

UNIVERSITY OF KWAZULU-NATAL

**A Real Options Approach to Evaluating Investments in the  
South African Chemical Industry**

by  
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# **Confidentiality Clause**

**November 2006**

**TO WHOM IT MAY CONCERN**

**RE: CONFIDENTIALITY CLAUSE**

Due to the strategic importance of this research it would be appreciated if the contents remain confidential and not be circulated for a period of five years.

Sincerely

A handwritten signature in black ink, appearing to read 'T. Moodliar', with a long horizontal stroke extending to the right.

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## Declaration

This research has not been previously accepted for any degree and is not being currently considered for any other degree at any other university. I declare that this Dissertation contains my own work except where specifically acknowledged.

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Signed.....  
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## **Abstract**

Investment in the South African economy is acutely needed for it to absorb the high numbers of unemployed and to grow the economy. The valuation of potential investments needs to capture all sources of revenue so that the investor has all possible information about the enterprise. The current methods of evaluating capital investment in the South African Chemical Industry continue to be based almost exclusively on Discounted Cash Flow (DCF) methods. While these techniques are certainly useful, they are unable to capture all aspects of capital investment viability. A more recent valuation technique of regarding investments as options can substantially change the decision making process about capital investment.

Investment in the chemical industry can be viewed as a strategic initiative to develop the long term potential of the industry. This investment can also contribute to growth in other sectors of the economy. While these benefits are difficult to measure, the criteria of maximizing investor returns remain the cornerstone of any investment decision. Using the DCF methods and real options framework for analyzing capital investments, a proposed investment to manufacture the chemical resorcinol in South Africa will be analysed. This study will illustrate how the real options approach, developed in this study, can more fully capture the dynamic and strategic value of the investment project, than the DCF methods.

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# **Chapter One: Introduction**

## **1.1 Introduction**

Investment in the South African economy is acutely needed for it to absorb the high numbers of unemployed and to grow the economy. However investment in any enterprise is driven by the profit motive: investors will only invest where their return on capital is maximized. The valuation of potential investments needs to capture all sources of revenue so that the investor has all possible information about the enterprise. However, current methods of evaluating capital investment in the South African Chemical Industry continue to be based almost exclusively on Discounted Cash Flow (DCF) methods. While these techniques are certainly useful, they are unable to capture all aspects of capital investment viability.

Regarding investments as options substantially changes the decision making process about capital investment. There has been a substantial effort in valuing financial options and the learning here have recently been extended to regarding investment in assets as options. The real options approach provides an alternative quantitative means to evaluate the capital investment. The real option analysis extends the work done on financial options, to obtain the inherent value in capital investments that cannot be captured by DCF methods.

Using the real options framework for analyzing capital investment, we will evaluate the investment in a plant to manufacture the chemical resorcinol in South Africa. We will show how this approach can capture the dynamic and strategic value investment in a facility to manufacture the chemical resorcinol.

## **1.2. Problem Statement**

There is, in the evaluation of capital investments, often important elements that are not completely reflected in a discounted cash flow (DCF) analysis

## **1.2 Aims of Study**

This study will focus on the application of the real options framework to value a capital investment in the South African Chemical Industry.

## **1.3 Background of Research Proposal**

### **1.3.1 South Africa in Transition**

Ten years after the fall of apartheid and the installation of a democratic government, South Africa has made remarkable progress closing the gap between historically privileged and disadvantaged groups. Major transformations of the judicial, education, health, housing and governance sectors have accompanied and facilitated this progress. Yet much work remains. South Africa's principal development challenge is a sluggish economy. Despite South Africa's adherence to prudent monetary and fiscal policies, the economy grew at an estimated 3.5% in 2004 and is currently projected to grow at rates of 3.5% to 3.8% per annum for the next three years. This projected economic growth rate is insufficient to significantly reduce unemployment, currently estimated at 35% (US Aid Report, 2003). It is generally agreed by most economists in South Africa and abroad that the South African economy has to grow by at least 6% a year to absorb both its currently unemployed workforce and new entrants to the economy.

The advent of democracy in South Africa coincided with the globalization phenomenon. The fledgling democracy felt the full force of globalization. In the previous Apartheid era, the economy was insulated against world events. High protective tariffs against imports and generous subsidies, especially for businesses setting up factories in the so-called "Homelands", allowed economic activity to continue. The Textile and Chemicals Industry, in particular, benefited from this protection. In addition, the Apartheid government offered generous export incentives to those industries that could export goods to outside countries.

