the parameters as given in Table 2.1 below:

Table 2.1 – *Project ABC with undiscounted cash flows*

	0	1	2	3	4
Net Cash Flow (NCF)	(100)	50	40	30	10
Cumulative NCF	(100)	(50)	(10)	20	30

Project ABC would then have a payback period of:

$$\text{Payback} = 2 + \frac{10}{30}$$

$$= 2.33 \text{ years}$$

In other words, it will take 2.33 years for the project to return the initial investment amount of 100. Bhandari (1986: 16) points out that the PP is attractive to practitioners because it is easy to calculate and interpret. Its most appealing attribute over other techniques is that it gives a time frame for the recovery of capital. When deciding between mutually exclusive projects, the project with the shortest payback period will be chosen as it results in the investment being recovered more quickly. However, because of this criterion, projects with higher cash flows beyond the payback period may be sacrificed for those with shorter payback periods but lower overall cash flows. On top of that, the PP ignores the time value of money as it is not based on discounting the project's cash flows.

b) Present Value Payback Period (PVPP)

The PVPP technique provides a solution to the latter limitation of the PP. Unlike the PP, the PVPP method takes the time value of money into account by discounting project cash flows. The cash flows are discounted at the relevant discount rate, which is normally the cost of capital. The formula used to determine discounted cash flows is the following:

$$PVCF = \frac{CF_t}{(1+r)^t} \quad \text{.....(2)}$$

Where CF_t = Cash Flows at time t,

r = discount rate, and

t = period/time

If we assume the cost of capital (discount rate) to be 13%, then the cash flows will be discounted to yield the values shown in Table 2.2 below. Due to discounting, the cash flows in period 1 become 44 (50/1.13), 31 ($40/1.13^2$) in period 2, in period 3 they become 21 ($30/1.13^3$) and 6 ($10/1.13^4$) in period 4. Compared to the cumulative NCF in Table 2.1 above, the NCFs in Table 2.2 are lower because discounting reduces the weight of cash flows. This also affects their contribution to the project's payback period.

Table 2.2 – *Project ABC with discounted cash flows*

	0	**1**	**2**	**3**	**4**
Net Cash Flow (NCF)	(100)	50	40	30	10
Discounted NCF	(100)	44	31	21	6
Cumulative NCF	(100)	(56)	(25)	(4)	2

The project's payback is then:

$$\text{Payback} = 3 + \frac{4}{6}$$

$$= 3.67 \text{ years}$$

This result suggests that the present value of the initial investment amount would be recovered in 3.67 years. This is a longer payback period than the one based on the PP (3.67 vs. 2.33), a less desirable but a more realistic result. While it takes the time value of money into account, the PVPP also ignores the size of cash flows that occur subsequent to the payback period. This technique is used mostly to decide between mutually

exclusive projects but it can also be used for a single project provided that a threshold payback is set.

c) Profitability Index (PI)

The PI measures the ratio of a project's discounted cash inflows to its discounted cash outflows. As a result, all of the cash inflows and outflows expected to occur over the project's entire estimated life, are taken into consideration. The PI is expressed as:

$$PI = \frac{\sum_{t=0}^{n} \frac{CIF_t}{(1+r)^t}}{\sum_{t=0}^{n} \frac{COF_t}{(1+r)^t}} \quad \text{.....(3)}$$

Where CIF_t = Expected Cash Inflow at time t, and

COF_t = Cash Outflow at time t

Project ABC would have a PI of:

$$PI = \frac{102}{100}$$

$$= 1.02$$

The PI of 1.02 suggests that the project's discounted benefits are higher than the discounted costs and therefore the project has a positive NPV (discussed later in the section). The project is then worth investing in. In the same way, a firm would not invest in a project that has a PI less than 1. This is because such a project would not be viable as the discounted benefits would be less than the discounted costs. However, the investor would be indifferent to a project with a PI equal to 1, as the benefits would be equal to the costs.

The PI decision rule is fairly easy to apply and can be useful when deciding on independent projects. However, the rule is less useful for choosing between projects as it

ignores the scale of a project. When deciding between mutually exclusive projects, a lower scale project may be selected over a more profitable (in absolute terms) and larger scale one. As a result, this technique can lead to sub-optimal decisions.

d) Net Present Value (NPV)

The NPV remains one of the more prominent techniques used in the analysis of investment projects. According to Brigham, Gapenski and Ehrhardt (1999: 440), most academics prefer this technique to others techniques discussed in this section. The decision rule of the NPV is usually quite straightforward. A project with a positive NPV is accepted while a negative NPV project is rejected. Moreover, the NPV criterion will lead to an immediate decision of whether to invest in a project now or not. According to Brigham, Gapenski and Ehrhardt (1999: 429) a project's NPV can be determined using the following formulae:

$$NPV = COF_0 + \frac{CIF_1}{(1+r)^1} + \frac{CIF_2}{(1+r)^2} + ... + \frac{CIF_n}{(1+r)^n} \quad .....(4)$$

$$NPV = \sum_{t=0}^{n} \frac{CIF_t}{(1+r)^t} - PVCOF \quad .....(5)$$

It is often the case that more than one scenario is possible from an investment opportunity. Each scenario is likely to yield different cash flows, and mostly with different profit potentials. When assessing the viability of the investment, it is important to determine the likelihood (probability) of realising each possible scenario. According to Hall (n.d. 8), Monte Carlo Simulation can be used to generate possible cash flows from different scenarios. A normal probability distribution can then be constructed using these values and their associated probabilities (Managerial Economics, n.d.). The expected cash flows for each period are then estimated using the more likely cash flows from each scenario and their associated probabilities. The following formula can be used to estimate the expected cash flows:

$$\text{Expected Cash Flows at time T } (CIF_t) = \sum_{i=1}^{n} (P_i)(CIF_i) \quad \text{.....(6)}$$

Where CIF_i = cash inflow for scenario i, and

P_i = probability of scenario i.

Consider the following example of an investment in Project XYZ, which is based on the production and sale of widgets:

Investment cost: R115m (investment to be made in a year's time)

Possible Cash Inflows (CIF_i): CIF_1= R170m and CIF_2 = R60m

Probability of CIF_i (P_i): P_1 = 0.5 and P_2 = 0.5

Cost of capital: 15 % per annum

Risk free rate: 8% per annum

Only two scenarios are possible from Project XYZ, with each scenario equally likely to occur. The occurrence of each scenario is assumed to depend on the price widgets. Should Scenario 1 unfold, with CIF of R170m, the project's NPV will be:

$$NPVc_1 = \text{Discounted Cash Inflow} - \text{Discounted Investment}$$

$$= \frac{\text{R170m}}{1.15} - \frac{R115m}{1.08}$$

$$= R41.3m$$

The project is deemed to be viable because it yields a positive NPV of R41.3m. It should be noted that the initial investment amount is discounted because it is incurred in a year's time. The appropriate discount rate is the risk free rate of 8% in this case because unlike the project's cash inflows, the investment amount is assumed to be certain should the investment be made. Alleman (2003: 40) points out that cash inflows are discounted at a discount rate higher than the risk free rate because they are associated with a higher level

of risk. However, since the investment amount is assumed to be known, it is seen as certain and should therefore be discounted at the risk free rate.

Alternatively, if Scenario 2 unfolds, with CIF of R60m, the project's NPV will be:

$$NPVc_2 = \frac{R60m}{1.15} - \frac{R115m}{1.08}$$

$$= -R54.3m$$

The project is unprofitable as it yields a negative NPV of R54.3m.

A summary of the possible scenarios, their parameters and attributes is shown in Table 2.3 below.

Table 2.3 – *Summary of possible scenarios for Project XYZ*

Project Parameters	**Scenario 1**	**Scenario 2**
Initial Investment*	R106.5m	R106.5
Cash Flow	R170m	R60m
Probability (P_i)	0.5	0.5
Discounted Cash Flow	170/1.15 = R147.8m	60/1.15 = R52.2m
NPV	R41.3m	(R54.3)
Decision	Accept	Reject

* The initial investment is discounted at the risk free rate and not at the cost of capital.

Under Scenario 1 the project yields a positive NPV of R41.3m but under Scenario 2 the project has a negative NPV of R54.3m.

At time t=0, we are then faced with the problem of deciding whether to invest in the project, as we are uncertain whether it will lead to the profitable Scenario 1 or the unprofitable Scenario 2. According to Boute, Demeulemeester and Herroelen (2004:

1716), the NPV method tells us to weigh the future cash flows based on the respective probabilities for them to occur in order to determine the project's expected cash flows as discussed above. The project's discounted expected net cash flows at time 0 will be:

$$\text{Expected Cash Flows} = \frac{[(0.5)\,\text{x}\,(R170m) + (0.5)\,\text{x}\,(\text{R60m})]}{1.15}$$
$$= R100m$$

The project's Expected NPV will then be:

$$NPV = 100 - \frac{R115m}{1.08}$$
$$= -R6.48m$$

The project yields a negative expected NPV of –R6.48. Based on the NPV technique, Project XYZ should be rejected.

e) Internal Rate of Return (IRR)

Chang and Swarles (1999: 132) define the IRR as the rate that equates a project's discounted cash inflows to its discounted cash outflows. The NPV in that case is therefore equal to zero and PI is 1. While with the NPV technique we solve for the excess of cash inflows over outflows, with the IRR we determine the discount rate. The IRR can be determined iteratively or by way of trial and error or even more accurately with a financial calculator. The following formula is used to determine the IRR:

$$COF = \frac{CIF_1}{(1+IRR)^1} + \frac{CIF_2}{(1+IRR)^2} + \ldots\ldots + \frac{CIF_n}{(1+IRR)^n} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7),$$

So that:

$$0 = -COF + \frac{CIF_1}{(1+IRR)^1} + \frac{CIF_2}{(1+IRR)^2} + ...\frac{CIF_n}{(1+IRR)^n} \quad .....(8)$$

If a project's IRR is greater than the cost of capital (or opportunity cost), IRR > r, then the project is accepted. The project is rejected if the IRR is less than the cost of capital, IRR < r. The IRR for Project XYZ would be 13%. Since the IRR is lower than the cost of capital of 15%, the project would be rejected.

The excess of the IRR over the cost of capital (when IRR > r) is the level of wealth being created for stakeholders while the shortfall (IRR < r) is the level of wealth being eroded. The benefit of using the IRR is that the investor is able to determine, in percentage terms, how much wealth is being created or destroyed by undertaking the project. However, like the PI, the IRR ignores the scale of a project and can result in misleading conclusions.

The IRR can also give inconsistent results if the structure of a project's cash is non-formal. This is the case when COFs occur between a stream of CIFs during the project's life. The project will yield multiple IRRs. It is possible in this case to have one IRR greater than the cost of capital while the other IRR is less than the cost of capital. The investor would then be uncertain whether or not to invest in the project. Furthermore, the IRR is based on an implicit assumption that the project's cash flows are reinvested at the IRR until the project's maturity, which may not necessarily be the case (Anderson and Barber, 1994: 613).

f) Modified Internal Rate of Return (MIRR)

The IRR was formulated to address the limitation of multiple IRRs of the technique discussed above. According to Chang and Swales (1999: 133) the MIRR is the rate that equates the present value of a project's costs to the present value of its terminal value. The MIRR can be calculated using the expressions below:

$$PV\ Costs = PV \text{ terminal value} \quad .....(9)$$

$$\sum_{t=0}^{n}\frac{COF_t}{(1+r)^t}=\frac{\sum_{t=0}^{n}CIF_t(1+r)^{n-t}}{(1+MIRR)} \quad \text{.....(10)}$$

The term on the left side of equation 10 is the present value of the project's cash outflows discounted at the cost of capital. The term on the right is the future value of the cash inflows compounded at the cost of capital and discounted at the MIRR. This future value is the project's terminal value (TV). The above equation can be simplified to:

$$PV\ \text{costs}=\frac{TV}{(1+MIRR)^n} \quad \text{.....(11)}$$

The MIRR has an advantage over the IRR in that it does not assume that cash flows are reinvested at the IRR but rather invested at the cost of capital (opportunity cost of capital). This is a more realistic assumption. Furthermore, there can be no conflicting interpretations for a project with a non-normal structure of cash flows because with the MIRR only one discount rate is yielded. However, the MIRR also suffers from the same limitation that plagues the IRR and the PI. For a choice between mutually exclusive projects, the scale of the projects is still ignored. For a standalone project, the IRR and MIRR will always lead to the same accept/reject decisions as the NPV method, but there can be a conflict when deciding between mutually exclusive projects with differing scales. In the literature, the NPV is usually preferred over the other techniques.

2.1.2 Criticisms of the DCF and NPV

Analysis of Project XYZ above illustrates the simplicity of using the NPV method to determine a project's viability. However, it is perhaps due to the simplification of decision-making that the DCF techniques have been criticised. The criticism is primarily based on three broad categories, regarding their assumptions and in practice:

1) Managerial flexibility,
2) Discount rates, and

3) Irreversibility of investments

1) DCF techniques ignore managerial flexibility in projects:

- It is assumed that investment projects are passively managed. In other words, it is assumed that managers will not alter, say, the level of production in response to dramatic changes in market conditions such as significant unanticipated price movements or demand shifts (Keswani and Shackleton, 2006: 241).

- The traditional DCF-based techniques ignore the flexibility to time investment in a project. It is assumed that a project is a now or never investment (Etsy, 1999: 2). If investment in Project XYZ can be delayed for one period during which the uncertainty about the level of cash flows would be eliminated, a more optimal decision could then be made. If for example at time T=1 the price of widgets goes up and it becomes clear that Project XYZ will yield cash flows of R170m, the firm will decide to invest in the project. The firm will decide not to invest in the project if the price goes down as the project would yield cash flows of R65m and a negative NPV as a result. The NPV does not consider the benefit of delaying the investment decision, but rather focuses on the expected NPV of –R6.48m.

- Traditional DCF-based techniques lack the ability to capture the sequential interdependence of projects (Trigeorgis and Mason, 2001: 47). Based on these techniques, a company will be indifferent between project A that promises the possibility to enter a new profitable market, and project B that promises no future possibilities of growth, if the two are otherwise identical with similar NPVs, investment cost, life and risk. In reality, we would expect Project A to be chosen because it provides the possibility to grow and should thus be more valuable than project B.

2) Though the decision criteria of the traditional DCF-based techniques are relatively straightforward, determining the required inputs may prove to be more challenging.

According to Paddock, Siegel and Smith (2001: 775), it is quite difficult to estimate discounted cash flows at a very high level of certainty. Dixit and Pindyck (1995: 107) further point out that managers tend to use unrealistically high discount rates to compensate for their inability to accurately estimate these cash flows.

3) DCF techniques are based on the assumption that the investment can be wholly reversed should any unanticipated changes adversely affect the project's viability (Dixit and Pindyck, 1995: 106). While in practice it may be possible to salvage a portion of the investment, it is not common to recover the entire investment amount in most projects.

Table 2.4 below shows some of the characteristics of the capital budgeting techniques discussed above, as well as their advantages and limitations.

Table 2.4 – *Summary of capital budgeting techniques*

Factor	PP	PVPP	PI	IRR	MIRR	NPV
Accept (if)	PP < Critical period	PVPP < Critical period	PI > 1	IRR > r	MIRR > r	NPV > 0
Reject (if)	PP > Critical period	PVPP > Critical period	PI < 1	IRR < r	IRR < r	NPV < 0
Mutually exclusive projects	- choose shortest PP	- choose shortest PVPP	- choose highest PI	- choose highest IRR	- choose highest MIRR	- choose highest NPV
Benefits	- easy to calculate - gives time of recovery	- gives time of recovery - takes time value of money into account.	- good for ranking projects by return level.	- easy to communicate - good for ranking projects by return level.	- only a single rate of return - does not assume CFs reinvested at IRR.	- recognises the scale of a project. - takes time value into account.
Limitations	- ignores time value of money, - ignores CFs after payback period.	- ignores CFs after payback, - Ignores scale of project, - unreliable for mutually excl. projects.	- ignores scale of project.	- assumes CFs reinvested at IRR, - unreliable for non-normal CFs.	- ignores scale of project. - unreliable for mutually exclusive projects.	- assumes now or never decision - assumes investment is wholly reversible.

As already mentioned, the NPV method seems to be the most desirable of all the techniques discussed above as it is more theoretically sound. It has fewer limitations and leads to better decisions compared to its peers.

2.2 Real Options and Flexibility

2.2.1 The gap between Strategy and Finance

A firm's success is largely dependent on how successfully it deploys its limited investment resources. Both strategic and financial objectives have to be pursued when considering capital projects, to ensure this success. In today's global economy, opportunities can be available for a limited period of time only, which if taken, can affect the longevity of the firm. Strategists aim to pursue investment projects that not only promise immediately obvious profit but also offer potential growth opportunities and long-term strategic benefits. They recognise that some investments create potential strategic benefits that could lead to a larger market share and profit, even if this is not immediately apparent. In fact, some projects may be pursued solely because they provide the possibility to open future opportunities that would otherwise be unavailable to the firm.

Corporate finance based on traditional DCF techniques, suggests that a project show its promise of profit today otherwise it is rejected. The potential strategic benefits are not explicitly taken into account. There is therefore little room on the basis of these techniques, for projects that only offer a profit potential. R&D and other pilot projects, which tend to have negative NPVs, are advocated by strategists mainly due to their potential strategic and eventual financial success. Yet, they would be rejected from a DCF perspective if they offer a negative NPV. This highlights the gap between strategic planning and finance theory.

2.2.2 Closing the gap

Real option valuation (ROV) is suggested as a solution to resolve this conflict. This is because it applies corporate finance concepts in project evaluation, while accounting for the flexibility emphasised in strategic planning. The concept of real options is not new, but has been in existence for about 30 years. According to Barnett (2005: 63) Stewart Myers is credited with realising the analogy between financial options and capital

investments in 1977. Myers derived ROV from the concepts of the Black-Scholes model used for valuing financial options. A financial option is, though not always, written on an exchange-traded commodity such as oil, gold or financial assets including shares, interest rates etc. When using ROV, opportunities in investments are treated as real options. According to Damodaran (1997: 196) a real option is a non-obligatory right on a non-traded asset such as a capital project. Real options give managers the opportunity to act on an investment decision at a later date (Carlsson and Fuller, 2003: 298).

2.3 Valuing Real Options

2.3.1 ROV versus DCF

The criticism of DCF does not imply that these techniques do not have a place in the capital budgeting process. On the contrary, some ROV principles are based on DCF tools and techniques such as the NPV. According to Dias (2004: 94) ROV is seen as a complement to, rather than a substitute for DCF techniques. As illustrated in Section 2.3.2, real options on projects are valued based on the value of the underlying project, which in turn, is estimated using the NPV technique. Under the ROV technique, the immediate NPV of a project will determine whether it is worth considering.

Pindyck (2001: 200) points out that buying or owning a real option does not necessarily constitute an investment in a project. It only gives the firm an opportunity to act on the flexibility (e.g. invest, abandon, rescale) in the project at a later date when more information about the project becomes available. The role of ROV is then to quantify the current value of that opportunity. This value is seen as the premium of the option and is the maximum payment the company should be willing to make to obtain the option(s).

In return for the payment, managers are given the flexibility to manage and adjust the project in response to certain changes. These changes relate to parameters that may directly or indirectly affect an investment's NPV drastically. Some of a project's critical parameters tend to be fairly unpredictable and cannot be estimated with a reasonable

level of certainty. Uncertainty in these parameters may arise from a number of factors, including, market conditions, demand shifts or patterns, prices and economic conditions (Pike and Neale, 1999: 347). A change in any of these parameters, would affect the project's viability, and managers would act accordingly, either to limit losses or to increase the project's profit potential. The DCF assumption that projects are passively managed is then shown to be unrealistic.

2.3.2 Real Options vs. Financial Options

Financial Options

According to Briginshaw (2002: 188) a financial option gives the holder the right but not obligation to buy/sell the underlying financial asset at a predetermined price over a given period. There are two types of options, the call option and the put option. A call option gives the holder the right to buy the underlying at the exercise price while a put option gives the holder the right to sell the underlying at the exercise price. As already mentioned, financial options are normally written on financial assets such as shares, bonds and futures and even on commodities such as oil or gold.

From Financial to Real Options

Real options are seen as an extension of financial options as both value the right an investor has on an underlying, but differ in that the former relates to investment projects while the latter normally relates to financial assets and commodities. The analogy between real and financial options makes it possible to value real options using financial options pricing models. However, Gitelman (2002: 60) warns against the direct application of financial option methodologies to value real options despite many obvious similarities between the two. Such a practice could result in misleading results if not properly done as there are some fundamental differences between financial and real options that cannot be ignored.

Comparing and contrasting of financial and real options may make it easier for users of real options to identify when and how to apply ROV. The two can be compared in terms of the following fundamental characteristics:

- Types,
- Trading,
- Option position,
- Value drivers, and
- The Decision rule.

Table 2.5 below shows a summary of the comparisons between financial and real options on the basis of the five characteristics mentioned above.

Table 2.5 – *Comparison of Financial and Real Options*

Factor	**Financial Options**	**Real Options**
Types	Can be American or European style, can be Put or Call option	Can be American or European style, can be Put or Call option
Trading	The options may be either OTC or exchanged-traded.	Not standardized or formal – OTC instruments.
Option Position	Option is purchased from option seller.	Option can be created or can be inherent to the project - it is not a tradable instrument.
Value Drivers	S, X, r_f, T, σ, and δ.	S, X, r_f, T, σ, and δ. Refer to Figure 2.1 to see how these are mapped for real options.
Decision Rule	Exercise call when S > X and a put when S < X.	Exercise call when S > X and a put when S < X.

Financial options can be either American or European style. Copeland and Antikarov (2001: 12) define an American style option as one that can be exercised at any time during the option's life, while a European style option can be exercised only at maturity.

Most real options tend to be American style as they are normally exercisable at any time during the option's life. According to Apostolou and Crumbley (2000: 66) a call option gives the holder the right to buy an underlying asset while a put option gives the holder the right to sell the underlying asset. Copeland and Antikarov (2001: 12) suggest that American call options are synonymous with the option to delay investing in a project or expansion projects. The option to abandon and the option to reduce the scale of a project are synonymous with American put options. (Please refer to Section 2.4 for illustrations of these options).

Since financial options are normally bought/sold on tradable assets, they tend to be (but not always) fairly standard and are often exchange-traded. Real options on the other hand, are non-standard, over-the-counter (OTC) instruments. It is easy to observe the value of the underlying for a financial option if the underlying is traded on an exchange, e.g. share price, futures price. It is not as easy to observe the underlying for a real option.

Because different holders may have different capabilities (e.g. exclusive access to a certain market, other resources such as land) to exploit opportunities in investments, real options also tend to be more holder-specific. In other words, the value of option in a project can differ in the hands of different owners, depending how each can exploit this flexibility. Refer to the Merck case in section 3.2.2 for an example of this in practice. The value of a financial option on the other hand, is generally the same in the hands of any owner. According to Bailey, Couët, Bhandari, Faiz, Srinivasan and Weeds (2003: 10), financial options typically involve an arrangement between the investor and an outsider. As a result, neither of them should interfere with the value of the option. Before and after a financial option is exercised, the holder cannot legally influence the price of the underlying. On the other hand, the holder of a real option can influence the value of the underlying in order for the option to be in-the-money. For example, while the holder of the real option may find it difficult to influence the price of a widget, he/she may affect the value of the underlying by say, developing new technologies for the project or generating greater demand through more aggressive marketing.

Financial options are usually sold by an option seller. Although a real option can be bought or sold, it is generally not traded as a plain vanilla option. In fact, some real options may be inherent to a project, while some are created intentionally or negotiated into a project by managers. Merck's venture (discussed in section 3.2.2) to acquire Gamma is a typical negotiated option, since the opportunity was not inherent to project but required Merck to negotiate it into the contract between the two parties. According to Boute, Demeulemeester and Herroelen (2004: 1716) and Berk and Kaše (2005: 4), many real options are inherent to the particular project. Examples of real options in business may include:

- Owning a plot of land that can be used for mineral resource extraction (oil, coal, gold etc.),
- The opportunity to abandon a project during construction if the next required investment offers a superior return than when invested in an alternative project,
- Ownership of a patent that gives an owner the opportunity to invest in an industry relevant to the patent,
- A R&D investment of a pharmaceutical company to develop a new drug,
- The option to switch production between different plants based in different countries depending on the price of inputs in each country (Kogut and Kulatilaka, 2001: 747), and
- The cost of owning a technology that could be further developed and used to expand or enter a new market (check Merck example in Section 3.2 of Chapter 3).

The options to contract, defer, shut down or abandon an investment are typically seen as natural. On the other hand, the options to grow or to switch between alternative inputs or outputs are usually planned into an investment (Wang, 2005: 102). A planned option normally requires payment of a fee and is then not natural to the project (Real Options Group, n.d.). The first two examples above can occur naturally while the last four can be created through planning.

A company may invest initially in a small project that has a negative NPV in order to obtain the opportunity to invest in a larger and potentially high profit project. The challenge then becomes, how to value the real option itself. Like financial options, real options can be valued using either the Binomial or the Black-Scholes model (The models are discussed in greater detail in Section 2.3.4). There are primarily five inputs used to estimate the value of a financial option, with a sixth input if the option is on a dividend-paying stock. These inputs are denoted by S_0, X, T, r, σ, and δ. The same inputs are used to determine the value of a real option. However, it may be more difficult to obtain some of these parameters for the analysis of real options especially because the underlying project is not traded on an exchange. Damodaran (1999: 778) and Boute, Demeulemeester and Herroelen (2004: 1718) provide some guidelines on how to determine these parameters. Figure 2.1 below illustrates how financial option parameters are mapped on real options.

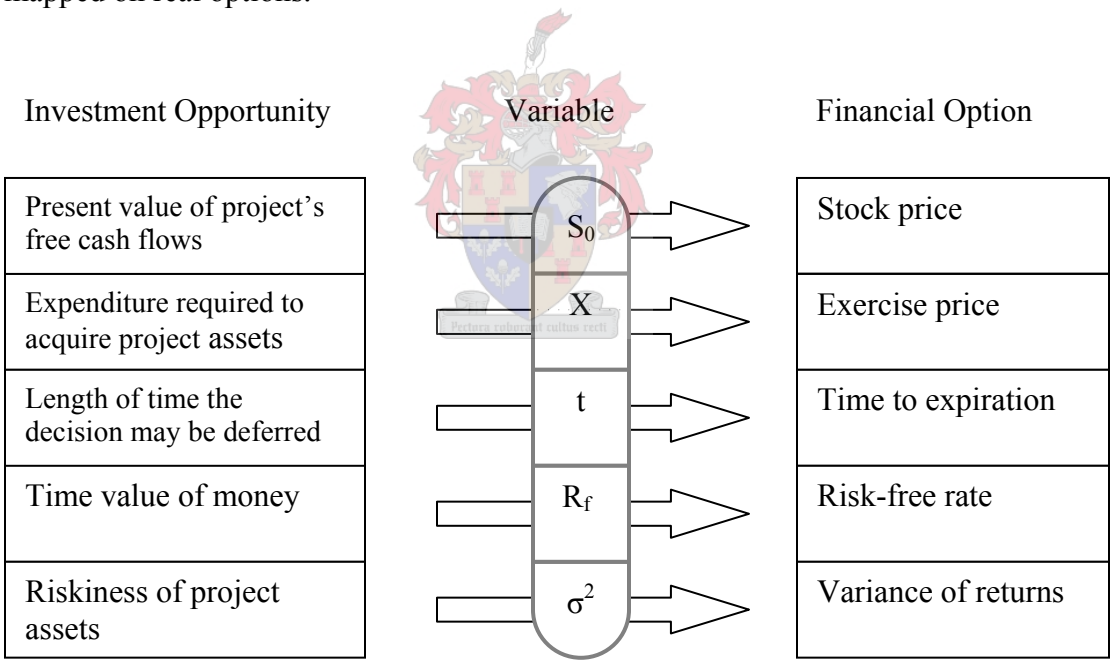


Figure 2.1 *Real Options: The Link between Investments and Black-Scholes Inputs*

Source: Luehrman (1998)

Value of underlying (S_0)

S_0 represents the value of the underlying. For a financial option on a share, S_0 is the market price of the share. The share is normally that of a listed company. Since the underlying project is not traded on an exchange, Gitelman (2002: 61) suggests using other proxies in commodity markets, physical and financial investments, similar investments or even proxy company stocks as the underlying for the real options. The aim is to use a traded asset that is expected to closely mirror the risk profile and movement of the value of the underlying project. However, Copeland and Antikarov (2001: 6) argue that a proxy that mirrors the movements in the value of the underlying may not always be available. They therefore recommend using the project's net present value without flexibility as the underlying security. In other words, the project's now or never NPV should be used as the market price (S_0) of the underlying. Copeland and Antikarov maintain that this is because the present value of the project's cash flows without flexibility is probably the most unbiased estimate of the project's market value. The challenge however, lies in estimating these cash flows.

The exercise price (X)

The exercise price of the option is denoted by X. In the case of a call option, the present value of the initial investment made by the holder of the option is seen as the option's exercise price (Benaroch, 2002: 81). This makes intuitive sense as the project's market value has to be above the investment amount in order for the option to be exercisable (in-the-money). For a put option in a real option setting, X represents the exercise price that the holder would receive when exercising the option to sell (abandon, contract the project). This is the salvage value or the present value of the cost saving that the investor would accrue by abandoning a project or contracting the scale of the project.

Time to Maturity (T)

Benaroch (2002: 81) considers T to be the maximum time for which the investment decision can be deferred, i.e. it is the period over which the option is available to the holder to exercise. Financial options tend to have a relatively short time to maturity while real options may be open to holders for a much longer period. Some may even be available in perpetuity. Such options are referred to as perpetual options (Keswani and Shackleton, 2006: 246). An option on the best use of a piece of land may be one such option, especially if the land is available for use in a number of different investment opportunities. Some investments can be postponed for as long future opportunities to use the resources appear to be superior to currently available opportunities.

Risk-free rate (r_f)

The risk-free rate (r_f) used for both financial and real options is usually the same. The Treasury Bill rate on a bond whose term to maturity matches that of the option, is normally used as the risk free rate (Hull, 1995: 268). The long-term rate used is based on the assumption that short-term interest rates remain constant. According to PWC (2003: 13) a study revealed that South African firms tend to use the rate on the R153 bond as a proxy for the long term risk free rate.

Volatility (σ)

As with financial options, σ represents the volatility of the underlying asset. For real options, this is the volatility of a project's cash flows. Estimating this parameter is a crucial but complex part of the ROV process, as with pricing financial options. Amram and Kulatilaka in Bowman and Moskowitz (2001: 774) observe that while it is becoming easier to find risk profiles of a security that matches some projects, there are still no such traded instruments for most other projects. This makes it more difficult to estimate the project's volatility.

According to Cobb and Charnes (2004: 121) the assumption of volatility is the most difficult to hold when calculating real options. This is firstly because there is usually no available history of the project's value. Secondly, there tends to be few if any projects whose returns are exactly correlated with the project's cash flows. Cobb and Charnes (2004: 121) suggest using simulation methods such the Monte Carlo Simulation to estimate a project's volatility. The derivation and application of these methods are beyond the scope of this paper, and are therefore not discussed further in the current study.

Dividend rate/yield (δ)

δ represents the dividend yield on a dividend paying stock. Blake (2000: 322) points out that this parameter is not explicitly factored into the Black-Scholes model because the model was formulated to estimate option values on non-dividend paying stock. A dividend on the underlying represents a loss to the option holder since the dividend is forfeited by holding the option and not the underlying asset. To incorporate this in the option value, it is first assumed that the dividend is known and is constant over the life of the option. Then the underlying value is reduced by the present value of the dividend payable over this period (Hull, 1995: 274). The dividend should only be included in the calculation if it occurs during the option's life.

In the case of real options, the dividend yield can for example, be represented by the opportunity cost of delaying investment (Smit and Trigeorgis, 2004: 11). This may be in the form of lost and irrecoverable cash flows from delaying or the threat of competitors investing in similar or competing projects that erode the delayed project's cash flows. The time value of money is also higher the more in the future the project is, resulting in cash flows being heavily discounted. The dividend value should be factored into the option value by offsetting it against the value of the underlying when estimating the value of the option.

Another comparison of financial and real options involves the decision rule for exercising the option. First of all, a financial call option is exercised by purchasing the underlying asset. Similarly, a real call option is exercised by investing in the underlying project. In the case of a put option, the firm has the right to disinvest (wholly or partially) from the project. A real call option is exercised when the value of the underlying project is higher than the exercise price (S > X). Copeland and Antikarov (2001: 11) point out that the difference between these two (S and X) is the profit (payoff) on the option. This also happens to be the project's NPV. The higher the value of the underlying relative to the exercise, the higher the potential NPV and the more in-the-money the project becomes. A real put option on the other hand, is exercised when the value of the underlying is lower than the exercise price (Carlsson and Fuller, 2003: 299) where X > S. The payoff of the option increases as the value of the underlying decreases. In other words, the option gets deeper in-the-money with lower values of the underlying, below the exercise price.

2.3.3 Steps in Valuing Real Options

Several steps are followed when valuing a real option. According to Janney and Dess (2004: 60) valuing real options entails at least two parts or decisions. The first decision has a wait-and-see feature as it involves creating the opportunity to make a subsequent, contingent decision. The second decision is then built upon the first decision, and is based on management's discretion given all relevant variables. The first decision is more about creating an option while the second is about exercising the option. However, we must first value the option itself. According to Wang (2005: 103) the entire valuation process can be divided into six steps. The six steps are illustrated in Figure 2.2 below.

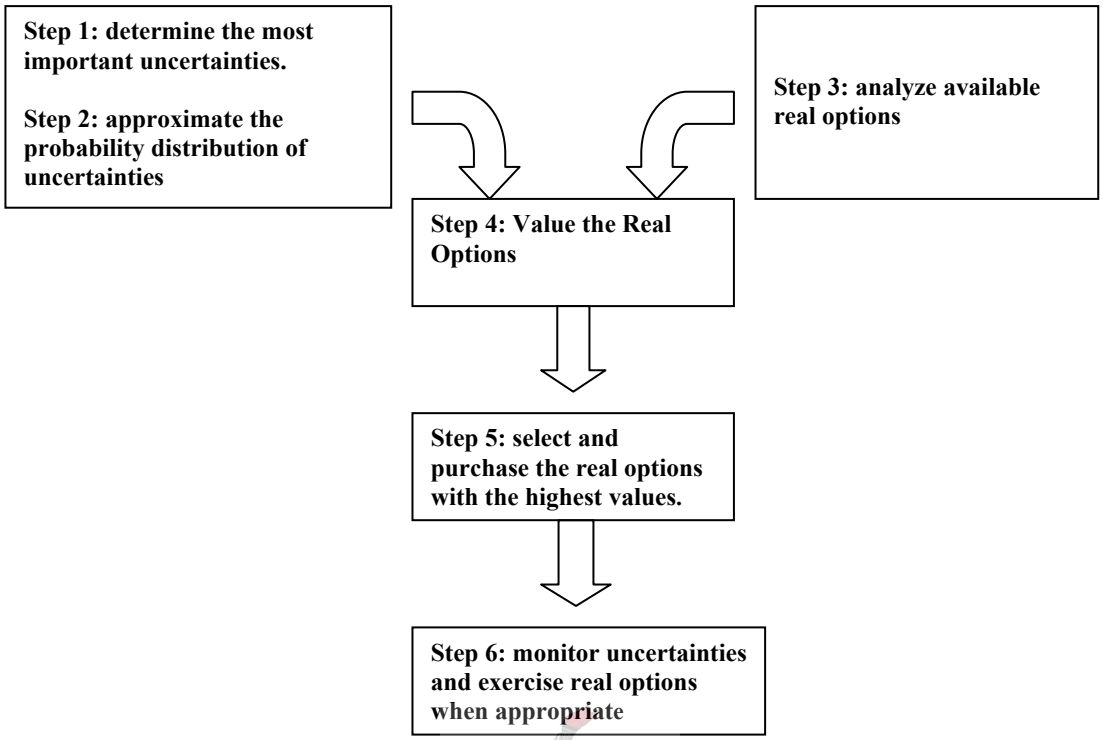


Figure 2.2 *Frameworks for Real Option Valuation Process*

Source: Wang: 2005

Step 1 – ***Identify the most important drivers and uncertainties of the project's value***. It is important to identify the uncertainties that may be critical to the project's viability. As mentioned above, these may include market conditions, the price level, the economic cycle as well as technical and market risks.

Step 2 – ***Approximation of the probability distribution of uncertainties***. Wang (2005: 104) points out that a lognormal distribution is normally assumed for market risk but that a closer view of the project by project probability should still be taken.

Step 3 – *Identification and analysis of the most relevant options*. All possible options that are relevant to the project and are available to the firm to exploit are then studied. Some options may be relevant but unavailable to the firm due to any number of factors, including regulatory restrictions, commercial commitments and a lack of option sellers. It is therefore important firstly to determine that an option is available to the firm.

Step 4 – ***Valuation of real options***. The appropriate model to be used to value the option is then selected. Either of the Black-Scholes or Binomial models can be used. The choice of the model depends on the characteristics of the option being valued.

Step 5 – *Comparison of real options and selection*. All the options that have been identified and valued, are compared, and those with the highest payoffs are then selected.

Step 6 – *Monitoring of uncertainties and exercising the option*. Uncertainties of the chosen real options are closely monitored and are then exercised when appropriate.

2.3.4 ROV Methodologies

Consider again Project XYZ mentioned in Section 2.1.1. If we expect that the parameters and assumptions of the project to hold and that they are true reflections of what will happen in the future, there will either be a negative NPV of R54.3m or a positive NPV of R41.3m. It is therefore certain that the project will definitely not yield the expected NPV of -R6.48m, as it will be either the NPV of Scenario 1 or that of Scenario 2. The problem is that at time T_0, it is not known which direction the market will go. Investing in the project now could lead to a loss of R54.3m but not investing could mean forfeiting a profit of R41.3m. Based on the NPV, the project is rejected because it leads to a negative NPV of –R6.48m. But, what if it was not necessary to make the investment decision immediately? What if the firm could delay deciding on whether to invest in the project until it was known with a reasonable amount of certainty, which of scenario 1 or 2 would unfold? How valuable would this option be to the firm?

The value of the real option on a project is added to the relevant project's NPV. The option adds value to the project because it gives management the ability to reduce risk and/or enhance the project's returns. The project's NPV is increased by the option value to yield an Expanded Net Present Value (ENPV) (Lewis, Enke and Spurlock, 2004: 38), which is expressed as:

$$ENPV = Passive\ NPV + Option\ Value \quad \text{.....(12)}$$

From the equation above, it is apparent that the ENPV will cannot be less than the passive NPV because the value of managing flexibility is always positive negative (Copeland and Antikarov, 2001: 13). There are fears that ROV might perhaps justify projects that should be rejected because ENPV will always be higher than the passive NPV. However, Copeland and Antikarov (2001: 13) point out that the NPV technique by its nature undervalues projects because it ignores the value of managerial flexibility. A positive value of flexibility does not necessarily justify pursuing that project.

The rule is to create or purchase the opportunity to delay the investment decision if the term on the left in equation 12 above, is greater than the term on the right. The firm then needs to determine the value of flexibility and add it to the ENPV. If this value is positive then the manager can consider whether the option is worth buying. As with financial options, the flexibility in an underlying asset is worth buying if the value (the real option value) of owning the option is greater than the cost of obtaining it. To determine the real option value, Lewis, Enke and Spurlock (2004: 39) suggest two approaches, both of which are used for pricing financial options. They are the Binomial Lattices approach and the Black-Scholes model.

2.3.4.1 Binomial Lattices Approach

From the current state of the world with a given project value, it is assumed that in the next period, the value of the underlying project will either go up or down. These up or down movements are used to determine up or down factors that are assumed to be consistent throughout the project's life. In subsequent periods, the upward and downward movements of the value of the project depend on these factors. These are illustrated in a binomial tree as shown below, with each branch representing a move up or down from the previous period project value. The value of the option is determined from these branches given the relevant risk neutral probabilities (Chance, 2003: 197). The tree is illustrated in Figure 2.3 below.

At time T_0, the value of the project is S_0 but in the next period T_1, it can go either up to S_0u or down to S_0d at a given probability. At time T_2, the value of the project can go down further to S_0d^2 and even further down to S_0d^3 in the next period (T_3). But it can also go up for two consecutive periods from S_0 to S_0u^2 in T_2 and higher still, to S_0u^3 in T_3. The value may go up from S_0 in period T_0 to S_0u in period T_1 but then go down to S_0ud in the next period, T_2, and go up again to S_0u^2d in period T_3. It is important to note that this value would be similar to that of the project at T_3 if the value goes down at period T_1 and then goes up for two consecutive periods to S_0du^2. In other words, the path leading to S_0u^2d would yield the same project value as the one leading to S_0du^2. In fact a number of nodes along the lattice could be collapsed into one node as they would lead to similar values.

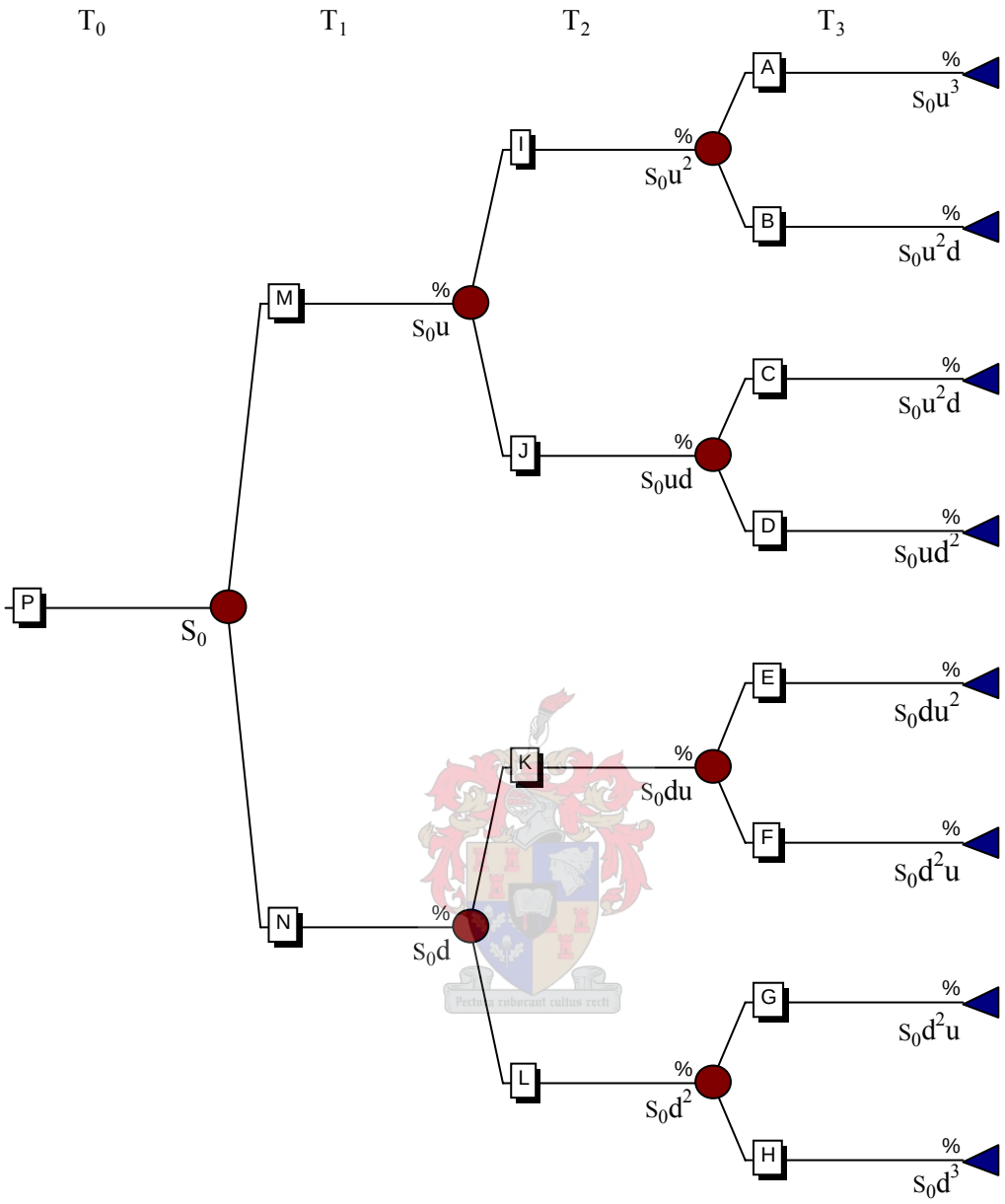


Figure 2.3 *Valuing Real Options Using Binomial Trees*

The letters in boxes, A, B, C up to P, represent the value of the option to delay at each node and period. The value of the option to delay at T_0 is represented by the letter P, which is the one we are most interested in as it tells us the value now, of postponing investment in the project. Some of the option values on some nodes are similar to each other as the project values on which they are based are also similar. For example, the

option values B, C and E would be similar because they are based on the same underlying value ($S_0u^2d = S_0du^2$). The same would apply to D, F and G as well as to J and K.