The new South African state opened its economy to the world, as it was a founder member of the general agreement on tariffs and trade. It was determined to overcome the isolation of the 1980s and wanted to be seen as recognizing economic competitiveness. South Africa therefore followed a more rapid liberalization of the requirements under GATT. This immediately affected the Textile industry as the flood of cheap imports from the Far East, increasingly made the local textile industry uncompetitive in material and labour costs. This led to an increasing number of factory closures with a consequent increase in unemployment. Where factory closures were averted, it was through reduced labour employed and improved productivity that allowed them to survive.

This phenomenon was replicated in other industries, most notably the chemical industry. Sentrachem, once a huge chemical conglomerate in South Africa was sold off to Dow Chemical, the US conglomerate. Many of its previous divisions have been closed down and those that remain have been streamlined with reduced staff and improved productivities. AECI (another big chemical company in South Africa), followed a similar fate.

### **1.3.2 The Need for Investment**

In the light of such a changed economic landscape, the challenge of growing the economy is indeed a daunting one. Investment in the SA Economy either by local entrepreneurs/businessmen or foreign enterprises is seen as critical to reducing unemployment and growing the economy. Investment, whether local or foreign rests on following timeless rule: capital will only be invested in enterprises where return on investment is maximized. The competition for capital investment is intense with developing and developed countries both vying for scarce resources. However with the current economic growth of India and China attracting huge amounts of foreign investment, competition for foreign capital amongst other nations is more intense than normal. Corporate managers have to show how return on capital invested in their companies is more profitable than that invested in other companies.

Central to attracting capital to a proposed investment is the realistic valuation of the proposed project. Valuation of prospective Capital projects needs to capture the superior return on capital. Otherwise, investors will move their investments to projects that do provide maximum return on capital. How should a corporate manager facing uncertainty over future market conditions, decide whether to invest in a new project?

## **1.4 Literature Review**

### **1.4.1 Valuation of Investments**

Corporate managers have long used methods such as the payback method, internal rate of return (IRR) and net present value (NPV). IRR and NPV are discounted cash flow (DCF) techniques. The NPV is one of the most widely used methods for valuing capital projects. In the absence of managerial flexibility, NPV is the only currently available valuation measure consistent with a firm's objective of maximizing its shareholder's wealth (Trigeorgis, 1996). In this technique, the first step is to calculate the present value of the expected cash flow inwards from the investment. The next step is to calculate the present value of the stream of expenditures required to undertake the project. The final step is to determine the difference between the two – denoted as the net present value (NPV) of the investment. If it is positive, the rule is to invest in the project. Various issues are taken into account such as taxes, depreciation, inflation and most critically, what discount rate or rates to use. The main issue is determining whether the NPV is positive or negative. The practical value of any type of valuation analysis hinges on how the analysis is performed (Trigeorgis, 1995).

### **1.4.2 Shortcomings of NPV**

Investing in a capital project is to invest in uncertainty. The returns on capital invested are uncertain. Investors are poorly served by DCF techniques when evaluating capital projects. The NPV criterion works well for cost reduction type projects where future cash flows are relatively certain. But DCF techniques are imperfect when used to evaluate strategic investments where

the payoff is uncertain. There are three main limitations of DCF –based techniques when applied in situations of uncertainty (Herath, Jahera and Park, 2001):

- Firstly, investment decisions are typically viewed as now or never. Investments are irreversible and are capable of being delayed. The NPV approach leads to accepting a project immediately if NPV is positive. This is a very passive approach. This may work in situations of certainty but has limited application under conditions of uncertainty. A growing body of research shows that the ability to delay irreversible investment expenditure can profoundly affect the decision to invest (Dixit and Pindyk, 1995). The ability to delay also undermines the validity of the net present value rule. It is unable to capture the value of this delay.
- Secondly, DCF techniques ignore the flexibility to modify decisions as new information arrives. This flexible investment framework is useful for understanding and managing risk. Flexibility allows for resolution of uncertainty.
- Thirdly, selecting an appropriate discount rate is difficult and may very well be the wrong rate chosen for the risk.

Thus for analysing investments, especially strategic investments, a richer framework is needed, one that enables managers to address the issues of irreversibility, uncertainty and timing more directly.

### **1.4.3 Extending Financial Option Theory**

Instead of assuming that investments are either reversible or that they cannot be delayed, the recent research on investment stresses the fact that companies have opportunities to invest and that they must decide how to exploit those opportunities most effectively. The research is based on an important analogy with financial options (Dixit and Pindyk, 1995).

A company with an opportunity to invest is holding something much like a financial call option: It has the right but not the obligation to buy an asset (namely, the entitlement to the stream of profits from the project) at a future time of its choosing. When the company makes irreversible investment expenditure, it “exercises”, in effect, its call option. How does the company exercise that real option optimally? Financial options have been studied extensively by academics and financial professionals for more than three decades. This study has generated a large body of knowledge on financial options which can be applied to real options (capital investment projects).