At each stage of the lattice, there is an opportunity to make an investment decision. The firm will decide either to exercise the option by investing in the underlying project or delay the investment decision for a further period. However, as reflected by the three stage lattice, the investment decision cannot be delayed further at time T_3 because the opportunity elapses (expires). It now becomes a now or never decision. If the option were exercised at T_2 after two consecutive upward movements, its value would be at I while it would be at L should the market experience two consecutive downward movements.

To estimate the final option value, P, all option values along the lattice first need to be determined. The first step is to estimate the upward and downward factors that determine the extent of movements up or down along the lattice over the option's life.

The following expression can be used to determine the factor for the upward movement (Lewis, Enke and Spurlock, 2004: 39):

$$u = e^{\sigma\sqrt{\delta t}} \quad \text{.....(13)}$$

Where σ = volatility of cash flows, and

δt = length of each time step .

The downward movement (d) is defined as:

$$d = e^{-\sigma\sqrt{\delta t}} = \frac{1}{u} \quad \text{.....(14)}$$

The risk neutral probability is defined as:

$$P = \frac{e^{r\delta t} - d}{u - d} \quad \text{.....(15)}$$

Where r = the risk free interest rate.

If Project XYZ is analyzed over three periods in a year, we will have a binomial lattice with three time steps as shown in Figure 2.4. However, we must first make some assumptions about the path of cash flows over time right up to the third period. To determine the cash flows along the lattice, we can use either the market-replicating portfolio or the risk neutral probability approach. Both approaches should lead to similar results. However, we shall use the risk neutral probability approach as it is generally used for real options calculations while the market-replicating portfolio is used for financial options.

Additional assumptions for Project XYZ:

T = 1 year (with three periods in year),
S_0 = R100m
X = R115m
N = 3 times steps,
δt = 0.33 year (T/N)
σ = 30% (volatility)
r_f = 8%

$$u = e^{\sigma\sqrt{\delta t}} = e^{(0.3)\sqrt{0.33}} = 1.19$$

$$d = \frac{1}{u} = 0.840$$

$$P = \frac{e^{r\delta t} - d}{u - d} = \frac{e^{(0.08)(0.33)} - 0.840}{1.19 - 0.840}$$

$$= 0.5336$$

The S_0u, S_0d, S_0d, S_0u2, S_0d^2 and S_0d^3 parameters are determined as follows:

$$S_0u = 100(1.19) = 119$$

$$S_0 d = 100(0.84) = 84$$

$$S_0 u^2 = 100(1.19)^2 = 142$$

$$S_0 d^2 = 100(0.84)^2 = 71$$

Please refer to **Appendix B** for a full illustration of all calculations of project values at each point on the lattice.

Project values are shown at each node or time step in Figure 2.4 below. The values in boxes represent the option value at the given node. At T_0, the project's expected value will be R100m. If the market goes up in two consecutive periods and the option is exercised at T_2, then the value of the project will be R142m. In the same way, the value will be R71m at T_2 if the market declines in two consecutive periods. At T_3, we will be fairly certain whether the project's value will be R167m, R119m, R84m, or R60m. At this stage, delay is no longer possible and the investment decision should then be made.

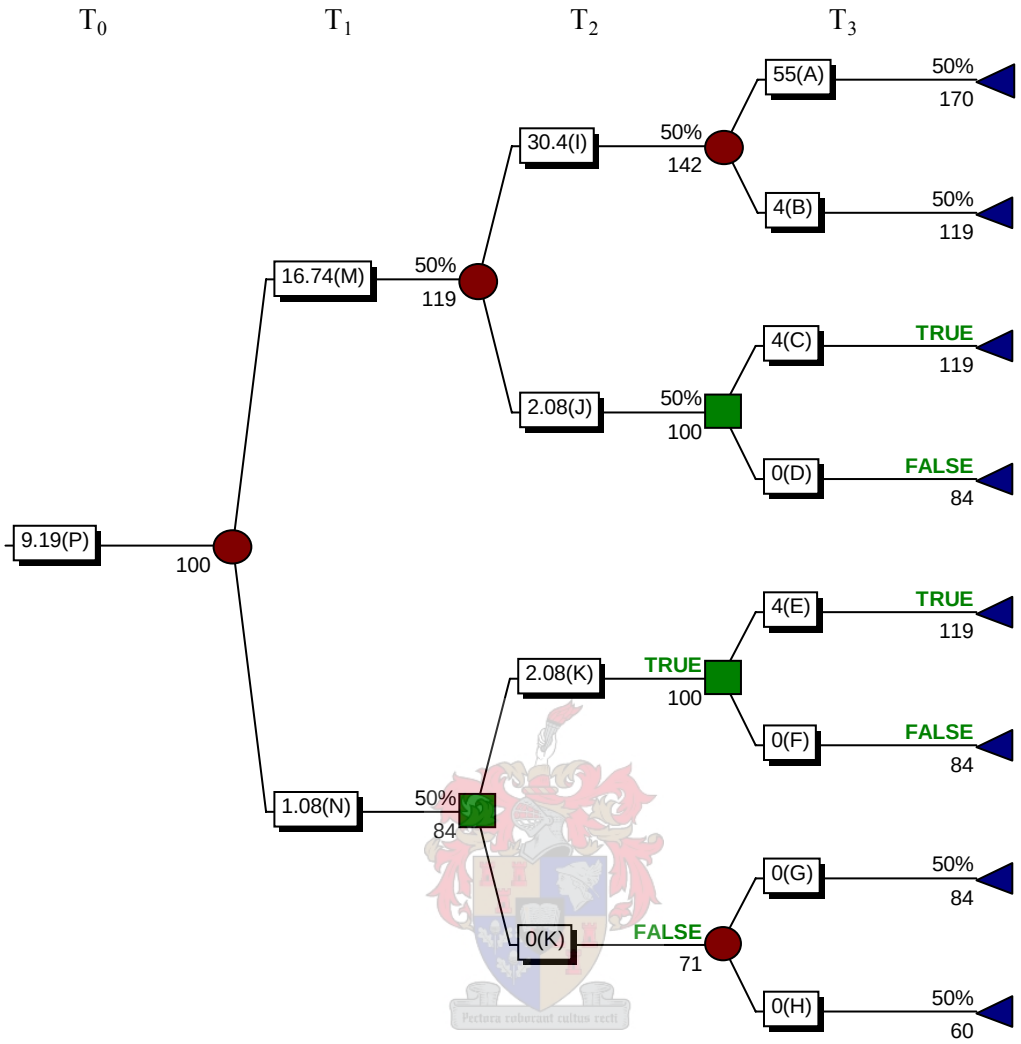


Figure 2.4 *Valuing the Real Option for Project XYZ*

The value of the option to delay (at P) can be determined using backward induction. This method is used regularly to estimate financial option values from a binomial tree. We first to estimate the value of the underlying at each node on the last time step T_3. We can work backwards to determine the value of the option at each node. It is important to note that at the last time step, the option no longer has a time value, only the intrinsic value remains. We then proceed to work backwards to determine option values on the other time steps, T_2, T_1, T_0. Blake (2000: 306) suggests the following formula to calculate the option's intrinsic value:

$$Option\,value\,at\,T = \max(V - X, 0) \quad \text{.....(16)}$$

Where T = time step, such that T = 0, 1, 2 or 3,

V = the value of the underlying, and

X = the exercise price (the required initial investment)

$$Option\,value\,at\,A = \max(170 - 115, 0) = 55$$

$$Option\,value\,at\,B = \max(119 - 115, 0) = 4$$

$$Option\,value\,at\,G = \max(84 - 115, 0) = 0$$

$$Option\,value\,at\,H = \max(60 - 115, 0) = 0$$

Working back we calculate the value of the options at time T_2:

$$Option\,value\,at\,I = [P(A) + (1-P)(B)]e^{r\delta t}$$

$$= [(0.5336)(55) + (1-0.5336)(4)]e^{-(0.08)(0.33)}$$

$$= R30.4003m$$

$$Option\,value\,at\,J\,and\,K = [(0.5336)(4) + (1-0.5336)(0)]e^{-(0.08)(0.33)}$$

$$= R2.0788m$$

$$Option\,value\,at\,P = [(0.5336)(16.7432) + (1-0.5336)(1.0803)]e^{-(0.08)(0.33)}$$

$$= R9.1921m$$

The same procedure is repeated to determine other option values at C, D, E, F, L, M and N. The option value at P is the one that gives the current value of delaying investment. For a full illustration of all the calculations, please refer to **Appendix B**. The value of keeping the option open is then given as:

$$ENPV = -6.48 + 9.19 = R2.71m$$

It would seem beneficial for the firm to have the option to delay since the opportunity yields an ENPV of R2.71m, which is higher than the –R6.48 NPV of the project without flexibility. As a result, it would be more optimal to delay the investment decision as it gives the firm the opportunity to invest in the project when market conditions are favourable. The first decision (discussed in section 2.3.3 by Janney and Dess) of whether to obtain the option on the project, depends the cost the firm would have to incur to obtain or create the option can be obtained. If the cost of obtaining the option is greater than R9.19m, then the option is not worth buying as the cost of flexibility is higher than its benefit.

If the option is in-the-money, the next important step is then to determine the optimal time to exercise it before it expires. In all states of the world where the market initially goes up in the first period, the opportunity to delay is always valuable, except at D. The rule is to exercise the option when the value from exercising is greater than the value from delaying the project even further, i.e. exercise the option when ENPV $\leq$ NPV_T + Intrinsic Option value. If at time T_2, the market moves up in two consecutive periods and the investment decision is delayed, the option is worth R30.40m to the firm. However, if the option is exercised at that time, only the option's intrinsic value is realised. The intrinsic value at I is:

$$\begin{aligned} NPV_E &= S_0u^2 - X \\ &= 142 - 115 \\ &= R27m \end{aligned}$$

The value realised from exercising the option (the intrinsic value) at T_2 is lower than that realised from delaying for another period and investing only in T_3 i.e. R27m < R30m. The value of keeping the option alive, which is also seen as the opportunity cost of exercising the option, is R3m (R30m – R27m). The same applies when making the decision at T_1 as the option's intrinsic value, R4m (R119m – R115m), is lower than the R17m value of keeping the option alive. If we assume that the value of the project is not eroded by postponing the investment decision (there is no dividend on the underlying)

during the life of the option, it will be most optimal to keep the option alive until the final period at time T_3. The greatest value is realised by postponing up to this period.

This example illustrates that it is usually optimal to delay investment for as long as possible when a project's viability is uncertain. This is corroborated by Smit and Ankum (1993: 245), who prove that a project with a positive NPV can be delayed for as long as the market dynamics of demand suggest that cash flows gained will be higher than if an investment is exercised immediately. But as discussed in Section 2.5 below, delaying is not always beneficial.

2.3.4.2 Black-Scholes Model

The Black-Scholes model can be used as an alternative to the Binomial Lattice approach to estimate the value of the option to delay Project XYZ. This model was developed for pricing financial options by Black and Scholes in 1973. The functional form of the model is given as (Eaton and Prucyk, 2005: 68):

$$V = S_0 N(d_1) - Xe^{-rT} N(d_2) \quad \text{.....(17)}$$

Where V = option value,

$N(d_x)$ = the cumulative standard normal distribution of the variable d_x,

r = risk free rate,

S_0 = value of the underlying,

X = exercise price,

T = term to maturity of the option,

e = the base of natural logarithms, constant = 2.1728……,

$$d_1 = \frac{(\ln \frac{S_0}{X}) + (r + \frac{\sigma^2}{2})T}{\sigma\sqrt{T}} \quad \text{.....(18)}$$

$$d_2 = d_1 - \sigma\sqrt{T} \quad \text{.....(19)}$$

σ = standard deviation of the underlying

The value the option to delay investment for Project XYZ would then be:

$$d_1 = \frac{(\ln\frac{100}{115}) + (0.08 + \frac{0.3^2}{2})1}{0.3\sqrt{1}} = -0.04921$$

Therefore $N(d_1) = 0.4801$

$$d_2 = -0.04921 - 0.3\sqrt{1} = -0.34921$$

Therefore $N(d_2) = 0.3632$

$$V = R100m(0.4801) - 115e^{-(0.08)(1)}(0.3632)$$
$$= R9.4533m$$

The Black-Scholes model and the Binomial Lattice approach should lead to converging results (R9.4533m vs. R9.1921m) as the number of binomial steps increases. Since the calculation is done manually, it is at best, an estimate of the option value. However, the manually calculated option value converges to the one determined using an option calculator. The OTrader Software options calculator yields an option value of R9.4526m. This value is even closer to the result obtained from the Black-Scholes model.

2.4 Types of Real Options

Different types of flexibility in investment projects can be classified into any one of several types of real options, with classification depending on the features of the flexibility. Below are six of the main types of real options discussed by Broyles (2003: 135):

- The option to delay or defer investment in a project,
- The option to abandon,
- The option to expand a project,
- The option to contract a project,
- The option to phase (stage) a project, and
- The option to grow (growth options)

2.4.1 The Option to delay

The option to delay gives the holder (a firm) the opportunity to defer making the decision of whether or not to commit investment resources in a capital project. The option becomes valuable if by delaying, the project's risk can be reduced and/or its return improved. The option gives management the option to invest in a project if and when it is most optimal. The option may be held over a relatively short period of time or it may be substantially long-lived. The option to enter a new market may prove to have a short term to maturity. On the other hand, the option to extract minerals on a piece of land that an investor owns, may be held for a relatively longer time. In general, the characteristics of the option to defer investment are analogous to a call option, as both options give the holder a non-obligatory right to purchase the underlying at a specified price. As with the call option, the option to defer investment becomes exercisable when the project's value is above the investment cost (Bowe and Lee, 2004: 91). The analysis of Project XYZ discussed above illustrates the recognition, valuation and exploitation of a real option to defer investment.

2.4.2 The Option to Abandon

With an abandonment option, the holder has the opportunity to get rid of a risky asset at a predetermined price. According to Copeland and Antikarov (2001: 126) the option to abandon is important in R&D projects, exploration of natural resources and in merger and acquisition deals. In a merger and acquisition agreement, the option to abandon would allow the acquiring firm to back out of the acquisition at a floor price (exercise price). In financial option terms, the option to abandon is equivalent to a put option, with the

investment (e.g. value of the acquired firm) as the underlying. The option is in-the-money when the value of the underlying falls below the exercise price, implying that there is more value in disinvesting from the project than staying invested in it.

2.4.3 The Option to expand

The option to expand gives the holder the opportunity to increase a project's scale at a later date, should market conditions improve beyond expectations. Bowe and Lee (2004: 91) point out that this option represents the initial base-case project plus a call option on the underlying project. This is similar to owning a share and having a call option on that share. According to Trigeorgis (1993: 204), this option is very common in natural resource industries, in construction, fashion apparel, commercial goods as well as in real estate. In these industries, producers can generate substantial profits from scaling up production when market conditions improve. Creating the option would entail investing in capacity that would allow the firm to respond to changes in production needs.

Consider an oilfield available for exploration. The investing firm may go ahead with the project if it is economically viable to do so. However, if there is a possibility of a significant rise in the price of oil in the near future, the firm may decide to obtain or create an expansion option that would enable it to expand should the oil price rise substantially enough to justify expansion. Creating such an option could entail putting in place exploration infrastructure that enables the firm to scale-up capacity and accelerate production levels. Without this option, the firm may find it difficult merely to increase production in response to favourable market conditions without a significant investment. With the option to expand, a producer has the opportunity to increase production in the future (at a relatively lower cost) but is not obligated to do so.

The initial expansion option, V can be determined as follows (Trigeorgis, 1993: 215):

$$V = S + \max(0,\ yS - Iv) = \max(S, (1 + y)S - Iv) \quad \text{.....(20)}$$

Where S = the project value of the base case

Iv = additional investment

y = rate of acceleration of the project as a percentage S.

Let us suppose the firm had already invested in Project XYZ and that it were possible to expand production levels by around 50% should market conditions (e.g. price) become favourable. Let us also assume that an additional cost of R55m would be required for this expansion. The option to expand can be determined as follows:

$$V^{+} = \max(S^{+}, 1.5S^{+} - Iv)$$
$$= \max(170, 255 - 55) = R200m$$

$$V^{-} = \max(S^{-}, 1.5S^{-} - Iv)$$
$$= \max(60, 90 - 55) = R60$$

To justify expansion, the additional cash flows as a result of expansion should exceed the additional cost of expanding. Put differently, the value of the scaled up project, $1.5S^{+}$ minus the additional cost has to be higher than the base case value S ([1.5S – Iv] > S). If the market goes up, project cash flows can also go up to R170m. If the option to expand is then exercised, the project will yield a net cash flow of R200m. This is higher than the base case of R170m, representing an increase in the NPV of R30m (200 – 170). The option should then be exercised if market conditions improve. If however, the market goes down, the project should not be expanded as the additional cash flows will be eroded by an even higher additional cost required for expanding the project. In that case, the project base case would yield a superior cash flow to that of the expanded project; 60 vs. 35 (90-55). The option should therefore not be exercised.

The value today of the investment opportunity (including the value of the option to expand) is then:

$$V_0 = \frac{pV^{+} + (1 - p)V^{-}}{(1 + r)} - I_0$$

$$= \frac{(0.534)(200) + (1 - 0.534)(60)}{1.08} - \frac{115}{1.08}$$

$$= R18.30m$$

The value of the option to expand becomes:

$$\text{Option to expand} = \text{Expanded NPV} - \text{Passive NPV}$$

$$\text{Option to expand} = 18.30 - (-6.48) = R24.78m$$

The firm should therefore spend no more than R24.78m to obtain or create the option to expand production because the option to expand is worth R24.78m to the firm.

2.4.4 The Option to contract

The option to contract a project can be seen as the opposite of the option to expand, as it gives the holder the option to scale down a project or switch inputs should market conditions turn out worse than expected. Exercising the option would involve shrinking the scale of the underlying project to operate below the project's capacity, thereby saving at least a portion of the project's operating costs. An opportunity allowing the firm to choose between differing capacities such as different production plant sizes, is typical of an option to contract. Trigeorgis (1993: 211) suggests that a plant requiring a low construction outlay and high maintenance costs may be preferred if a firm has to decide on technologies and production plants with different cost mixes. This plant would give the firm the opportunity to reduce its maintenance costs by reducing its use of the capacity of the plant, effectively contracting the scale of the project.

Alternatively, the investing firm can sublet its equipment or plant to another firm to offset the unused capacity of its project. The option to contract a project amounts to the initial base-case of the project while owning a put option on that project. This option is equivalent to a protective put in financial option terms. According to Brosch (2001: 3) the

options to expand, to contract and to abandon can be classified as operating options because they deal with assets in place. Operating options allow the investor to alter some configuration features of an investment such as the timing, the scale and the scope of the investment with relative ease, in time and monetary terms. Both the option to expand and the option to contract require investing in capacity that enables the firm to follow the intended action (expand or contract).

2.4.5 The Option to phase a project

It may also be possible for a firm to at first, commit partially to a project in such a way that it has the right to abandon the project during construction should it be deemed viable to do so. The option is of most benefit in the construction phase of a project (Trigeorgis, 1993: 216). It gives the investing firm the opportunity to pay only a portion of the entire construction cost of a project and withhold the rest until a later period. The balance of the cost can be incurred in subsequent phases of the project. The firm effectively has the option to abandon plans to make a subsequent investment during the construction phase of the project. If we assume it possible to phase Project XYZ, the project could be implemented in stages. Let us suppose that only R50m of the entire investment outlay is necessary for initiating the construction of the project's infrastructure, with the balance of 65 (R115 – 50), payable in a subsequent period. The future value of the balance would be 70.2(65 x 1.08) after one period, assuming a risk free rate of 8%. The current value of the investment opportunity is given by:

$$V^{+} = \max(0, S^{+} - I)$$

$$= \max(0, 170 - 70.2) = 99.8$$

$$V^{-} = \max(0, S^{-} - I)$$

$$= \max(0, 60 - 70.2) = 0$$

$$V_o = \frac{pV^{+} + (1-p)V^{-}}{(1+r)} - I_0$$

$$= \frac{(0.534)(99.8) + (1 - 0.534)(0)}{1.08} - 50 = -R0.65m$$

The value of the option to stage the project is then,

$$\text{Option to phase} = -R0.65 - (-6.48)$$
$$= R5.83m$$

The option to phase an investment is seen as a series of call options, because it gives the holder subsequent opportunities to invest further in the project at different stages of the construction phase. In fact, the option gives the holder the opportunity to save investment resources by investing only in stages. It is important to note that the holder is not under obligation to invest in a subsequent phase, but has the option to do so. The firm may decide to make a follow-on investment if the previous phase is concluded successfully and if there is promise that the next phase will also be successful. This type of option is common in R&D intensive industries such as Information Technology and Pharmaceuticals because these investments normally involve several stages, with one building on the other. For example, a Pharmaceutical company can go through the following stages in the development and production of a new drug:

Stage 1 – Research and Development of a drug,
Stage 2 – Testing and obtaining FDA approval for the drug,
Stage 3 – Marketing the drug once FDA gives approval, and
Stage 4 – Rolling out and distributing the drug.

The project phases are sequentially dependent on each other, and the company can abandon the project at any one of the stages if it considers it viable to do so.