#### **1.4.4 Real Options vs. NPV**

In their work, Dixit and Pindyk (1995) proclaim that being able to “delay an irreversible investment undermines the simple net present value rule, and hence the theoretical foundations of standard neoclassical investment models”. NPV is unable to capture the value in being able to delay a project. NPV does not recognize the managerial alternative of waiting or delaying the start of a project. However real options recognize that the decision can be deferred (Luehrman, 1998).

The recent research on investment offers a number of valuable insights into how managers can evaluate investment opportunities as options, and highlights the basic weakness of the NPV rule. When a company exercises its option by making an irreversible investment, it effectively “kills” the option. In other words, by deciding to go ahead with expenditure, the company gives up the possibility of waiting for new information that might affect the desirability or timing of the investment; it cannot disinvest should market conditions change adversely. The lost option value is an opportunity cost that must be included as part of the cost of the investment. Thus the simple NPV rule has to be modified: instead of just being positive, the present value must exceed the cost of the project by an amount equal to the value of keeping the investment option alive.

Numerous studies have shown that the cost of investing in an opportunity can be large and that the investment rules that ignore the expense can lead investors' astray (Dixit and Pindyk, 1995). The opportunity cost is highly sensitive to uncertainty over future value of the project; as a result, new economic conditions that may affect the perceived risk of future cash flows can have a large impact on investment spending – much larger than, say, a change in interest rates. Viewing investment as an option puts greater emphasis on the role of risk and less emphasis on interest rates and other variables.

Another problem with the conventional NPV rule is that it ignores the value of creating options. Sometimes an investment that appears uneconomical when viewed in isolation may, in fact, create opportunities that enable the company to undertake other investments in the future should market conditions turn favourable. It may be desirable to delay an investment decision and wait for more information about market conditions, even though the standard NPV indicates that the investment is economical right now. On the other hand, there may be situations in which uncertainty over future market conditions should prompt a company to speed up certain investments. Such investments create additional options that give the company the ability (though not the obligation) to do additional future investing.

#### **1.4.5 Real Options: Mapping an investment onto an Option**

An investment opportunity is like a financial call option because the company has the right, but not the obligation, to exploit an opportunity for business. Most business opportunities are unique. Finding a financial option that is similar to a business opportunity is difficult if not impossible. Therefore a model of real options will be developed using a specific investment project.

The work of Black and Scholes (1973) and Merton (1973) provided a method to properly value financial options. Due to its success in valuing financial derivatives, the Black and Scholes options valuation model will be extended to

determining the value of business investment opportunities. In developing this model, we will establish a correspondence between the investment project's characteristics and the five variables of the Black and Scholes model. In this manner, a model can be obtained with the structure of a call option. The option that will be used is a *European* call, which is the simplest of all options because it can be exercised on only one date, its expiration date. In summary, the model will be outlined as below:

Capital projects involve spending money to build a productive asset. Spending money to exploit such a business opportunity is analogous to exercising an option on a share. The amount of money expended corresponds to the option's *exercise price*, denoted as  $X$ . The present value of the asset or project corresponds to the *stock price* ( $S$ ). The length of time the company can differ the investment decision without losing the opportunity corresponds to the option's *time to expiration* ( $t$ ). The uncertainty about the future value of the project's cash flows (that is, the risk of the project) corresponds to the *standard deviation of returns* on the stock ( $\sigma$ ). Finally, the time value of money is given in both cases by the risk-free rate of return ( $r_f$ ). By pricing an option using values for these variables generated from our project, this study shows that more can be learnt about the value of the project than the simple DCF analysis.

## **1.5 The Investment Project**

In South Africa, the chemicals sector represents an area where possible growth and profit can be realized in the medium to long-term. South Africa imported more than R4 billion worth of chemicals in 2004 (Department of Finance, 2004). A competitive import substitution strategy, where certain currently imported chemicals are made locally, seems a feasible strategy to grow both the chemical industry and the economy. As South Africa imports many intermediates for end-product chemicals, an opportunity exists for

starting intermediate chemical manufacture in South Africa. The intermediate chemical chosen for this case study is resorcinol.

Resorcinol is used primarily in the production of specialty adhesives and/or adhesive improvers for rubber/tyres and wood products. South Africa imported more than 400 tons of the intermediate chemical resorcinol in 2004. This local consumption can represent an important basis to start manufacturing resorcinol locally. In 2004, on a global basis, 52 thousand metric tons of resorcinol was consumed, (SRI International, 2005). This is projected to grow at a rate of 5 percent annually. There is no patent protection on the chemical.

The chemical manufacturing industry is capital intensive, requiring an up-front outlay of capital. Investment appraisal of capital outlay is therefore of utmost importance in order for the investor to assess whether the risk and return on one's investment is acceptable. The proposed capital investment in the Resorcinol Plant will evaluate potential cash flows, tax incentives and expenses over several years. A real options approach will be used to evaluate investment in this enterprise.