2.4.6 The option to Grow

Kester (2001: 34) defines a growth option as a discretionary opportunity to invest in infrastructure and other productive assets at a future date. Such options normally involve an initial pioneer venture which may even be unprofitable, but provides the platform and opportunity to invest in future ventures if and when market conditions are favourable. Growth options are also common in R&D intensive industries. These options are particularly common when firms attempt to enter new markets that they would find difficult to penetrate without such an option. Some acquisitions may be the result of firms creating opportunities to enter new markets, where the acquired company is considered a growth option. These options are important to a firm's potential profitability and tend to make up a significant portion of a company's value. According to Kester (2001: 36), the results of a study revealed that growth options constituted about 50% of the value of an average company in the survey. In the Information Technology industry, growth options can even constitute up to 80% of a firm's value, illustrating how important these options can be for firms.

2.5 Strategic Options and Competition

The essence of real options is that they give the holder the opportunity to delay an investment decision in the face of uncertainty. If a company is considering entering a new and uncertain market, having this option can prove to be valuable. It then becomes important for the firm to determine whether they actually do have the option to delay the decision. According to Smit and Ankum (1993: 241), the option to delay an investment decision may not always be exclusive to a single firm. The exclusivity of the option may depend on the structure of competition in that industry. A firm may not be able to delay the investment decision without losing value if competitors are vying for the same market. This is particularly the case when entering new markets or launching a new product that could revolutionise an industry.

In a competitive industry, the firm is exposed to the risk of being pre-empted by competitors if it delays the investment. Competitors may invest in similar projects that directly or indirectly compete with the firm's own project, while it delays making its decision of whether to invest or not. Such a move by competitors may lead to strategic benefits being lost to competitors, to the firm's detriment. The firm then needs to determine whether it has the ability to delay the investment. This may depend on whether the firm has a competitive advantage in that market or not. The firm should also assess whether the advantage it has is temporary or permanent. With a permanent advantage, the firm is not under much pressure to make a quick investment decision. However, in markets where it has a temporary advantage, the firm may be prompted to make a quicker decision. Smit and Ankum (1993:242) attest that it is in such markets that the firm has to concentrate its efforts to exploit this temporary advantage and gain market share before the advantage is lost. Therefore, delay in this case is not recommended.

The value of the option to delay will also depend on the likely actions of competitors. As these actions are not easy to predict, it then becomes difficult to factor in the threat of a competitor when using ROV. Weeds (2002: 1) points out that it may not always be possible to use ROV when facing competition for an investment opportunity. Using ROV and delaying without incorporating the threat of competitors, is in some cases, likely to lead to a loss of value. This is because ROV estimates the value associated with postponing the investment decision, and this value would be eroded should a competitor pre-empt the firm.

If firms are afraid of being pre-empted, then each one may decide to invest early in order to avoid losing the investment opportunity (Smit and Ankum, 1993: 243). The optimal time of investment is then brought forward, thereby suggesting that the use of ROV could be undermined. Weeds (2002: 3) asserts that delay is costly if there are significant advantages to investing early and if pre-empting a competitor will lead to sustainable gains. This advantage is referred to as a first mover advantage (FMA). There may however, still be value in delaying even in the face of competition. Moving after a

competitor may in some instances prove more beneficial than pre-empting. Weeds (2002: 7) refers to this as second mover advantage (SMA).

SMA exists when there is no advantage gained from being the first to move, but when in fact, there are significant advantages associated with waiting for the first mover to make its investment. Such an advantage might exist if the new market is highly uncertain and the second mover can learn from what happens to the first mover. The use of ROV can be relevant if a SMA exists. In general, Weeds (2002: 2) argues that in a competitive environment, it is possible to apply ROV but at other times, the traditional DCF-based techniques are more appropriate. Smit and Ankum (1993: 249) maintain that while option valuation methods can be extended to incorporate the game-theoretic elements of valuing real options, the mathematical complications of such models would sacrifice some of the advantages of using intuition to view flexibility in projects. However, Boyer, Gravel and Lasserre (2004: 1) argue that dealing with ROV in a game-theory setting is still in its infancy in terms of research and could still prove useful. In the meantime, it may be sensible to use the traditional DCF techniques when there is a significant and sustainable advantage to pre-emption.

In a broad guideline of when ROV is applicable, Weeds (2002: 2) points out that the following conditions should **all** hold for a firm to be able use the technique:

i. The future must be uncertain,
ii. The investment must be fully or in part, irreversible, and
iii. The holder of the option must have the ability to delay.

The first two conditions are briefly mentioned in earlier sections of the paper and are generally common for real options in a non-competitive environment. Firstly, when the future outcome of an investment is known with certainty, there seems to be no justification for delaying the investment decision. In that case, a firm can decide now whether to invest or not. Secondly, if resources are available, and in the absence of competing projects, a firm can decide now to invest in a project if the required investment

resources are wholly reversible. There is therefore not much reason to delay investing as the resources will be fully recovered. The third condition implies that the holder of the option must be able to delay investment without losing value. The firm has no ability to delay if a competitor exists in the market and if the investment is associated with a strong and sustainable FMA. The FMA may exist in a venture to enter a new market or if customers can incur significant costs by switching between suppliers. The difficulty for customers to switch between suppliers without cost can lead to the first mover dominating a market for a sustainable period of time.

In **Table 2.6** below are some guidelines Weeds (2002) suggests for when to use ROV, and when it might be more optimal to use DCF techniques instead.

Table 2.6 – *Effect of industry characteristics on investment appraisal*

Characteristics	Effect on single firm option value	Strategic effect on ability to hold option	DCF or ROV
Size of FMA	none	↓	DCF
Presence of FMA	none	↓	DCF
Irreversibility	↑	↓	ambiguous
Uncertainty	↑	↑	ROV
Dividend yield	↓	↓	DCF
Presence of SMA	none	↓	ROV
Time to build (likely-hood to catch-up)	none	↓	ROV

Source: Weeds (2002)

The table also illustrates the effect of various industry characteristics and project dynamics on the value of an option, thereby justifying the recommended analysis method in each case. The second column of the table shows the effect of these factors on the

option value, assuming a single firm in the industry. The third column shows the effect assuming the existence of competition in the industry. Without competition, the size of FMA does not affect the value of an option as there is no competitor to take advantage of the FMA. In a competitive industry, the ability to hold the option would however, decline with a rising and persistent FMA as the value to delay would be low. In either case, the DCF seems to be the more pertinent choice.

In a single firm industry, the more irreversible an investment, the higher the option value and therefore, the more relevant ROV becomes. In a competitive environment, the effect of irreversibility of an investment on the choice between the traditional DCF-based techniques and ROV is less clear, as it depends on several factors. First of all, the customers' switching costs in a highly irreversible investment can also be very high. The first mover may retain a large market even if competitors later invest in the market because customers may be unable to switch suppliers without incurring significant costs. In this case, moving first may prove more beneficial. However, the first mover will lose a significant amount of it resources should their product or service not be successful as the investment would be largely irreversible. As a result, it may still be worthwhile for the firm to delay when switching costs are low. The dividend yield on the other hand, has a negative effect on the option's value in both the single and multiple firm industries. The DCF method is then preferred in this case as delaying erodes the value of the underlying project.

In a competitive industry, the presence of a SMA coupled with the possibility to catch up to the first mover, would probably increase the value to delay. For a single firm industry, the presence of a SMA has no effect on the value of the option. In general, the competitive structure of an industry may affect the ability of a firm to delay making investment decisions. This may in turn affect a firm's capital budgeting practices, i.e. whether to use ROV or the traditional DCF-based techniques. However, it should be noted that the countervailing forces between the characteristics of the industry and unique project features should all be taken into account when deciding which technique to use.

2.6 Limitations and Challenges of ROV

The application of ROV is associated with a number of limitations, which **might** explain why it is still not universally used:

- Busby and Pitts (1997: 170) cite one of the major limitations of ROV as the technique being complicated and conceptually difficult. ROV entails a lot of complicated and exhaustive calculations which might in the end discourage managers from using it. According to Dias (2004: 94), the complexity of ROV may require a firm to establish a ROV programme that may also require time and the training of staff.

- Bowman and Moskowitz (2001, 775) further note that ROV can only be applied if the assumptions of the model being used are similar to the characteristics of the investment being evaluated. For example, the Black-Scholes model may not be used to value options on some projects because the model assumes a normal distribution of outcomes. This assumption may prove to be quite unrealistic for some projects.

- Busby and Pitts (1997: 170) also note that having an option on a project may reduce a firm's commitment to a targeted outcome. The firm that holds the option may feel less compelled to influence the value of the underlying if it is not fully invested in the project. If a firm has not committed all its resources to an investment, there may be less urgency and drive to make the investment succeed.

- McGrath in Burger-Helmchen (2004: 11) points out that options are seen as innovative ideas, therefore identifying and obtaining them may prove to be somewhat of a challenge. It may not always be easy to identify flexibility in investments. Furthermore, even when identified, options may not always be available to the firm due to competitive factors, legislation and regulation.

- Bowman and Moskowitz (2001: 774) indicate that the value of an option is as good as the inputs (σ, P, X, r_f, T and δ) used to estimate it. As mentioned in the previous section, real option inputs, especially the value of the underlying and its volatility, may be difficult to obtain. If the inputs are incorrectly estimated, then the value of the option on which these inputs are based may also be inaccurate.

2.7 Benefits of ROV

Some of the benefits associated with using ROV for capital budgeting decisions, are summarised below:

- Investment decisions can be delayed until more information about the project is available. When using ROV, a firm is able to wait for more information about the project while at the same having an exclusive right to the opportunity.

- ROV can be used to alter the probability distribution of the returns of an investment opportunity by skewing it to the right. The implication is that the project's potential upside is improved while the risk is reduced, similar to the long financial option position. Based on the concept of a long put, costs incurred can be curtailed by investing in an option to abandon or contract the scale of an investment, especially one that yields a lower profit than expected.

- Generally, ROV recognises and explicitly values the flexibility in projects that other techniques do not.

Summary

The traditional DCF-based techniques have been heavily criticised for their shortfalls in the analysis of project viability. There is dissatisfaction with these techniques because

they tend to assume that investment opportunities are based on now-or-never decisions. They ignore crucial strategic possibilities in projects that may give investing firms options to grow or even delay investment. There is generally a gap between strategic planning and finance practice. The gap can be bridged by using ROV to plan these investments. ROV recognises flexibility in projects by treating opportunities in investments as real options. Financial option pricing concepts and models are used to determine the values of real options. However, it is not always easy to map a capital project's parameters onto option pricing models, partly because real options themselves and their underlying are normally not traded. In addition, it is not always possible to delay making an investment decision particularly in the face of competition. It may be more appropriate to use traditional DCF-based techniques when competition and other factors significantly reduce or eliminate the value of delaying the investment decision. ROV should only be used when the investing firm has the ability to delay the investment decision.

Chapter 3
Capital Budgeting in Practice

3.1 Previous Studies

Researchers and institutions have conducted studies on the capital budgeting practices of South African firms. Their focus varies from the choice of capital budgeting techniques used by firms, to measuring risk in projects and to accounting for risk in capital budgeting. Some of the studies found in some South African journals date as far back as the early 1970s. Parry and Firer in 1990, Hall in 2000 and then Gilbert in 2003 completed some of the later surveys on the capital budgeting practices of South African firms. Similar studies were conducted in other emerging markets, notably Eljelly and Abuldris (2001) in Sudan and Abdullah and Nordin (2005) in Malaysia. The results of these studies suggest that the capital budgeting techniques used by firms are consistent across emerging markets. It seems that the theory-practice gap of capital budgeting practices still has not narrowed in emerging markets. Not surprisingly, the gap has closed considerably in the more developed countries (Abdullah and Nordin, 2005: 5). Perhaps, if firms in emerging markets were also to close this gap, this could portray a higher level of sophistication in their capital budgeting practices, and maybe allay some of the fears of foreign investors of investments in these markets being risky.

3.1.1 Capital Budgeting in South Africa

In a survey of 65 South African industrial firms, Parry and Firer (1990: 52) corroborate Bierman's (1993: 24) argument that firms tend not to use the capital budgeting techniques generally accepted by academics. Parry and Firer find the Internal Rate of Return (IRR) to be the most popular primary capital budgeting technique with managers, followed by the Return on Investment (ROI) and the Accounting Payback, with the NPV as the fourth most used technique. Hall (2000: 361) comes to a similar finding in the 2000 survey of 70 South African companies listed on the JSE.

However, Hall's study reveals the ROI to be considered the more important capital budgeting technique, followed by the IRR, with the NPV and PVPP equally popular. In Parry and Firer's study, only 10% of respondents report the NPV as their primary capital budgeting technique. In Hall's study, conducted 10 years subsequent to Parry and Firer's, 16.9% of respondents claim to be using the NPV as their primary technique lending some proof to the belief that the theory-practice gap in firms in emerging markets is still wide. Hall (2000: 367) points out that this finding goes against the (mainly academic) view that the NPV is superior to other capital budgeting techniques. However, the increase in the number of companies using NPV, from 1990 to 2000, would seem to suggest that finance theory and practice could converge over time.

3.1.2 Risk Assessment and Adjustment

The popularity of the traditional DCF-based techniques among South African firms may imply that managerial flexibility is not implicitly incorporated in the financial analysis of investment projects. This is because these techniques are based on evaluating investments on a now-or-never premise. However, even if firms use the NPV for example, this does not necessarily mean that managers do not consider the strategic implications or the uncertainty associated with their projects. Parry and Firer (1990: 57) note that most of the respondents use sensitivity analysis and scenario analysis to assess uncertainty. Other firms base their decisions on (unrealistically) high hurdle rates to account for cash flow risk when using the IRR to determine project viability. However, it seems they use the high discount rate to account for the risk associated with project cash flows rather than with the financing of the project. This was highlighted as one of the limitations of using the traditional DCF-based techniques in section 2.1.2 of Chapter 2. This practice is insufficient for dealing with project uncertainty. As a result, managers seem to use their intuition to yield values which tend to be over and above the simple NPVs of the projects.

Howell and Jägle (1997: 915) question whether managers' intuitions about investments are in line with what the theory prescribes. If the two are in line for firms that do not use ROV, then real option theory does not add value to what managers already know.

However, if their intuitions are not in line with ROV estimates, then there is a gulf between theory and practice, and therefore a need for the use of ROV. This could also support the belief that managers generally under-invest because they do not accurately value the option portion of an investment.

Howell and Jägle also conducted a survey in 1997 to observe how managers price options into their investments. The survey entailed giving a group of managers case studies of investments with growth options, to determine how accurately they would value these options. The values that managers came up with were then compared to the option values calculated using the Black-Scholes model. It was found that managers generally did not value projects with embedded options at their simple NPV valuations. This then suggested that managers do recognise that options affect the value of projects over and above their simple NPVs. However, Howell and Jägle (1997: 932) found that managers regularly under-valued or overvalued these options. It was then concluded that the intuition of managers was a weak approximation of the value of real growth options. This reinforces the idea that managers may recognise flexibility but do not necessarily value it accurately. It also highlights the importance of using ROV in planning investments.

3.1.3 Real Options Surveys

In 1997 Busby and Pitts conducted a survey based on the use of ROV by some of the largest firms listed on the Financial Times Exchange (FTSE) in the United Kingdom. They targeted the Finance Directors of companies included in the FTSE 100 index. The aim was not so much to draw a general conclusion for the entire population of UK firms from the results of the survey, but rather to assess the use of ROV among these firms as well as to determine how and whether managers deal with flexibility in their projects. Collan and Långström conducted a similar study in Finland in 2002, targeting firms included in the Helsinki Exchanges (HEX) main list.

Of the target sample of 100 firms in the UK study, 44 returned usable questionnaires. Out of the 86 Finnish companies surveyed by Collan and Långström, 36 returned completed

questionnaires. Most respondents indicated that some of the various types of options do occur in their companies. In both studies, the growth and postponement options were found to occur more frequently, while the option to abandon was found to be the least recurrent. It also emerged that very few respondents (less than 15%) seemed to be familiar with real and growth options. More importantly, both studies suggested that few, if any of the respondents, actually use ROV in investment valuation.

Altering the mindsets of practitioners towards using ROV after years of lobbying for the traditional DCF-based techniques is expected to be a challenge, especially as the latter techniques are eventually being accepted in practice. However, in 2000, in a survey of 392 large United States (US) firms, about a quarter of respondents were found to be using ROV to plan their capital investments (Graham, 2001: 199). Graham finds this result somewhat of a surprise given that ROV is still fairly new and that its quantitative applications tend to be demanding on users. Graham attributes this unexpected finding to the likelihood that ROV is not yet applied as a valuation technique in practice, but rather as a "strategic planning tool". This may suggest that convincing practitioners of the benefits of using ROV may not be as difficult as was expected.

3.2 Real Options in Practice

3.2.1 ROV Applied

Some researchers have used the ROV technique to assess the viability of some government projects in their respective countries. However, it is not clear whether any decisions on these projects were made based on the researchers' findings. Kitabatake (2002) conducted an ex ante evaluation of a large scale road construction project in the Minami Alps forest using ROV. Kitabatake (2002: 289) came to the conclusion that the market value of an underlying project and its volatility can be estimated using historical data from similar projects. This requires paying attention to related market-evaluated goods and services.

Spencer-Young and Durand (2003) investigated the difference between the NPV and ROV evaluation of game lodge concessions in South African national parks. They concluded that the difference between winning bids for concessions and mean concession values is to a large extent, represented by the real option values of the concessions. In other words, winning bidders paid more than the traditional NPV method justified, due to what is suspected as a 'feeling' the bidders had about the concessions' actual values. Spencer-Young and Durand (2003: 33) advocate the use of ROV in practice and recommend that bidders use it to value concessions as it can lead to more accurate concession values.

3.2.2 ROV Case Studies

According to AT Kearney (2005: 1) ROV is gaining support, not only among academics but also in the corporate world. Some of the largest companies, mostly in the US, are noted to have applied ROV. Boyer, Christoffersen, Lasserre and Pavlov (2003: 3) discuss some of the companies that have used ROV, and these include Airbus, General Electric, Hewlett Packard, Intel and Toshiba. Despite its subsequent problems, Enron is considered an 'innovative user' of ROV and its concepts. The company's eventual downfall is believed to be in spite of, not as a result of using ROV (Teach: 2003).

According to Mauboussin (1999: 17), Enron saw the volatility in the electricity price as more of an opportunity than a risk. The company then proceeded to use ROV to plan their investments in the power industry. They then capitalised on the electricity price volatility by building less efficient power plants to save on construction costs (Coy, 1999). The plants were left idle during periods of low electricity prices but then put back into operation as soon as the price went sufficiently high. The power plants were considered options because Enron had the option to fire them up when prices went up. But the key feature of this investment is that there was no obligation on Enron to commit itself to investing at any point in time regardless of which direction the price of electricity took.

Another example of the use of ROV to evaluate a business opportunity is one of Merck & Co.'s ventures, in the early 1990s. Merck was looking to enter a new line of business and contemplated purchasing a new technology from a small biotech company codenamed Gamma (Bowman and Moskowitz, 2001: 773). Since Gamma had patented the technology, Merck planned to licence the new technology in order to use it in the development of the new product line. However, Merck was facing some uncertainty from this venture, firstly due to the fact that the technology was in such a preliminary stage that it was not certain that a product could in fact be developed from the venture. Secondly, even if developed, the product's commercial potential could not be predicted with a fair amount of certainty. This case illustrates an earlier point that real options tend to be holder specific. The biotech company was willing to sell the option to Merck, because the option would be more valuable in the hands of the latter, maybe because of Merck superior capabilities and better market access.

Merck then decided to use ROV to plan and evaluate the investment opportunity. The following are some of the features of the agreement regarding the Gamma project:

- If the product appeared to be commercially viable after two years, then Merck would have to construct a plant for production. Additionally, there would be associated marketing, start-up costs and working capital expenditures.

- It was then agreed that Merck would pay Gamma $2 million over three years to licence the technology, as well as royalties when the product went to market. However, Merck was given an option to abandon this agreement if progress was deemed unsatisfactory at any stage of the research.

This opportunity represented a call option for Merck as it gave them the opportunity but not obligation to roll out the product in exchange for a premium. The premium was in this case, equal to the sum of the licence fee plus the R&D costs. For the option, Merck would benefit from the increase in the value of the technology and would then construct the plant if the technology proved to be a success. The value of the technology was

considered to be the underlying asset. However, since Merck was not obligated to construct the plant, the start-up costs, working capital and marketing costs could be avoided if the technology was later deemed unlikely to produce a commercially viable product.

ROV of Merck Project

Merck used the Black-Scholes model to determine the value of the option associated with its acquisition of Gamma. It was decided that the stock price method would be used to value the project. The stock price does not refer to the stock price of Merck, but rather to the discounted cash flows of the project. The stock price was based on Merck's estimation of these cash flows using the traditional net present value (valuation of the underlying is discussed in greater detail in section 2.3.2 of Chapter 2). The exercise price was made up of the cost of building the plant plus the start-up and marketing costs. Merck would only consider exercising the option if the stock price was above this exercise price.

A sensitivity analysis was conducted, and it was then agreed that the option's time to maturity would vary from two, three to four years. This was based on the expectation of the timing of competing products entering the market after which, Merck would find it very difficult or even impossible to enter the market. The project's volatility was based on the standard deviation of the returns of biotechnology stocks of Gamma's size. The prevailing four-year Treasury bond was used as the risk-free interest rate when calculating the option value. Merck eventually found the value of the option to be worth $11.9m using the Black-Scholes model, which was far greater than the $2.8m required to buy the option. Based on this information, Merck decided to buy the option.

3.3 Relevance of ROV for South African firms

3.3.1 ROV in South Africa

None of the previous studies encountered seem to suggest that any of the respondents or any other South African firms are using ROV. In general, there appears to be nothing to suggest that firms in any of the other emerging markets are using ROV. This is not very surprising given the apparent theory-practice gap in capital budgeting of firms in emerging markets mentioned by Abdullah and Nordin. There appears to be very little published on real options in South Africa with just the one study by Spencer-Young and Durand (2003) found. This could be because the topic of real options is still somewhat new in South Africa, which could explain why South African firms are not using ROV. It would then be pertinent to determine why South African firms would consider using ROV to plan their capital projects. In other words, what factors are likely to influence South African firms to use ROV in capital budgeting.

3.3.2 Determinants of the use/non-use of ROV

A number of authors have suggested some of the factors that could explain why firms are not using real options in evaluating their investments. Some (Weeds, 2002) suggest that competition may affect the firm's choice to use ROV while others suggest that managers are simply not aware of real options. Below is a list of some of the factors suspected to affect the use of ROV:

- Extent of awareness of ROV,
- Perceived complexity of ROV,
- Capital intensity of projects, and
- Competitive structure of the industry (FMA/SMA)

Extent of Awareness of ROV

Some authors, Lewis, Enke and Spurlock (2004), think it is possible that firms are not using ROV because managers are still uninformed about the technique and its concepts. They further point to the fact that published material on the subject does not adequately address application of ROV in practice, thereby not enticing managers to use it. Given that there appears to fairly little relevant research and publications on ROV in South Africa, it is possible that the lack of awareness of the technique may be one of the determinants of the non-use of ROV in firms in the target population. However, South African firms are exposed to international publications and the corporate practices of firms in the more developed countries, especially as some of the respondents do not only have operations in the US and the UK but are also listed on some of the larger international exchanges. There is therefore, a possibility that managers in these firms might have some knowledge of the technique.

Busby and Pitts (1997: 184) say: "Very few decision-makers had heard of the terms 'real-options', 'growth-options' or 'operating options' as used in the research literature and management periodicals…". Collan and Långström (2002: 9) found that more than half of the respondents in their study do not know any of these terms. This might suggest that the managers who have not heard of such terms have not received formal training on the use of ROV. But it does not guarantee that those who claim to have heard of them have received any such training. Busby and Pitts (1997: 177) found that respondents claimed to know the terms, gave meanings to the terms that suggested they were not interpreting them in line with their use in the literature. It is because of this that managers were asked to demonstrate their knowledge of the term by defining it in the questionnaire.

Complexity of ROV

According to Leslie and Michaels (1997: 6), ROV may be more conceptually difficult than its traditional DCF counterparts, and managers may find it more difficult to apply. The relative complexity of ROV could be a major factor deterring managers from using

it. In fact, Amram (n.d.) does suggest that one of the reasons for ROV not being applied is because it is complicated. If managers have a problem understanding and applying ROV, it is reasonable to expect them not to use it. Complexity was measured as managers' perceptions of the complexity of ROV on a scale. This variable was expected to have a positive causal relationship with the non-use of ROV. The more complex respondents find ROV, the greater the possibility that they will not use it and vice versa.

Capital Intensity of Projects

According to Gitelman (2002: 59) the application of ROV is generally more relevant to highly capital intensive industries and projects. In Collan and Långström's study as well as in Busby and Pitts', the larger firms in Finland and the UK respectively, were targeted for the survey. These firms were targeted because they were thought to be more likely to consider using ROV given that they tend to invest in capital intensive projects. According to Ulfelder (2003), even though the use of real options is primarily being advocated by academics and is slated by some practitioners, it is also starting to gain a lot of support from organizations that finance capital-intensive projects. The option to abandon in particular, is more valuable in capital-intensive investments (Trigeorgis, 2002: 4). Pharmaceuticals and energy traders are among the advocates of ROV mainly because of the capital intensity of their investments.

Furthermore, Petry in Parry and Frier (1990: 54) comes to the conclusion that highly capital intensive firms favour using a wider range of capital budgeting techniques. Perhaps due to the size of capital at risk, managers feel the need to employ more than one capital budgeting technique to verify the validity of their investment decisions. This suggests that the larger firms are more likely to use more than one capital budgeting technique. This in turn, implies that these firms are more likely to use ROV.

This belief influenced the choice of the population to study. The FTSE/JSE Top 40 firms were chosen as they are some of the largest listed firms in South Africa. It was expected that most of these firms as in the UK and Finnish surveys, were more likely to consider

using ROV. First of all, firms in the FTSE/JSE Top 40 are fairly large ranging from hundreds of millions to billions of US dollars in market capitalisation. Though no literature was found to suggest the size of a firm considered as large and likely to use ROV, it is expected that these firms could even by UK and Finnish standards, be considered fairly large.

Gitelman (2002: 59) further notes that ROV is generally used in infrastructure projects and industries. These may be in power, gas or mining industries where at least a part of the output is traded in commodity markets. Some of the JSE Top 40 companies are heavily invested in mining and oil extraction, further strengthening their candidacy as users of ROV.

However, ROV application is not restricted to natural resource industries. Borison (2003), Trigeorgis (2001) and Wang (2005) support Gitelman but argue that real options methodologies can also be adopted in various other industries as well. Real options are also observed in Real Estate, for R&D projects, in Information Technology, Pharmaceutical, Manufacturing, Venture Capital, Government Regulation, Shipping, Environmental Pollution, Global Warming and Infrastructure projects. This then suggests that respondent firms in industries other than mining, may also benefit from using ROV.

Industry Competition Structure (Strength of SMA/FMA)

Weeds argues that the presence and strength of a SMA or FMA can affect a firm's decision to use ROV, because the firm's ability to delay the investment decision may be affected differently for either case. A firm should therefore first determine whether there is a SMA or FMA in a project. As already mentioned, ROV is recommended if a SMA is prevalent for that investment, while the traditional DCF-based techniques are recommended for projects that exhibit FMA. It is therefore expected that firms that generally observe a FMA in their industries will not use ROV to plan their investments. However, it is noted that neither FMA nor SMA can exist in an industry. This may be the

case where the firm faces no competition, in which case, a firm might have the ability to delay an investment and therefore consider using ROV.

Summary

Studies on the capital budgeting practices in emerging markets seem to suggest that most firms are still not using techniques advocated by academics. In recent studies in South Africa, firms are found to favour the less academically acceptable IRR over the NPV. Studies of UK and Finnish firms reveal none of the firms to be using ROV, even though it is recommended over the traditional DCF-based techniques. Managers are however, deemed to recognise flexibility in their projects despite not using ROV. A study in the US surprisingly finds a few firms to be using ROV, suggesting a trend of firms starting to adopt the use of ROV. Some of the firms recently reported to be using the technique include Airbus, Enron, General Electric, Hewlett Packard, Intel, Merck and Toshiba. Several factors are considered to be possible reasons influencing firms to use ROV. Those tested in this study are Awareness of ROV, Perceived complexity of ROV, Capital intensity of projects and Competitive structure of the industry (FMA/SMA).

Chapter 4
Research Methodology

The scope of the study is discussed in this section of the paper, with a focus on the target population and sample size. The data collection process, the survey, the measurement of the key variables, the questionnaire and the analysis methodology are also explained.

4.1 Scope of the Study

4.1.1 Target Population

As mentioned in Chapter 3, ROV is thought to be more relevant in planning capital intensive projects. Firms investing in capital-intensive projects are therefore more likely to use ROV. The larger firms are the ones expected to be investing in capital intensive projects given the size of their operations and their better access to capital. It was then decided that the current study would target some of the largest firms in South Africa, as they are deemed more likely to consider using ROV. This is in line with Busby & Pitts' (1997) and Collan & Långström's (2002) studies. The target population in each study was identified as the firms included in an index of the largest listed firms on the FTSE in the UK and the HEX in Finland.

The target population for this study is then defined as all firms included in the FTSE/JSE Top 40 index. The index represents a diversified portfolio of 40 of the largest firms listed on the JSE from different sectors of the economy. Inclusion of firms in the index is based on high market capitalisation and share liquidity (Absa, 2004: 15). However, given that market conditions and company structures may be subject to change, the list of firms included in the index may vary from one time period to another. This could happen if a member firm were to be acquired and subsequently de-listed or if it became insolvent. The firm might then not meet the conditions for inclusion, and as a result, be removed from the index.

For the survey in the current study, 30th June 2005 was set as the cut-off point for the inclusion of firms in the index. There was therefore a possibility that a target firm in the study would no longer be in the index by the time the survey was conducted. In that situation, the (former) member would still be considered for the study provided that they were still solvent and willing to take part in the survey. Appendix A of the paper shows a full list of firms in the target population as given by a Satrix 40 fact sheet. The Satrix 40 is a fund that tracks the performance of the FTSE/JSE Top 40 index.

4.1.2 Sample Size

As previously indicated, the FTSE/JSE Top 40 index is made up of 40 listed firms. All 40 firms on the index are surveyed for this study, which effectively means a sample of 40 respondents for the study. The aim is to study a small population, and from the results, determine whether a follow-up study based on a larger population of firms would be warranted. It is therefore not the intention of the study to claim representation of the whole South African market, but rather to get an indication of whether the study is worth extending to be more representative, by later studying the entire population of JSE listed companies.

4.2 Data Collection

4.2.1 Survey

The study involves observing the capital budgeting activities of the 40 respondents by way of a survey. It is expected that the study will reveal how managers prepare for and create flexibility in capital investments and also their general attitudes towards such flexibility. This information is not available in any of the reports that the firms release to the public, nor was it found in any previous studies conducted on the target population. Therefore, Babbie and Mouton (1998: 102) suggest a survey as the most reliable method of collecting such data.

As in previous studies, the CFOs and Finance Directors of respondent firms are the targets of the survey. However, there are cases where other finance officers are considered more suitable to take part in the survey than the CFO. An online approach was considered the best method to complete the survey, to save time and other resources. This approach entails sending respondents a questionnaire via email. However, initial contact is established with the respondent firms telephonically prior to sending the questionnaire. This is done to determine the most appropriate person in the firm to complete the questionnaire. Telephonic contact is also used to emphasize the importance of the study to respondents and to further reassure them of their anonymity in the survey. Such contact is meant not only to ensure the quality of the collected data but also to increase the response rate by establishing some trust with respondents.

4.2.2 Pilot study

A pilot study was conducted to further test the validity and reliability of the questionnaire. This was done to ensure that respondents would understand the questionnaire. Feedback from the pilot study was then used to further refine the questionnaire and assess the practicality of the survey approach taken. Prior to this though, a pre-test survey was conducted at the Department of Business Management at Stellenbosch University. The pilot study itself was only conducted after feedback from the pre-test survey. For the pilot study, the questionnaire was sent to a small targeted group of firms that are not in the eventual survey but are considered to have characteristics (e.g. industry and size) similar to those of some of the respondents included in the survey.

It was during the pilot study that the suggestion was made that some CFOs might not deal with all the capital budgeting intricacies of projects. Finance directors and financial managers were in some cases found to be more involved in the in-depth financial analysis of projects. As a result, some of the CFOs contacted elected to allow other finance officers in their companies to take part in the survey as they felt the latter would make a better contribution. This was taken into consideration when conducting the survey. When

making first contact with respondents, the content and purpose of the questionnaire was fully explained to the relevant individuals in the respondent firms. This made it easier to identify specific individuals to whom questionnaires were to be sent.

4.2.3 The Questionnaire

The questionnaire was sent to respondents via email in Word format. The email included a covering letter with the questionnaire as an attachment. The questionnaire is included in Appendix C and the covering letter is included in Appendix E of the paper. The questionnaire is similar and mostly in line with those used in the two previous surveys discussed above, with some variations to achieve other objectives of the study. The first page of the questionnaire explains the purpose of the study, reassures respondents of their anonymity when completing the questionnaire and then gives some guidelines on how to complete it. The structure of the rest of the questionnaire and the motivation behind including each questionnaire are discussed in section 4.3 below.

4.3 Measurement of key variables

The questionnaire was designed to address three key factors/variables in the study with respect to the target population, and these include:

1) The Use of ROV,
2) The recognition of flexibility in capital projects, and
3) Possible factors affecting the Use of ROV.

4.3.1 The use of ROV

The most pertinent question posed by this study is whether respondent firms are using ROV in their projects. Question 20 of the questionnaire addresses this issue. Respondents are deemed to be using ROV if they claim to use it either as a primary or secondary capital budgeting technique. That a respondent may be using it as a secondary technique

and not as a primary one will not affect the quantitative analysis intended for this study. It only serves to highlight whether or not the firm has fully adopted ROV in capital budgeting. If a firm claims to use ROV as a secondary technique it suggests that the firm has not fully adopted the technique but rather uses it mainly as a strategic planning tool (Graham, 2001: 199). A secondary aim in this question is to assess which other capital budgeting techniques firms use, in order to establish whether they are using techniques recommended in the literature.

In Section A of the questionnaire, Questions 1 and 2 attempt to determine respondents' demographics, which in this case, are the industries the firms are in and the location of the core of their operations. The aim is to use this data to observe whether there is an association between the demographics and capital budgeting practices of firms. For example, comparisons can be made to determine whether the difference in how much flexibility firms have or how highly they value such flexibility is possibly industry-based. It is also important to determine whether ROV is used by firms in industries whose output is traded, as Gitelman (2002:59) suspects, or whether firms in other industries might be using the technique as well.

4.3.2 Flexibility in projects

One of the main objectives of the study is to determine whether respondents recognise flexibility in their projects by incorporating real options in their capital budgeting decisions. Questions 5, 8 and 11, firstly attempt to determine the existence of the option to delay, the option to abandon and the option to rescale, respectively, in respondent firms' projects. It was thought that respondents would find it easier to identify these three types of flexibilities in their projects than they would the other two (options to phase and to grow) discussed in section 2.4. The options to expand and to contract have been placed into one type of flexibility in the questionnaire, referred to as the option to rescale. This is because both involve altering the scale of a project Questions 6, 9 and 12 are intended to determine the frequency with which the above-mentioned options occur, while Questions 7, 10 and 13 are meant to evaluate the importance that respondents generally attach to

each of these options. The intention was to use responses to these questions to assess whether the existence of options and the importance attached to each, varies across firms and industries, whether any of the options appears more desirable than others and most importantly, whether this is somehow associated with the use of ROV.

A series of questions (Questions 14, 15, 16, 17, 18 and 19) is then used to determine whether respondents generally recognise flexibility. Question 14 is expected to reveal whether a respondent is aware of the presence of flexibility during the planning stages of projects. Question 15 then proceeds to establish whether a respondent's decision on a project has ever been contingent on the presence of such flexibility. This would to a large extent, suggest that respondents consider flexibility when planning their projects. Question 16 addresses the availability of the option to a firm. An option on a project might not be exploited if it is not available to the firm to exploit.

Even if a respondent does claims not to have exploited an option (Question 17), it is not necessarily assumed that the respondent does not recognise flexibility. This is because many other reasons could be attributed to such a response, including the one mentioned above i.e. the option being unavailable to the firm. It is also possible that an option would not be exercised if it is out-the-money. The aim in Question 18 is to determine how the stated options came to be part of the projects. A negotiated option would lead to a more conclusive finding that the respondent does recognise flexibility as the option was deliberately created for the project. The same applies to Question 19, as respondents having a policy to identify flexibility in projects, would appear to at least have the intention to incorporate flexibility in their decisions on projects. Whether the respondent quantifies this flexibility, would depend on the capital budgeting technique the firm uses to plan their investments (e.g. ROV).

4.3.3 Possible factors affecting the use of ROV

This section addresses the factors expected to affect the use of ROV, namely:

- Awareness of ROV,
- Complexity of ROV,
- Competitive structure of the industry,
- Capital intensity

Awareness of ROV

Questions 21 and 23 are essentially intended to address the 'awareness of ROV' factor. While earlier sections of the questionnaire investigate flexibility on a general level, Question 21 directly poses a question on some of the terminology used in real options. This is done to assess respondents' familiarity with real options. It was noted from previous studies that respondents claimed to know the term Real Options but could not define the term as it is used in the literature. In previous studies, respondents tended to confuse the term with flexibility in financing investments. As a result, Question 23 attempts to confirm whether respondents actually know the term as it is intended in the literature.

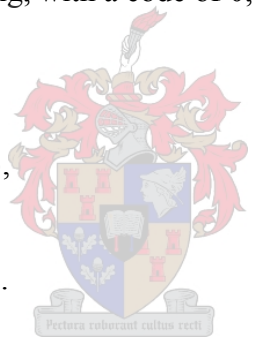
The respondents that claim to know the term and subsequently give what is deemed an accurate definition are considered to be aware of ROV. In the same way, giving an incorrect definition of the term or not answering Question 23 at all, leads to the conclusion that a respondent is not aware of the term regardless of their response to Question 21. The terms Growth Options and Operating Options represent some of the terminology used in real options literature. However, they cannot on their own be used to determine whether a respondent is aware of ROV, especially as these terms can be used in a context other than in real options. They are merely meant to assess the extent of a respondent's knowledge of the real options topic. Respondents are asked to indicate the extent of their knowledge of each of the terms on a scale of 1 to 3. 'Heard of' implies a

rating of 1 for the relevant term, 'Known' a rating of 2, and 'Used Regularly' a rating of 3. Unknown is assigned a code of 0 just to indicate the fact that the respondent cannot give a rating of their knowledge.

Complexity of ROV

Respondents claiming to have some knowledge of real options are then asked to give a rating of how complex they deem the application of ROV to be (Question 22). Complexity of ROV is measured on the basis of ratings given by respondents in Question 22. The scale is from 1 to 5, with 1 representing the lowest level of complexity and 5 the highest. The varying levels of the scale are represented in the questionnaire as follows:

- Not Sure represents no rating, with a code of 0,
- Very Straightforward – 1,
- Relatively Easy – 2,
- Somewhat Complicated – 3,
- Very Complicated – 4, and
- Extremely Complicated – 5.



It was expected that the higher the complexity rating a respondent gives ROV, the less likely that respondent is to use the technique.

Competitive Structure of the Industry

The intention in Question 3 of the questionnaire was to measure respondents' perceptions of which of FMA and SMA is more recurrent in their industries. Respondents believing their industries to exhibit a sustainable SMA are expected to be more likely to use ROV than respondents believing their industries to exhibit a FMA. As mentioned in Chapter 3, this expectation is based on Weeds's (2002) argument that a firm may be able to delay an investment if there is a sustainable SMA in a project while under FMA, their ability to delay is significantly reduced. Even respondents that do not observe either of the FMA or

SMA can find ROV applicable in their industries. Generally, all respondents except those that observe FMA in their industries are considered likely to use ROV, with respect to the structure of competition in their industries.

Capital Intensity of projects

In Chapter 3 of the paper, it was again noted that firms with capital intensive projects would most likely benefit from using ROV as it is based on incorporating the possibility to delay investments. Delay would enable firms investing in capital intensive projects to save a significant amount of their resources, which could otherwise be lost should the investment prove unprofitable. The capital intensity of a firm's projects is measured as the average investment amount a firm puts in its project. Question 4 of the questionnaire is used to obtain this information from respondents.

4.3.4 Qualitative Data

Fairly little qualitative data is required for this study. Only Questions 21, 23 and 24 involve such data. As discussed in section 4.3.3 above, Question 23 is aimed at confirming managers' knowledge of real options. The qualitative content of Question 21 is merely meant to allow respondents to give any comments they feel necessary about the terms mentioned in the question. Question 24 gives respondents the opportunity to discuss important issues about the research as well as to give their opinions on real options in general. Respondents are encouraged to raise any important issues that they may feel should have been addressed in the study but have not. All the qualitative data is aggregated where found to be uniform, but analysed on a case by case basis if not uniform.

Summary of Questionnaire

Some of the reasons for the line of questioning used in the questionnaire are shown in Table 5.1 below. The table gives a summary of the rationale used for including each of the questions.

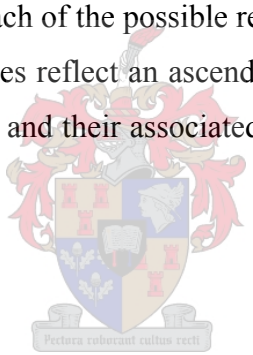
Table 4.1 – *Rationale for the inclusion of each question*

Questions	***Aim of the question***
Question 1	To enable the identification of cross industry differences with respect to flexibility.
Question 2	To determine whether the location of operations affects a firm's capital budgeting.
Question 3	The presence of either a SMA or FMA is expected to affect the use of ROV.
Question 4	Capital intensity of projects is expected to affect the use of ROV.
Question 5	To determine whether firms have the flexibility to delay investment in projects.
Question 6	The frequency of options in projects is expected to affect firms' capital budgeting.
Question 7	This reveals the value managers attach to having flexibility in their projects.
Question 8	To determine whether firms have the flexibility to abandon investment in projects.
Question 9	The frequency of options in projects is expected to affect firms' capital budgeting.
Question 10	This reveals the value managers attach to having flexibility in their projects.
Question 11	To determine whether firms have the flexibility to rescale the size of investments.
Question 12	The frequency of options in projects is expected to affect firms' capital budgeting.
Question 13	This reveals the value managers attach to having flexibility in their projects.
Question 14	This determines whether managers are aware of flexibility when planning projects.
Question 15	To determine whether managers ever factor in flexibility in their projects.
Question 16	An option on a project may not be exercised if the option is unavailable to the firm.
Question 17	A respondent exercising an option suggests they recognise flexibility while not exercising does not necessarily imply otherwise.
Question 18	This is meant to determine whether managers create flexibility in their projects or whether it comes naturally to the specific projects.
Question 19	Managers with programs for identifying options are considered to incorporate flexibility in their decisions.
Question 20	The intention is mainly to determine whether firms use ROV or not.
Question 21	This question attempts to determine respondents' awareness of ROV.
Question 22	The perceived complexity of ROV is expected to affect the use of ROV.
Question 23	This attempts to confirm whether respondents actually are aware of ROV.
Question 24	This is meant to get feedback about real options and about the study itself.

4.4 Analysis Methodology

4.4.1 Coding

Each possible response in the questionnaire has been assigned a code to make it easier to analyse each response of each respondent to a given question. Each code is assigned in line with the requirements of the question to which the response relates. For most questions in the questionnaire, codes have been assigned fairly arbitrarily. The reasoning behind assigning codes in this case is not reflective of importance but is only used for statistical processing. For example 'Yes' responses are assigned a code of 1 while 'No' responses are assigned a code of 2 and 'Not Sure' is assigned 0. This is not meant to suggest any particular order of importance for the responses. For other questions, a direct scale is used to attach a rating to each of the possible responses. This applies to Questions 4, 7, 10, 13 and 22, where the codes reflect an ascending order of importance or size. A complete list of possible responses and their associated codes is shown in Appendix D of the paper.



4.4.2 Data Analysis

Types of Variables

The variables discussed in the study are measured at differing levels. Variables are typically measured at the nominal, ordinal, interval or ratio level. According to Ruane (2005: 54), a variable is measured at the nominal level if it is qualitative and the values attached to it are merely to identify its qualitative differences. The 'Use of ROV', 'The Industry of the firm' and 'Industry Structure' are all measured at the nominal level. For the ordinal level, the values attached do not merely serve as labels but are used to suggest an order or ranking of the degrees of the variable (Aldridge and Levine, 2001: 130). In this study, the variables measuring the awareness of ROV, the capital intensity of projects, the complexity of ROV and the importance of options are all measured at the nominal level.

The interval level of measurement is used for variables that require more than just labelling or ordering the values of a variable but also give some actual distance between values. The ratio level of measurement is used when the numbers attached to the value of a variable represent the actual quantities or amounts of that variable (Ruane, 2005: 55). None of the variables discussed in this paper, seem to exhibit characteristics that require interval or ratio level measurement.

Statistical tests and analysis

Simple statistical analysis and tests of statistical significance are used to analyse the data in this study. The former is used mainly to summarise the data where necessary and also to assess patterns of behaviour among respondents with respect to certain variables. Some relationships were expected between the different factors discussed in the questionnaire. The Spearman's correlation test is used to test for correlation between ordinal variables. The relationship is deemed statistically significant if the p-value of the statistic is lower than the 5% alpha value (a 95% confidence level). The Mann-Whitney test is used to determine the relationship between an ordinal variable and a nominal variable at the 95% confidence level. This test is based on determining whether the means of different categories of a nominal variable with respect to an ordinal variable, are statistically different. A p-value lower than the 5% alpha suggests that the two means are statistically different and there is a difference between the groups.

Summary

The aim in this study is to observe the capital budgeting practices of respondent firms through a survey. The target population studied is identified as the 40 firms included in the FTSE/JSE Top 40 index as this population represents some of the largest firms in South Africa. Subsequent to pre-testing the questionnaire and conducting a pilot study, a questionnaire was sent to the relevant finance officers in respondent firms. The questionnaire contains 24 questions aimed at measuring three main variables, namely, the

use of ROV, recognition of flexibility in capital projects and the possible factors affecting the use of ROV. Each possible response in each question is assigned a code to facilitate the analysis of data. Most of the data is analysed using simple statistical analysis. Spearman's test for correlation and the Mann-Whitney test are also used to determine the existence of statistically significant relationships between some of the factors discussed in the study.

Chapter 5

Data Presentation and Analysis

5.1 Survey Results

The survey was conducted from 20th April to 20th August 2006. A response rate of 53% was achieved with 21 of the 40 respondents invited to take part in the survey returning completed questionnaires. Of the 21, one respondent did not complete one section of the questionnaire satisfactorily. There was inconsistency in some of the respondent's answers. However, the respondent duly completed other sections of the questionnaire. As a result, the usable responses from those sections are included in the analysis. Most of the completed questionnaires (14 of the 21) were collected via email, three came through the post while another three were obtained by way of face-to-face interviews with managers. This breakdown of survey responses is summarized in Table 5.1 below.

Table 5.1 – *Summary of survey results (Responses and Non-responses)*

Approach used to collect data	**Number of respondents**
Email	14
Face-to-face Interview	3
Postal	4
Total	**20**
Reason for Non-response	
The firm has been de-listed and is unavailable for the survey	1
It is company policy not to participate in surveys	3
The firm is not willing to participate in the survey	4
Promised to participate but questionnaire yet to be returned	11
Survey is not relevant to the firm's operations	1
Total	**20**

The other 19 respondents did not return completed questionnaires for various reasons. Some of these reasons are summarised in Table 5.1 above, together with the numbers of respondents associated with each reason. As shown in the table, a majority of firms promised to respond but did not complete the questionnaire, while others were simply not willing to participate in the survey. For some, it was company policy not to participate in surveys at all, and as had been anticipated, one firm was acquired and was subsequently delisted from the JSE just prior to conducting the survey. Attempts were made to reach the respondent but without success. One other respondent, having studied the questionnaire, felt that the questionnaire was not relevant to them, given the firm's operations. We can assume that a firm does not use ROV if the questionnaire is deemed irrelevant. As a result, the statistic for the use of ROV is based on 22 respondents and not on the 21 as is done with the other factors.

Of the 21 firms that responded, only two use ROV to plan their projects. As a result, no firm conclusion can be reached on the relationship between the use of ROV and the factors expected to affect its use.

5.2 Data Presentation

5.2.1 Respondent Demographics

Of the 16 expected industries only 10 are represented by the 21 respondents. Rather representative of the Top 40, five (23%) respondents are in the mining industry and two of these claimed that the core of their operations was in South Africa. Three respondents are in banking, two are in food and beverages, two in insurance and another two in retail. The forestry and paper, industrial goods and services, media, oil and gas, retail, construction and metals and telecommunications industries are each represented by a single firm. Another respondent indicated to be in packaging, which was not an option given in the questionnaire. It was noted that the two firms using ROV have the core of their operations based in South Africa. In addition, here was nothing to suggest that managers in the firms whose operations were not concentrated in South Africa were

much more aware of real options than those whose operations are locally based. It is then concluded that having internationally diversified operations does not necessarily expose the firm's manager to real options significantly more than the managers who have the core of the operations locally.

5.2.2 Presence of Flexibility

Flexibility in the respondent firms is represented by the presence of the options to delay, abandon and rescale. The presence of this flexibility is summarised in Figure 5.1 below. Each section of each of the bars in the graph represents a given response as a percentage of the total number of responses. The 'Yes' section of the bar represents the percentage of respondents who claim to have had the particular type of flexibility in their projects at some stage, with 'No' representing those that did not have such flexibility and 'Not Sure' representing the respondents who are uncertain about the presence of the flexibility option in their projects.

A high number of respondents (86%) claim to have had the opportunity to delay project as well as the opportunity to rescale. For each option, only two respondents claim never to have had the option, while another respondent is not sure. In fact, that same respondent was also found to be unsure about the other types of flexibility as well. In the two previous studies, the option to abandon seems to have been the least common of the three. A similar trend is found in the current study, where two respondents claim to never have had the option while another two are not sure. Out of the 20, 16 respondents claim to have this flexibility, which is the lowest count for any of the three types of flexibility.

It is however possible that this flexibility is less common in firms because managers may feel less inclined to abandon projects due to a fear of the abandoning of a project being interpreted as failure. They may therefore not recognise or feel the need to create an opportunity to abandon a project even if this were a feasible alternative. However, without evidence to the contrary, the option to abandon is then concluded to be the least common of the three.

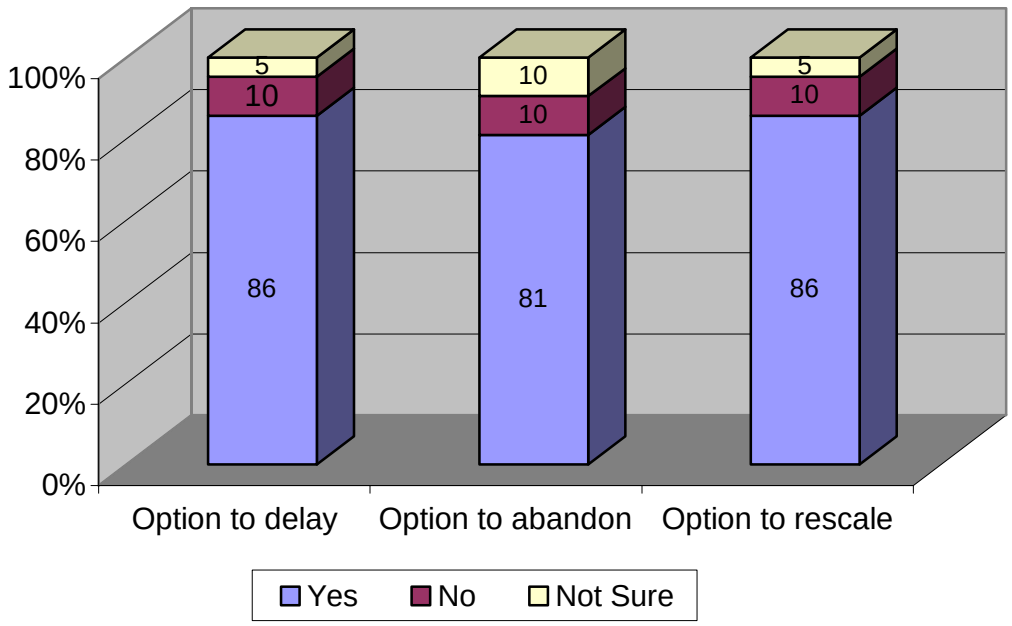


Figure 5.1 *Presence of the flexibility options in projects*

Since there are not enough instances where these flexibilities are found not to exist, it becomes difficult to determine whether their occurrence in firms varies across industries. It is however noted that each of the firms in mineral resource industries (mining and oil and gas), have had all the stated types of flexibilities in their projects. This is with the exception of the respondent who is not sure about any of them. All other firms do have at least one of the three types of flexibility in their projects.

Table 5.2 below shows a summary of the frequency of the different types of flexibility, with frequency indicated in five ranges of occurrence. The ranges represent a scale of 1 to 5, where the 1 – 20% range represents the lowest occurrence and a rating of 1 while the 81 – 100% range represents the highest occurrence range with a rating of 5. None of the three types of flexibility appear to be significantly more recurrent than any other. However, based on the medians and means of the respective ranges of occurrence, there appears to be at least some difference between the three types of flexibility. With a median of two and a mean of 2.4118, suggesting occurrence in the 21 – 40% range, companies generally seem to have the opportunity to rescale their investments more often than they do the other two flexibilities.

Table 5.2 – *Frequency of occurrence of flexibility options in projects*

Frequency	Option to delay		Option to abandon		Option to rescale	
Range	No.	%	No.	%	No.	%
0 – 20%	8	47	10	59	7	41
21 – 40%	6	35	1	6	3	18
41 – 60%	2	12	3	18	2	12
61 – 81%	1	6	2	12	3	18
81 – 100%	0	0	1	6	2	12
Total	**17**	**100**	**17**	**100**	**17**	**100**

Underlined cells represent median responses.

The difference is less clear between the option to abandon and the option to delay. The option to abandon has a higher mean of 1.8750 compared to the 1.7645 mean of the option to delay. The option to delay though, has a median of 2 while the option to abandon has a median of 1. Given that the mean can be significantly affected by outliers, especially in a small sample the option to abandon is then concluded to be the least recurrent of three as it has a lower median.

5.2.3 Importance of flexibility

Table 5.3 below shows a summary of managers' desire for flexibility, as reflected by the ratings of how important they consider each type of flexibility to be in their projects. 'Completely Unimportant' suggests no desire to have the flexibility while 'Extremely Important' reflects the greatest desire for the stated flexibility. As can be seen from Table 5.3, respondents generally deem flexibility in projects to be important. Only a few managers do not consider any of the stated flexibility options to be important, but not many consider the options to be absolutely imperative either. Based on a median of four, the options to abandon and to rescale appear to be the most important to respondents. However, given that the option to rescale has a mean of 3.5556 as opposed to the 3.2941 of the option to abandon, the former is considered to be more important, although marginally. It is noted also that the very few respondents rated the option to rescale to be unimportant compared to the other options. In addition, more respondents (12) deem it to

be important to have this flexibility than they do the options to abandon (10) and to delay (5). This suggests that the importance ratings for the option to rescale are skewed more towards the high levels.

Table 5.3 – *Importance of flexibility in influencing investment decisions*

Importance	**Option to delay**		**Option to abandon**		**Option to rescale**	
	No.	% of 18	No.	% of 17	No.	% of 17
Completely unimportant	0	0	0	0	0	0
Not especially important	2	11	4	22	2	11
Moderately important	11	61	4	22	4	22
Very important	3	17	10	56	12	67
Extremely important	2	11	0	0	0	0
Total	**18**	**100**	**18**	**100**	**18**	**100**

Underlined cells represent median responses.

Firms that desire flexibility were considered to be more likely to use ROV than those that desire it less. This is because ROV is specifically meant to address the flexibility in projects. As already mentioned, the number of respondents using ROV is too low to determine whether any pattern exists between use of ROV and the ratings firms give flexibility. The two respondents that use ROV do not appear to desire flexibility significantly more than the other respondents do. On that basis, it seems that firms that rate flexibility highly do not necessarily use ROV. It is however expected that those who do not consider flexibility to be important will most likely not use ROV. There is also no discernable pattern between the desire to have flexibility and the firm's industry. None of the firms within a given industry seem to desire flexibility equally nor are there suggestions that firms in certain industries consistently desire flexibility any differently from the way that firms in other industries do.

There does however, seem to be a relationship between the frequency with which a certain type of flexibility occurs and the importance attached to it. This relationship is reflected by the shapes of the graphs in Figure 5.3 below. The graph below captures this

relationship using the means of the respective options. It would appear that the higher the occurrence of a given type of flexibility, the more important it is considered to be. It is possible that managers are more likely to recognise the presence of the types of flexibility that they consider to be important to them. Alternatively, it may be possible that managers deem the flexibility that occurs more frequently in their projects to be the more important one (Collan and Långström, 2002: 5).

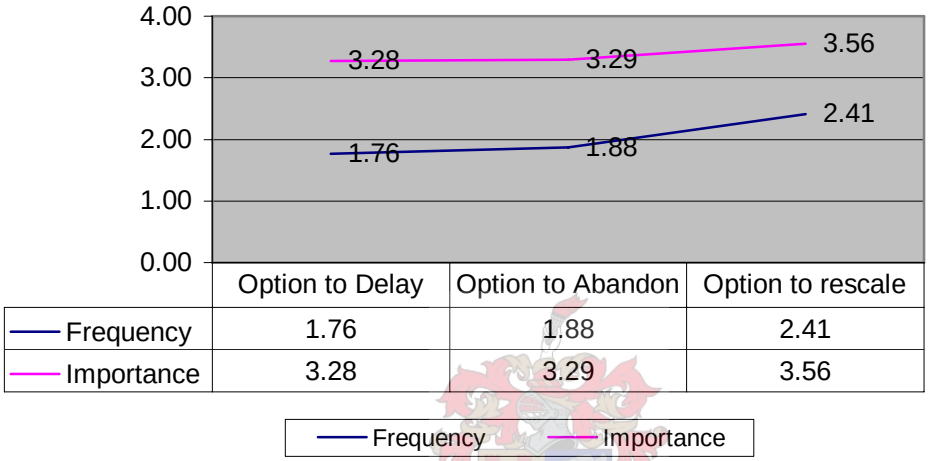


Figure 5.2 *Frequency of flexibility vs. Importance of flexibility*

The statistical significance of this relationship was tested using Spearman's Rank Order correlation. A statistically significant relationship exists between the importance and frequency for the option to abandon and for the option to rescale, while no such relationship is observed for the option to delay. The results of the test for each type of flexibility are shown in full in Appendix G but are summarised in Table 5.4 below.

Table 5.4 – *Correlation between frequency and importance of options*

Variable	p-value	Correlation co-efficient	Relationship
Option to delay	0.26900	0.26900	Statistically insignificant
Option to abandon	0.01779	0.51473	Statistically significant
Option to rescale	0.02737	0.48077	Statistically significant

The p-value for the option to abandon of 0.0178 was much lower than the 0.05 alpha, with a correlation of 0.5147. This suggests that a respondent is 51% more likely to give a higher rating to the option to abandon for every unit of rating of occurrence of the option. The p-value for the option to rescale was 0.0274 while the correlation coefficient was 0.4808. The p-value of 0.2690 for the option to delay was significantly higher than the 0.05 alpha, which led to the conclusion that no relationship exists between the frequency of occurrence of the option and the importance attached to it.

5.2.4 Creation of flexibility

Firms that have established programmes or policies to identify and assess options in their projects are thought to desire to have flexibility. A fair number of the surveyed firms have policies programmes to identify and assess flexibility in capital projects. However, the questionnaire does not require them to state the nature and specifics of these policies. Of the 21 respondents, 12 claim to have established these policies, 10 of which do not use ROV. This reinforces the belief that firms need and recognise flexibility in projects even if they do not use ROV. All three banks are among those who claim to have these policies, only half (three) of the natural resource companies have them and neither of the insurance firms claim to have such policies.

The results also suggest that firms that have these policies generally give the option to delay a higher rating of importance than those that do not have the policies. The mean importance rating given by firms in the group that have these policies is found to be significantly different from the mean of firms in the group that do have not the policies. The null hypothesis in the Mann-Whitney test that the two means are the same is then rejected based on a p-value of 0.02. From this, it is then concluded that this relationship is statistically significant. From Figure 5.2 below, it is does appear that the two means are different, with those who have policies included in category 1 while those without the policies are in category 2. The mean of 3.5 in category 1, is significantly higher than the mean of just under 2 in category 2.

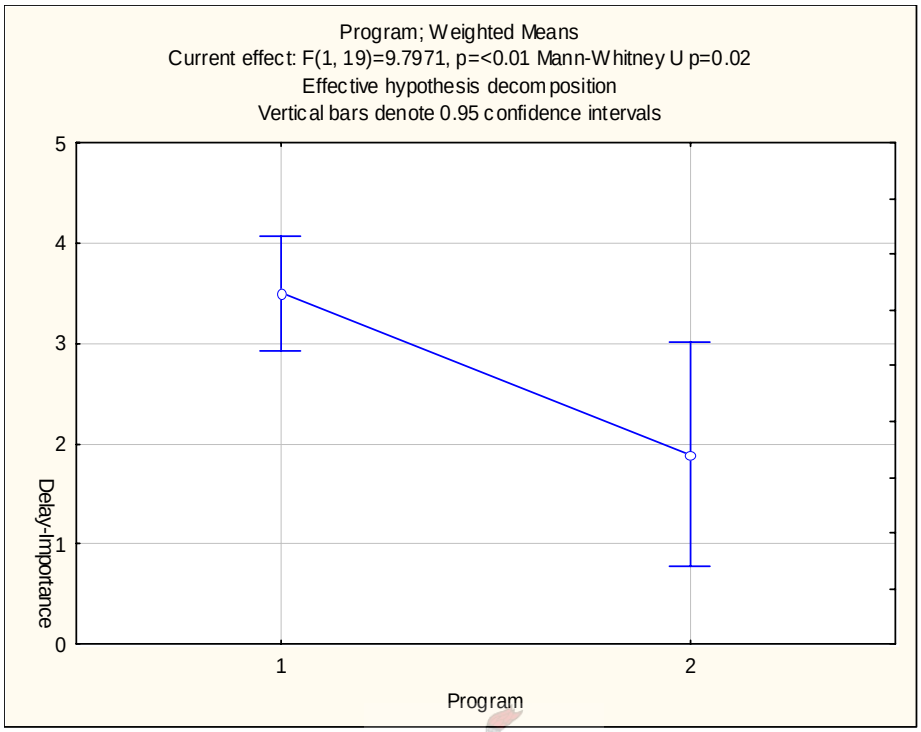


Figure 5.3 *Mann-Whitney test for correlation*

A similar test was conducted for the option to abandon and the option to rescale. The results suggest that there is no relationship between the importance attached to any of these options and a firm having a policy to identify flexibility. The results of the Mann-Whitney tests for these options are included in Appendix F. For the option to abandon, the p-value of 0.98 is too high to reject the null hypothesis and therefore the two means in categories 1 and 2 are considered to be similar. The p-value for the option to rescale is also too high at 0.26. This then suggests that firms establish these policies mainly to identify and assess the option to delay.

This finding seems to be in conflict with the conclusion that the option to delay is generally rated the least important of the three. However, even though the opportunity to delay investment seems to be the least important in some firms, it is valued more by firms that have policies to identify flexibility. It has a mean importance rating of 3.5 compared to the 3.0 and 3.1 of the options to abandon and rescale, respectively, among firms that have these policies. It is then concluded that firms that desire to have the opportunity to delay are more likely to have a policy to identify flexibility.

Of the 20 respondents that have had at least one of the stated types of flexibility, 19 claim to have anticipated the presence of flexibility in their projects. This implies that managers are able to recognise the presence of flexibility during the planning of a project, prior to implementation.

Table 5.5 – *Attributes of flexibility in investment decisions*

	Anticipated		**Necessary**		**Available**		**Exploited**	
	No.	%	No.	%	No.	%	No.	%
Yes	19	95	16	80	18	90	14	70
No	1	5	4	20	1	5	3	15
Not Sure	0	0	0	0	1	5	3	15
Total	**20**	**100**	**20**	**100**	**20**	**100**	**20**	**100**

Most of the firms attempt to incorporate the possibility of flexibility in their decisions when planning projects. This is reflected by the large number of respondents claiming to have considered some type of flexibility as necessary when deciding whether to approve a project. Of the 19 firms that anticipated the possibility of flexibility, 16 considered the presence of flexibility to be a necessary feature of the project. This result reaffirms the finding that managers generally deem flexibility in projects to be important.

A very small number of respondents, 3 out of 20, could not recall exploiting any of the flexibilities that had been available to them, while three respondents were not sure whether they had. It is possible that the possibilities of flexibility were not taken up because the firms did not deem it worthwhile to do so, given the prevailing conditions around the project. This would be similar to having an out-the-money option. However, some respondents might claim to be unsure of whether the possibility had been taken up if the project to which the flexibility relates is still under way, and the possibility is still available to be exploited. Ten respondents claim to have always negotiated flexibility in their projects, while nine experienced both the flexibility that came naturally to the

project and actually negotiated some into it. None of the 20 respondents claims to have never created flexibility in their projects.

5.2.5 Factors affecting the use of Real Options

Awareness of ROV

Of the three terms relating to the awareness of ROV, respondents appear to be more familiar with 'real options'. The terms 'growth options' and 'operating options' seem to be relatively less known. Six of the 20 respondents have never heard of any of the three terms. The responses of the other 14 differ regarding the knowledge of the terms. These results are summarised in Table 5.4 below.

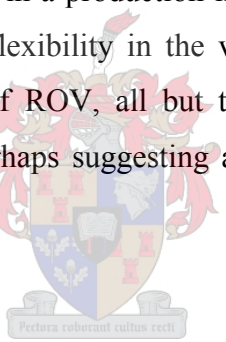
Table 5.6 – *Familiarity with real options terms*

Term	Real Options		Growth Options		Operating Options	
	No.	%	No.	%	No.	%
Unknown	9	43	11	52	11	55
Heard Of	6	29	4	19	5	25
Known	5	24	3	14	2	10
Used Regularly	1	5	3	14	2	10
Total	**21**	**100**	**21**	**100**	**20**	**100**

Although very few managers are found to be aware of real options, a larger percentage is aware, compared to the results in the previous studies. In total, 12 respondents claim to know about Real Options, however claiming different levels of knowledge. Of these, only seven are able to illustrate their knowledge of the term by giving what are deemed as accurate definitions and examples of real options. Two of the remaining five give definitions of the term that are not in line with the way it is used in the literature, and are therefore conclusively considered not to know about the term. The other three respondents do not give any definitions or examples to illustrate their knowledge of the

term and are also considered to be unaware of ROV. Ultimately, 33% (7 out of 21) of all respondents are concluded to be aware of ROV, with only two out of this seven actually using it to plan their projects. From this, it is also concluded that although awareness seems to affect the use of ROV, it is most likely not the only factor. This is because 70% (5 out of 7) of respondents that are aware of ROV are not using it.

Only three respondents claimed to have some knowledge of growth options and operating options without knowing about real options. As mentioned in Chapter 4, these respondents are classified as unaware of ROV, despite their claims to know about growth options and operating options. This is because growth options and operating options can be used in a context other than the one intended in the study. In fact, this was found to be the case where one respondent interviewed face-to-face, considered operating options to imply switching between operations in a production line but not necessarily considering or incorporating the value of this flexibility in the value of the project. Of the seven respondents deemed to be aware of ROV, all but two claim to know about Growth Options and Operating Options, perhaps suggesting a more in-depth knowledge of the real options topic in general.



Complexity of ROV

The two respondents that claim to know real options really well but are not using ROV, deem the technique to be very complicated. This could perhaps explain why they do not use the technique. Both respondents that use ROV give fairly accurate definitions and illustrations of the technique, suggesting that they deal with real options regularly. However, neither of these two considers the application of real options to be straightforward. At best, one respondent claims it to be ‘somewhat complicated’. Of the five firms that are aware of ROV but do not use it, three are not sure how complicated it is, suggesting that their knowledge of real options is perhaps not very deep. It is still possible that their knowledge of the technique is not shallow but rather that they have not attempted to use it in their projects and are therefore not certain how complicated it would be.

Based on these results, no definitive conclusion can be drawn on whether the complexity of ROV affects its use among firms as none of the respondents deems its application straightforward. It is however expected that in general, firms that consider flexibility in their projects to be important and simultaneously deem ROV to be straightforward, would be more likely to use the technique as it captures flexibility and is considered theoretically more sound than the traditional DCF-based techniques.

Industry Structure

Managers in three of the respondent firms think there are strong SMA in most of the projects in their industries. As can be seen from Table 5.7 below, those in nine firms believe that FMA are strong in most of the projects in their industries while seven believe both are equally represented by projects in their industries. Of the remaining two, one is not sure about the structure of competition in their industry while another feels that none of the two is recurrent in their industry. The latter could be possible if either FMA or SMA can exist but without being sustainable. In fact, of the two firms that use ROV, one observes neither FMA nor SMA in their industry.

This is not in contrast with Weeds's (2002) argument that ROV is less applicable when there is a sustainable FMA. Weeds' recommendation to use ROV in the presence of SMA is based on the assumption that there is competition in the industry. It is possible that a firm may not encounter competition for its projects. In that case, there is no SMA but ROV can still be applicable because the firm may still have the ability to postpone the investment decision. The other firm that uses ROV observed a more or less equal number of projects in its industry where either FMA or SMA is strong. Though not confirmed, it is expected that the firm used ROV only in projects where a strong SMA was observed and the traditional DCF-based techniques where FMA was observed.

Of the seven respondents that observe a sustainable FMA in their industries, five claim that the option to delay occurs in the 1 – 20% range (the lowest range) in their projects, while it is in the 21 – 40% range for the other two respondents. One respondent who

believed that projects in its industry generally conferred FMA, claimed to have had the opportunities to abandon and to rescale investment but not the opportunity to delay investing. These finding seem to support Weeds's argument that the FMA diminishes the ability to delay an investment decision.

Table 5.7 – *Industry Structures*

Industry Structure	**No. of Respondents**	
	No.	%
Sustinable FMA	9	43
Sustainable SMA	3	14
Both equally recurrent	7	33
None observed	1	5
Not Sure	1	5
Total	21	100

The relationship between the structure of competition and the use of ROV cannot be tested because of the small number of firms using ROV. Furthermore, there appears to be little similarity between the two firms that do use ROV in respect of the industry structure. The only similarity is that none of them consistently experiences a sustainable FMA in most of their projects. It would also be difficult to determine the relationship between the desire to have flexibility and the industry structure because in some categories of the latter factor there are too few observations to obtain a statistically significant result.

Capital Intensity

Capital intensity is measured as the average level of investment that a firm makes in its projects. Most respondents were forthcoming with this information despite concerns that they would not. None of them refused to respond to Question 4, while only two claimed to be unsure of the average investment in their projects. In the end, the responses of 19

respondents could be used to determine relationships between capital intensity and other factors. Not surprisingly, the firms in mineral resource industries invest in capital-intensive projects. The oil and gas firm and all the other mining firms, except one who was not sure, have an average investment of R100m each in their expansion projects. Banks tend to have a low investment average as do retailers, with firms in both industries well below the average of all surveyed firms.

Firms investing in capital intensive projects were expected to desire flexibility more and are therefore more likely to use ROV. As already mentioned, a test for the statistical significance of such a relationship cannot be done in this study because of the low number of firms that use ROV. It was expected that firms that desire to have flexibility are more likely to use ROV because the technique is specifically used to value flexibility. As a result, the relationship between the importance attached to each of the types of flexibility and the capital intensity of projects was tested. The results of the test for correlation between the two are shown in Figure 5.4 below.

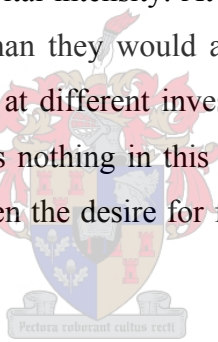
	Spearman Rank Order Correlations (Spreadshee MD pairwise deleted Marked correlations are significant at p <.05000			
Pair of Variables	Valid N	Spearman R	t(N-2)	p-level
Cap. Intensity & Delay-Importance	19	0.187146	0.785501	0.442971
Cap. Intensity & Abandon-Importance	19	0.322944	1.406916	0.177472
Cap. Intensity & Rescale-Importance	19	0.097107	0.402283	0.692489

Figure 5.4 *Correlation of Capital Intensity and Desirability of Flexibility*

The results of the Spearman test for correlation suggest that the relationship between capital intensity and the desire to have flexibility is statistically insignificant. The p-value for the option to delay was well above the 0.05 threshold at 0.44297, with 0.17747 recorded for the option to abandon and 0.69249 for the option to rescale. On this basis, it is then concluded that there is no discernible relationship between capital intensity and the desire to have flexibility. If there is no relationship between capital intensity and the desire for flexibility, the implication is that the capital intensity of firms would not influence a firm to use ROV, which of course would not make intuitive sense.

The average investment in expansion projects of one of the two firms that use ROV is no less than R100m, which also happens to be in the highest bracket of capital intensity. The average investment of the other firm that uses ROV, the average investment is between R21m andR30m, which is the fifth lowest average of 19 firms. It is apparent then that there are many other firms whose projects are capital intensive but which do not use ROV. This could support the conclusion that the level of capital invested in projects does not affect the use of ROV.

It is suspected though that there is a minimum amount of investment for which ROV becomes relevant, and this amount may be lower than the R21m – R30m range that the respondent's average investment level is in. In other words, it is possible that beyond a certain investment level, the desire to have flexibility (and the need to use ROV) is determined by factors other than capital intensity. At low levels of investment, firms are expected to desire flexibility less than they would at higher levels. Perhaps observing managers' desire to have flexibility at different investment levels would probably have made more sense. However, there is nothing in this study to suggest that a statistically significant relationship exists between the desire for flexibility and capital intensity as it is measured in the study.



5.2.6 Capital Budgeting

As suspected, traditional DCF-based techniques are still popular with firms. This is perhaps not too surprising as most firms, not just in South Africa, still seem to use these techniques. A summary of the capital budgeting techniques discussed in Section 2.4 of Chapter 2 and the percentages of firms that use them is shown in Figure 5.5 below.

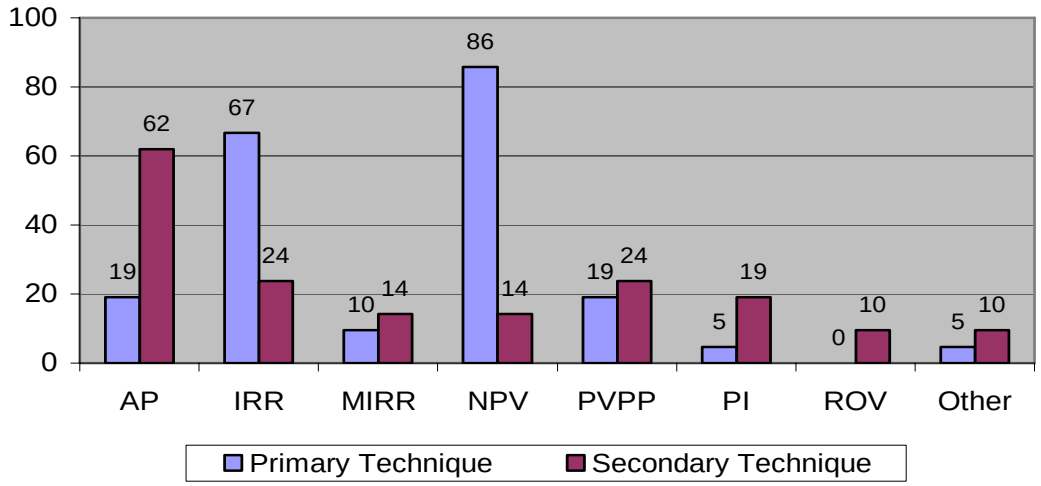


Figure 5.5 *The capital budgeting techniques used by respondents*

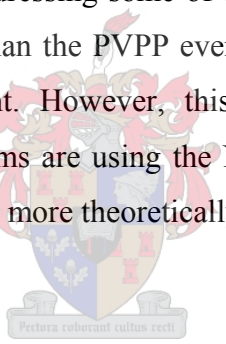
Petry's argument in Parry and Frier that capital intensive firms tend to use a wide array of capital budgeting techniques is reaffirmed by the findings of this study. It is noted though that firms that invest in less capital intensive projects also use more than one technique to plan and evaluate their investments. In fact, none of the firms are found to be using a solitary technique in their evaluation of projects. All firms use at least one technique as the primary technique and another as a secondary technique. Only one respondent firm uses no more than two techniques, with the NPV as its primary technique. Two firms use a minimum of six techniques, and these are the two that also use ROV. As already mentioned, managers possibly use more than one technique to ensure the validity of their decisions.

The NPV and the IRR appear to be the most popular techniques with respondents. They were both recommended in the literature prior to the emergence of the ROV. The NPV is the most widely used technique, with 18 (86%) respondents using it as a primary technique while three use it as a secondary technique. In effect, all respondents are using NPV in their project evaluations, whether as a primary or secondary technique.

The IRR is the second most popular technique (91%), followed by the AP (81%), then PVPP (43%), MIRR (24%) and then the PI (24%). The AP seems to be more popular as a secondary technique, with 13 of 21 respondents using as such. This reflects the needs of

managers to determine the payback periods of projects they invest in. Only two respondents claim to be using techniques in addition to those mentioned in the questionnaire. These include Capital Efficiency, Return on Net Assets (RONA) and Economic Value Added (EVA). And as already mentioned, 2 out of 22 (9.1%) firms claim to be using ROV, and one of the two is a mining firm. This lends some credence to Gitelman's (2002) belief that firms whose input or output is traded will find ROV to be relevant to them. Rather surprisingly, the other firm using ROV is in banking. This also supports the arguments of Borison (2003), Trigeorgis (2001) and Wang (2005) that ROV can still be applicable in industries whose input or output is not traded.

There is however still some suspicion that firms do not always use the best techniques recommended in the literature. First of all, the MIRR is less popular with respondents than the IRR, despite the former addressing some of the limitations of the latter. Rather surprisingly, the AP is used more than the PVPP even though the AP does not take the time value of money into account. However, this does not detract from a more encouraging finding that at least firms are using the NPV, which among the traditional DCF-based techniques, is considered more theoretically sound.



5.3 Qualitative Data

As already mentioned, only seven respondents in the current study, define the term real options in line with the way it is used in the literature. While most of these respondents merely stated their definitions of the term, some went further to give illustrations that further demonstrated their understanding of real options, using figures and examples. Not surprisingly, the two respondents that use ROV were more forthcoming about their knowledge of real options. Only two respondents responded to Question 24. One respondent recommends that the terms 'Real Options', 'Growth Options' and 'Operating Options' be defined in the questionnaire as respondents might be using similar concepts but under different names. While this is a valid suggestion, the whole point behind asking about these terms was to establish whether respondents were aware of real option terminology.

The other respondent suggested that while it is important to place some emphasis on the capital budgeting technique used to plan and evaluate a project, managers should not focus too much on choosing the valuation technique. Rather, the focus should shift to measuring as accurately as possible, all the factors relevant to the project such as expected cash flows and discount rate. More importantly, the technique and decision tools used should facilitate the decision-making process to make it as easy as possible without sacrificing accuracy. While the respondent firm acknowledges they use ROV to plan their investments, they do not necessarily believe it is the technique used that will influence whether or not a good investment decision is made.

Summary

A response rate of 53% was attained in the survey with 21 of the 40 targeted firms responding. One additional respondent is considered to not be using ROV despite not completing the question, because the firm deemed the study not relevant to them. In general, 2 out of 22 firms claim to be using the technique, although both firms are using it as a secondary technique. The opportunity to delay investment is observed to be the most common of the three among respondents, while the opportunity to rescale is the most recurrent in firms and is also rated the most important. It seems that firms that have established policies to identify flexibility generally desire to have the option to delay more than those without such policies. There seem to be no such relationship for the options to delay and abandon. It is concluded that managers recognise flexibility since most of them anticipate flexibility opportunities in projects, and at times, consider such flexibility to be necessary features of their projects. Few managers are aware of real options in application, and those that are aware deem the application of ROV to be difficult. Given the low number of firms (two) using ROV, it cannot be determined whether a statistically significant relationship exists between the use of ROV and any of the factors expected to affect its use (Extent of awareness of ROV, Capital Intensity, Industry Structure and Complexity of ROV).

Chapter 6
Conclusion and Recommendations

This chapter briefly summarises the main findings of the research and also makes recommendations for further research.

6.1 Conclusions

The study targeted firms included in the FTSE/JSE Top 40 index as they are some of the largest listed firms in South Africa. They are considered the most likely candidates for the use of ROV. A response rate of 53% was achieved, with 21 of the 40 firms participating in the survey. The other 19 firms did not respond for various reasons, and one of these firms deemed the questionnaire irrelevant to them given their line of business. It was then concluded that the firm does not use ROV as a result.

The following are conclusions with reference to the objectives of the study:

- Firms included in the FTSE/JSE Top 40 index generally do not use ROV,
- None of the factors suggested in section 4.3.3 of chapter 4 can be firmly concluded to affect the use of ROV, and
- Most managers seem to recognise or have a need for flexibility in their planning.

It is concluded that most respondent firms do not use ROV given that only 2 out of 22 (9.1%) are using it. Although this conclusion is based on half of the targeted sample, it seems somewhat unlikely that a notably higher number of firms out of the 18 that did not respond will be using ROV. This is because managers in many of the firms expected to consider using it (mostly mineral resource firms) are not even aware of real options.

The capital intensity of projects, the awareness of ROV, the industry structure and the complexity of ROV were all suggested as possible factors affecting the use of ROV. The

number of firms using ROV is too small to determine the existence of a statistically significant relationship between the use of ROV and any of these factors. As a result, no firm conclusion can be reached on any of the relationships between them.

It is noted though that very few respondents know about ROV, suggesting that the lack of awareness might explain the non-use of ROV, at least to some degree. Only 33% of the respondents are aware of ROV, but most of them appear to have a rather shallow knowledge of the technique. However, none of the respondents claiming to know about ROV deem the technique to be easy to use, including the two firms that use it. This has led to the conclusion that managers generally perceive ROV to be complex to use. It is noted though that the two respondents that use ROV are among those that deem the technique to be less complex. However, without sufficient data, no firm conclusion can be made regarding these observations.

Although intuition suggests otherwise, there is little from the results to suggest that capital intensity affects either the desirability for flexibility or the use of ROV. The same can be said about the industry structure, as there is no solid relationship between a firm's perception of the structure of its industry and whether it uses ROV. None of the two firms using ROV observe a recurrent and sustainable SMA in projects in their industries as would have been expected. At the same time, these firms' industries are not associated with a sustainable FMA either, suggesting that the firms may still have the ability to delay some of their projects.

While very few firms are using ROV, it may be encouraging for real options proponents that since the studies by Busby and Pitts and (1997) and Collan and Långström (2002), at least some are using it. It also seems that more managers are becoming aware of real options, and this could imply that firms could slowly start adopting the use of ROV. Furthermore, more and more firms are now using the NPV, a technique that academics advocated for a long time but which was largely ignored in practice. Firms sluggishly adopted the use of NPV in project evaluation but the technique is now predominantly used by most large firms. It might also be some time still before managers start to think

of the ROV as a viable alternative for evaluating projects. However, the fact that only a few managers seem to know about real options might delay the adoption of ROV in firms even more.

It is also concluded that managers recognise flexibility in their projects. This is based on a number of factors. First of all, managers appear to desire to have flexibility in their projects, as reflected by the high importance ratings they give the three types of flexibility. Secondly, managers also claim to have at some stage anticipated flexibility in a project before sanctioning it and to have also considered this flexibility to be a necessary component of the project. This suggests that managers recognise the presence of flexibility in their projects and somehow attempt to incorporate it into their decisions. In addition, most firms also seem to have established policies designed to identify flexibility in their projects. Some of the managers in the study claimed to have negotiated some of the opportunities for flexibility in their projects, suggesting that they see the need for this flexibility and might perhaps be willing to pay to have it in their investments.

6.2 Limitations of the study

Admittedly, results based on a larger sample would have provided a broader insight on the entire South African market compared to those based on a smaller sample, such as the one used in this study. As a result of using a small sample, none of the conclusions reached about the capital budgeting practices of FTSE/JSE Top 40 firms can be used to generalise about all listed South African firms. However, as already mentioned, the study was mainly aimed at observing flexibility in the larger firms that are more likely to use ROV. The study was intended to assess whether a larger-scale study focusing on the entire South African market would be warranted. Despite the relatively small scale of the study, some useful insights have emerged from surveying the large firms.

It was also observed that face-to-face interviews tended to yield more useful respondent feedback. With this approach, respondents were generally more forthcoming with information and were able to explain some aspects of their responses as well as giving

additional details about the flexibility in their projects. Respondents who did not know about real options also had the opportunity to ask about the concept, which seemed to incite their interest in ROV. However, due to a lack of resources, it was not possible to conduct face-to-face interviews with all targeted respondents.

6.3 Recommendations

6.3.1 Recommendations for further research

The following are some of the main recommendations for further research:

1. Based on the findings and conclusions reached in this study, a broader study on the use of ROV is not recommended for now, at least not one focusing on the use of ROV among all South African firms. It is doubtful whether an extended survey on the entire South African market would deliver significantly different results. If the JSE Top 40 firms are not using ROV, chances are good that it will be the case for the rest of the market.

2. It might however be worthwhile to conduct research on flexibility in South African firms, particularly focusing on firms in either Mining or IT as expansion projects in these industries tend to be very capital intensive and are associated with a lot of uncertainty. Therefore, these firms would be more likely to use ROV.

6.3.2 Recommendations for real options proponents

Below are the recommendations made to proponents of real options in capital budgeting, and they are largely made with a view to increasing the adoption of ROV in firms:

1. If the use of ROV in capital budgeting is to spread among South African firms, managers' awareness of the application of real options has to be addressed. This could entail publishing more articles about real options in popular financial

magazines, particularly focusing on case studies that highlight how the technique has been used by others to plan expansion projects. Case studies are probably more likely to illustrate better the benefits of using ROV as opposed to academic journal articles that present real options in an abstract theoretical manner. Copeland and Antikarov have attempted to do this in their book 'Real Options: A Practitioner's Guide' which is aimed at getting managers to think about optionality in projects. Even if managers are not entirely convinced that ROV is not significantly more complex to use than other techniques, exposure through publications may draw managers' attention to the technique, especially as some seem dissatisfied with some of the static assumptions of the traditional DCF-based techniques.

2. While the use of ROV in firms is still in its infancy, some are using it despite finding it difficult to apply. It might then be worthwhile to do more research on ROV applications to devise easier methods of applying the principles of real options to plan projects. This might encourage more managers to start using it.

3. It might also be advisable to encourage the inclusion of the topic of real options in the finance syllabus at tertiary level as one of the capital budgeting techniques. MBA programmes in particular, should include this module, to at least initiate some form of education and awareness of the technique.

6.3.3 Recommendations for managers

The following recommendations are made to managers in companies regarding the use of ROV:

1. It is clear that traditional DCF-based techniques undervalue company projects, as reflected by the difference between valuations based on managers' intuition and the values estimated using these techniques. As was done at Airbus, a small division in the finance department of a firm could be assigned to do research on the use of real options and to determine whether there will be financial benefits to using ROV.

2. As one respondent noted, it is perhaps more important to establish policies that lead to accurately measuring all parameters of a project rather than focusing on the complexity of the method used. It is pointless for a firm to use ROV if the parameters used are not accurately measured and if the policy framework does not support an easy decision making process.

The results of the study suggest that it will be some time before firms generally adopt ROV, as they did the NPV. However, it is encouraging that South Africa, as an emerging market, has at least some firms that show such a high level of sophistication in capital budgeting, that they use ROV. The complete adoption of ROV in companies in general, still seems to be some way off though. ROV represents an advancement of modern financial theory and should therefore take its rightful place in the financial management of South African companies.

Appendix A – List of JSE Top 40 firms

AGL	Anglo America Plc
AMS	Anglo American Platinum Corporation Ltd
ANG	AngloGold Ltd
ASA	Absa Group Ltd
BAW	Barloworld Ltd
BIL	BHP Billiton Plc
BVT	The Bidvest Group Ltd
ECO	Edgars Cons Stores Ltd
FSR	FirstRand Ltd
GFI	Gold Fields Ltd
HAR	Harmony Gold Mining Company Ltd
IMP	Impala Platinum Holdings Ltd
INL	Investec Ltd
INP	Investec Plc
IPL	Imperial Holdings Ltd
JDG	JD Group Ltd
KMB	Kumba Resources Ltd
LBT	Liberty International Plc
LGL	Liberty Group Ltd
MLA	Mittal Steel SA Ltd
MTN	MTN Group
NED	Nedcor Ltd
NPK	Nampak Ltd
NPN	Naspers Ltd
NTC	Network Healthcare Holdings Ltd
OML	Old Mutual Plc
PIK	Pick 'n Pay Stores Ltd
PPC	Pretoria Portland Cement
RCH	Richemont Securities AG
REM	Remgro Ltd
RMH	RMB Holdings Ltd
SAB	SABMiller Plc
SAP	Sappi Ltd
SBK	Standard Bank Group Ltd
SHF	Steinhoff International Holdings Ltd
SLM	Sanlam Ltd
SOL	Sasol Ltd
TBS	Tiger Brands Ltd
TKG	Telkom SA Ltd
VNF	Venfin Ltd
WHL	Woolworths Holdings Ltd

Appendix B – Option calculation from Figure 2.2, Chapter 2

From Figure 2.2, Chapter 2

Calculation of project values along the lattice:

$S_0 = 100$
$S_0u = 100 \times 1.19 = 119$
$S_0d = 100 \times 0.84 = 84$
$S_0u^2 = 100 \times 1.19^2 = 142$
$S_0du = S_0ud = 100 \times 1.19 \times 0.84 = 100$
$S_0d^2 = 100 \times 0.84^2 = 71$
$S_0u^3 = 100 \times 1.19^3 = 170$
$S_0du^2 = S_0u^2d = 100 \times 1.19^2 \times 0.84 = 119$
$S_0ud^2 = S_0d^2u = 100 \times 0.84^2 \times 1.19 = 84$
$S_0d^3 = 100 \times 0.84^3 = 60$

From **Figure 2.2**

Calculation of option values along the lattice:

Option value at A = max (170 – 115, 0) = 55

Option value at B = C = E = max (119 – 115, 0) = 4

Option value at D = F = G = max (84 – 115, 0) = 0

Option value at H = max (59 – 115, 0) = 0

Option value at I = $[(0.5336)(55) + (1 - 0.5336)(4)]\, e^{(-0.08)(0.33)}$
= R30.4003m

Option value at J = K = $[(0.5336)(4) + (1- 0.5336)(0)]\, e^{(-0.08)(0.33)}$
= R2.0788m

Option value at L = $[(0.5336)(0) + (1 - 0.5336)(0)]\, e^{(-0.08)(0.33)}$
= 0

Option value at M = $[(0.5336)(30.4003) + (1 - 0.5336)(2.0788)]\, e^{(-0.08)(0.33)}$
= R16.7432m

Option value at N = $[(0.5336)(2.0788) + (1 - 0.5336)(0)]\, e^{(-0.08)(0.33)}$
= R1.0803m

Option value at P = $[(0.5336)(16.7432) + (1 - 0.5336)(1.0803)]\, e^{(-0.08)(0.33)}$
= R9.1921m

Appendix C – Questionnaire

Survey supported by Stellenbosch University. This research is conducted by Lehlohonolo Mokenela – March 2006.

You have been selected to take part in a survey on 'Flexibility in Company Expansion Projects'. Some capital projects may require various flexibility options (option to delay, option to abandon or the option to rescale the size of a project). The purpose of this survey is to determine how South African firms initiate expansion projects. Respondents are assured of total anonymity in the study. Neither names of persons completing the questionnaire nor of their companies will be mentioned in association with any responses in the study. Please take a few moments to complete this questionnaire. Your feedback will be greatly appreciated.

Please mark the box with your answer/s with an 'X' and/or fill in the blank space provided. **FOR EXAMPLE:**

How important do you consider it to have the option to abandon a project when deciding on sanctioning the project?

	Completely Unimportant
	Not Especially Important
X	***Moderately Important***
	Very Important
	Extremely Important
	Not Sure

The box next to Moderately Important has been marked with an X to indicate the chosen response. The possible answers are organised in an ascending order of importance, where Completely Unimportant suggests the lowest level of importance and, Not Especially Important suggests a higher level of importance followed by Moderately Important, Very Important and then lastly by Extremely Important which indicates the highest level of importance attached to the issue in question. In all other questions, possible answers are not organised in any order of significance, such as questions requiring a Yes or No answer.

SECTION A: DEMOGRAPHIC

1. Please indicate in which of the following industries, the core of your business operations is:

☐	Banking	☐	Insurance
☐	Construction and Metals	☐	Media
☐	Financial Services	☐	Mining
☐	Food and Beverage	☐	Oil and Gas
☐	Forestry and Paper	☐	Personal and Household Goods
☐	Healthcare	☐	Retail
☐	Industrial Goods and Services	☐	Telecommunications
☐	Industrial Metals	☐	Other (Please specify)

2. Is the core of your business operations based primarily in South Africa or Internationally?

☐ South Africa
☐ Internationally
☐ Spread out evenly between the two

SECTION B: QUESTIONNAIRE

3. In some circumstances, it may be better to be the first to introduce a new product or service as it can lead to a significant and sustainable dominance in that market – this may be referred to as a **First Mover Advantage**.

   In some circumstances it is better to allow a competitor to be first to enter a market first in order to observe their entry and then follow only if the competitor realize success – this may be referred to as the **Second Mover Advantage**.

Which of these cases would you say is more recurrent in your industry?

☐ First Mover Advantage
☐ Second Mover Advantage
☐ Both equally recurrent
☐ Neither occurs
☐ Not Sure

4. What is the average initial investment expenditure on a single project in your company?

- ☐ R1m – R10m
- ☐ R11m – R20m
- ☐ R21m – R30m
- ☐ R31m – R40m
- ☐ R41m – R50m
- ☐ R51m – R60m
- ☐ R61m – R70m
- ☐ R71m – R80m
- ☐ R81m – R90m
- ☐ R91m – R100m
- ☐ Above R100m
- ☐ Not Sure

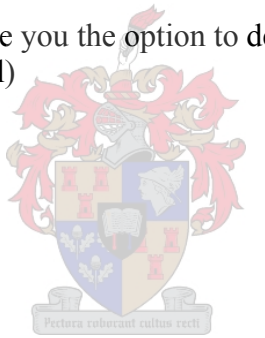
5. Do you ever invest in projects that give you the **possibility/option to delay** or **postpone** investing in a project until a later period?

☐ Yes ☐ No ☐ Not Sure

If 'No' or 'Not Sure', please go to Question 8.

6. How many of your projects give you the option to delay investment? (Answer expressed as percentage of total)

- ☐ 1 – 20%
- ☐ 21 – 40%
- ☐ 41 – 60%
- ☐ 61 – 80%
- ☐ 81 – 100%
- ☐ Not Sure



7. How important do you consider it to have the option to delay when deciding to sanction a project?

- ☐ Completely Unimportant
- ☐ Not Especially Important
- ☐ Moderately Important
- ☐ Very Important
- ☐ Extremely Important
- ☐ Never Considered it

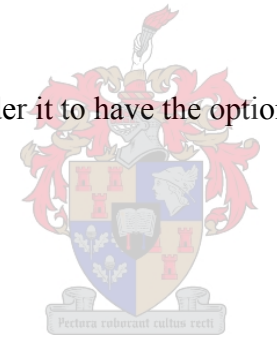
8. Do you ever invest in projects that give you the **possibility/option to abandon** a project if it is anticipated to be unprofitable?

☐ Yes ☐ No ☐ Not Sure

If 'No' or 'Not Sure', please go to Question 11.

9. How many of your projects give you the option to abandon a project? (Answer expressed as percentage of total)

☐ 1 – 20%
☐ 21 – 40%
☐ 41 – 60%
☐ 61 – 80%
☐ 81 – 100%
☐ Not Sure



10. How important do you consider it to have the option to abandon when deciding to sanction a project?

☐ Completely Unimportant
☐ Not Especially Important
☐ Moderately Important
☐ Very Important
☐ Extremely Important
☐ Never Considered it

11. Do you ever invest in projects that give you the **possibility/option to adjust** the scale of a project up or down if market expectations turn out better or worse than anticipated?

☐ Yes ☐ No ☐ Not Sure

If 'No' or 'Not Sure', please go to Question 14

12. How many of your projects give you the option to adjust the scale of a project? (Answer expressed as percentage of total)

- ☐ 1 – 20%
- ☐ 21 – 40%
- ☐ 41 – 60%
- ☐ 61 – 80%
- ☐ 81 – 100%
- ☐ Not Sure

13. How important do you consider it to have the option to adjust the scale of a project when deciding to sanction the project?

- ☐ Completely Unimportant
- ☐ Not Especially Important
- ☐ Moderately Important
- ☐ Very Important
- ☐ Extremely Important
- ☐ Never Considered it

14. Did you **anticipate** ANY of the flexibility options mentioned in Questions 5, 8 and 11 before the relevant project(s) was/were sanctioned?

☐ Yes ☐ No

15. Did you feel that ANY of the flexibility options mentioned in Questions 5, 8 and 11 were **necessary** in order for the relevant project(s) to be sanctioned?

☐ Yes ☐ No

16. Were ANY of the options mentioned in Questions 5, 8 and 11 **available** to you before the relevant project(s) was/were sanctioned?

☐ Yes ☐ No ☐ Not Sure

17. Did you **exploit** ANY of the options mentioned in Questions 5, 8 and 11?

☐ Yes ☐ No ☐ Not Sure

18. Did any of the options mentioned in Questions 5, 8 and 11 come coincidentally to the project or did you have to deliberately create or negotiate them into the project?

- ☐ Coincidental
- ☐ Created/Negotiated
- ☐ Some coincidental, some negotiated
- ☐ Other (Please Comment)

19. Do you have a program in your company to identify or assess any flexibility options in capital investments?

☐ Yes ☐ No ☐ Not Sure

20. Please indicate which of the following techniques you use for planning investments and whether you use them as primary or secondary techniques.

Capital Budgeting Technique	Primary Technique	Secondary Technique	Do not use Technique
Accounting Payback (AP)	☐	☐	☐
Internal Rate of Return (IRR)	☐	☐	☐
Modified Internal Rate of Return (MIRR)	☐	☐	☐
Net Present Value (NPV)	☐	☐	☐
Present Value Payback Period (PVPP)	☐	☐	☐
Profitability Index (PI)	☐	☐	☐
Real Option Valuation (ROV)	☐	☐	☐
Other (please specify):	☐	☐	☐

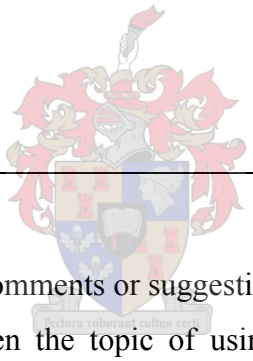
21. Please indicate how familiar you are with each of the following, with regard to capital budgeting:

	Unknown	Heard of	Familiar	Used Regularly
Real Options	☐	☐	☐	☐
Growth Options	☐	☐	☐	☐
Operating Options	☐	☐	☐	☐
Comments:				

22. Would you say you find the application of Real Options in planning capital investments to be:

- ☐ Very Straightforward
- ☐ Relatively Easy
- ☐ Somewhat Complicated
- ☐ Very Complicated
- ☐ Extremely Complicated
- ☐ Not sure

23. Please give an indication of what you consider the term real options to imply, either by definition or by way of example.



24. Please feel free to make any comments or suggestions on either the survey in general, the questionnaire itself or even the topic of using flexibility options in company expansion projects.

Please save the completed questionnaire and reply to the sender via email with the attached questionnaire.

Thank you very much for taking the time to fill out the questionnaire!

Appendix D – Response Codes

	Answer	Code		Answer	Code
Question 1	Banking	1	**Question 5**	Yes	1
	Construction & Metals	2		No	2
	Financial Services	3		Not Sure	0
	Food and Beverages	4			
	Forestry & Paper	5			
	Healthcare	6			
	Ind. Goods & Services	7	**Question 6**	1 - 20%	1
	Industrial Metals	8		21 - 40%	2
	Insurance	9		41 - 60%	3
	Media	10		61 - 80%	4
	Mining	11		81 - 100%	5
	Oil & Gas	12		Not Sure	0
	Personal & H/H Goods	13			
	Retail	14			
	Telecommunications	15			
	Other	16	**Question 7**	Completely Unimportant	1
				Not Especially Important	2
				Moderately Important	3
				Very Important	4
Question 2	South Africa	1		Extremely Important	5
	Internationally	2		Never Considered it	0
	Spread out evenly	3			
			Question 8	Yes	1
Question 3	First Mover Advantage	1		No	2
	Second Mover Advantage	2		Not Sure	0
	Both Equally Recurrent	3			
	Neither Occurs	4			
	Not Sure	0			
			Question 9	1 - 20%	1
				21 - 40%	2
				41 - 60%	3
Question 4	R1 - R10m	1		61 - 80%	4
	R11 - R20m	2		81 - 100%	5
	R21 - R30m	3		Not Sure	0
	R31 - R40m	4			
	R41 - R50m	5			
	R51 - R60m	6			
	R61 - R70m	7	**Question 10**	Completely Unimportant	1
	R71 - R80m	8		Not Especially Important	2
	R81 - R90m	9		Moderately Important	3
	R91 - R100m	10		Very Important	4
	Above R100m	11		Extremely Important	5
	Not Sure	0		Never Considered it	0

Appendix D Continued…….

	Answer	Code		Answer	Code
Question 11	Yes	1	Question 18	Coincidental	1
	No	2		Created/Negotiated	2
	Not Sure	0		Some Negotiated/Neg.	3
				Other	4
Question 12	1 - 20%	1			
	21 - 40%	2	Question 19	Yes	1
	41 - 60%	3		No	2
	61 - 80%	4		Not Sure	0
	81 - 100%	5			
	Not Sure	0			
			Question 20	***Technique***	
				Primary Technique	1
Question 13	Completely Unimportant	1		Secondary Technique	2
	Not Especially Important	2		Do Not use Technique	3
	Moderately Important	3			
	Very Important	4			
	Extremely Important	5			
	Never Considered it	0	Question 21	Unknown	0
				Heard Of	1
				Familiar	2
				Used Regularly	3
Question 14	Yes	1			
	No	2			
	Not Sure	0			
			Question 22	Very Straightforward	1
				Relatively Easy	2
				Somewhat Complicated	3
Question 15	Yes	1		Very Complicated	4
	No	2		Extremely Complicated	5
	Not Sure	0		Not Sure	0
Question 16	Yes	1			
	No	2			
	Not Sure	0			
Question 17	Yes	1			
	No	2			
	Not Sure	0			

Appendix E – Cover Letter

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Stellenbosch
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Mobile: (0027) (0)82 500 5775
Fax: (0027) (0)21 887 1261

RE: Survey on Capital Budgeting

Dear Sir/Madam,

This is in support of the questionnaire sent via email. We are conducting a survey on the Capital Budgeting practices of South African firms and how they deal with options in expansion projects. A questionnaire for the survey is attached to this letter together with a self-addressed envelope and postage stamp. Please take a few moments to complete the questionnaire and post it to the given address on the attached envelope.

The first page of the questionnaire gives a description of the survey and an example of how the questionnaire should be completed. You are assured of total anonymity as the results of this survey will be used in aggregate and there will be no mention of any particular respondent when reporting the results.

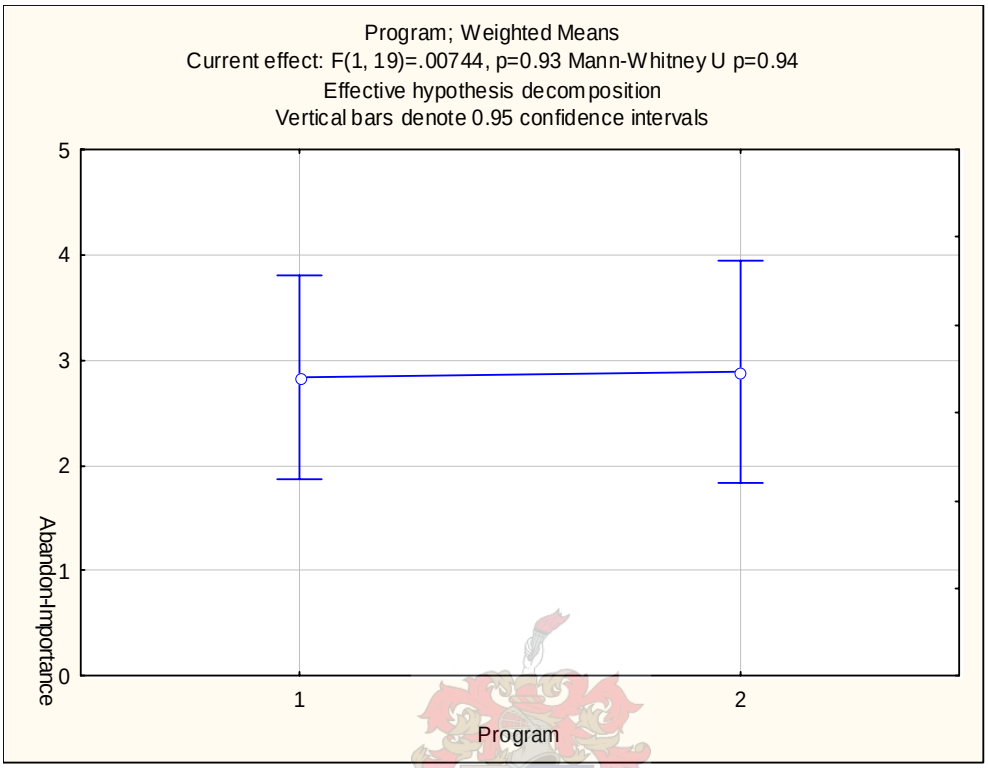
Please feel free to contact me anytime on the details above or get in touch with Professor Johan van Rooyen on 083 326 6886 if you have any questions.

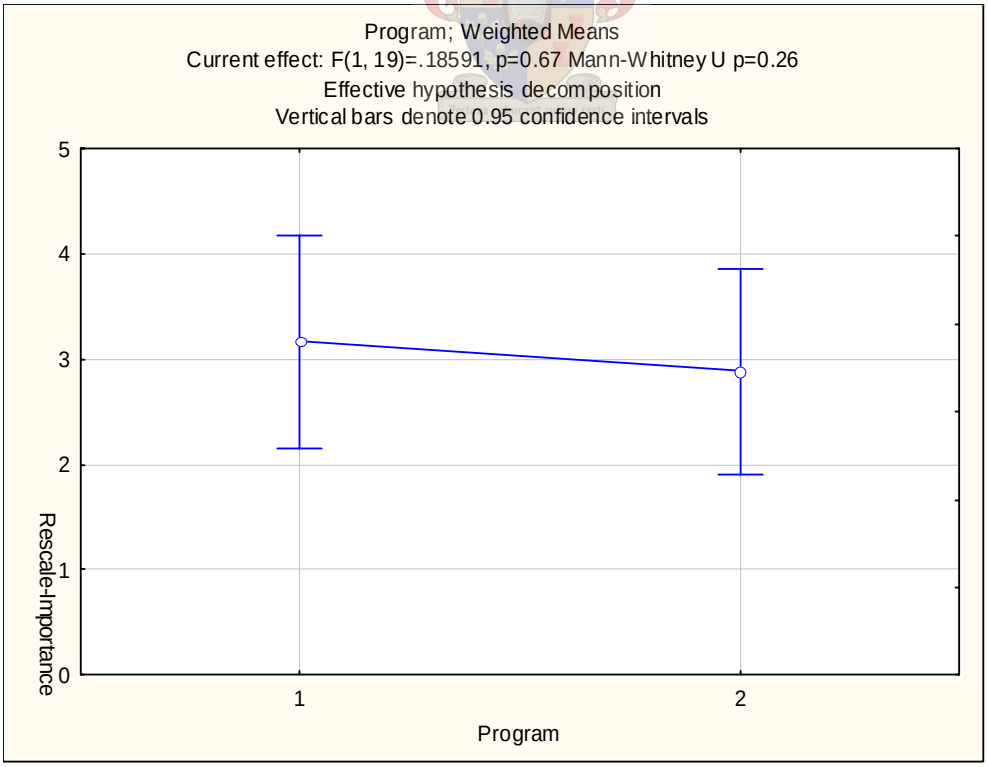
Thank you very much for your time.

Yours Faithfully,

Lehlohonolo Mokenela

Appendix F – The importance of options and the programs





Appendix G - The importance of options and the programs

Correlation for the option to delay

Pair of Variables	Spearman Rank Order Correlations (Spreadsheet1 MD pairwise deleted Marked correlations are significant at p <.05000 Valid N	Spearman R	t(N-2)	p-level
Delay-Occure & Delay-Importance	21	0.0.252744	.1.138656	.0.269001

Correlation for the option to abandon

Pair of Variables	Spearman Rank Order Correlations (Spre MD pairwise deleted Marked correlations are significant at p <. Valid N	Spearman R	t(N-2)	p-level
Abandon-Occure & Abandon-Importance	21	0.511473	2.594508	0.017792

Correlation for the option to rescale

Pair of Variables	Spearman Rank Order Correlations (Sprea MD pairwise deleted Marked correlations are significant at p <.0 Valid N	Spearman R	t(N-2)	p-level
Rescale-Occure & Rescale-Importance	21	0.4807658	2.389932	0.027372

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