## **1.6. Research Methodology**

The Research Program will:

1. Define the elements missing in conventional Discounted Cash Flow (DCF) analysis. Here we will look at the historical progression leading to DCF analysis, including Net Present Value (NPV) analysis. Situations will be discussed where NPV is limited in capturing all aspects of the investment value.
2. To determine if the real options approach more fully utilizes all available information in valuing investments, we will explore the application of financial options valuation, as developed by Black and Scholes (1973), to investment opportunities that can be regarded as options.

3. Demonstrate the use of the real options technique in a case study investment analysis. The case study involves analysing an investment in the South African Chemical Industry. We will evaluate the investment in the manufacture of the chemical resorcinol using the conventional DCF analysis and then comparing this valuation to the Real Options Approach.

## **1.7 Limitations**

One of the limitations of this study will be that exact raw material costs and material usage rates may not be readily available due to confidentiality agreements. Also import data supplied by SARS may be inaccurate because of the use of different codes to describe the same product in shipping documents.

## **1.8 Structure of Study**

The dissertation is presented in a number of chapters, which logically develop issues being addressed in the study.

Chapter 2 reviews literature, which is aimed at developing the theory of Real options analysis. The current and widely used method of capital investment appraisal will be discussed. In particular, the Discounted Cash Flow methods will be examined. Its disadvantages and advantages will be listed. The shortcomings of the DCF methods leads on to the real options view of capital investment appraisal. A model will be developed which views an investment opportunity as a call option. This model will be based on the Black and Scholes (1973) model for calculating the value of European options.

Chapter 3 presents a case study in setting up a resorcinol chemical manufacturing enterprise. Firstly an analysis of the South African Chemical Industry is conducted with the aim of describing the context within which a resorcinol manufacturing enterprise will operate. Then the market for resorcinol in South Africa and globally will be presented. Opportunities arising

thereof and competitive advantages for manufacture of resorcinol in KwaZulu Natal will be discussed. The advantages and disadvantages of site location, manufacturing technology and raw material supply will be assessed. In addition a detailed financial projection in terms of raw material usage costs, fixed costs and overhead costs are presented.

Chapter 4 uses the real options model developed in Chapter 2 to calculate the value of the Resorcinol investment project. It will compare and contrast the standard NPV analysis of evaluating the Resorcinol investment proposal with that of the real options analysis.

Chapter 5 presents recommendations to narrow the gap identified in Chapter 4. The recommendations will be based on the proposed investment in the South African Chemical Industry (Resorcinol Manufacturing Facility).

## **1.9 Conclusion**

This study will conclude whether the real options framework will provide improved methodology to evaluate investment in the South African Chemical Industry. The study will also provide a framework which managers can readily use to value investment using the real options approach.

## **Chapter 2: Literature Review**

### **2.1 Introduction**

Companies annually commit substantial funds to a variety of investment projects. Assessing the viability of a capital project before commitment is one of the most challenging tasks facing a company. The overriding factor in committing shareholder capital (including loans) is to be thoroughly certain that this investment will produce or return shareholder value higher than the risk less rate. There are many project appraisal techniques to assess investment opportunities. The majority of these techniques are based on the discounted cash flow (DCF) concept. Recently however, another project appraisal technique has been used to evaluate investment projects. This technique is called real options analysis. This approach seems to be better able to capture the higher strategic value inherent in a project that DCF techniques have been unable to. When traditional DCF methods are applied to evaluate strategic projects, future opportunities that could create value are often ignored in the process. This results in too little strategic investment. In contrast, real options analysis is able to capture more of the strategic value of the investment decisions.

### **2.2 Discounted Cash Flow Techniques**

Over the last 30 years Discounted Cash Flow (DCF) has become firmly entrenched in assessing financial value in the corporate world. Surveys in the UK between 1975 and 1997 (Pike 1988, 1996; Arnold and Hatzopoulos, 2000) show that, while all firms surveyed conduct financial appraisal on capital projects, the choice of methods varies considerably, and most firms employ a combination of appraisal techniques.

The use of DCF methods in larger firms increased greatly from 58 per cent in 1975 to 100 per cent by 1997. Previously, the internal rate of return (IRR) was favoured over the net present value (NPV) approach. In recent years, there

has been an increase in the use and adoption of the NPV approach, with virtually all firms now adopting it.

**Table 2.1: Capital Investment evaluation methods in 100 large UK firms**

Firms using:	1975	1981	1986	1992	1997
	%	%	%	%	%
Payback	73	81	92	94	66
Average accounting rate of return	51	49	56	50	55
DCF methods (IRR or NPV)	58	68	84	88	100
Internal Rate of Return	44	57	75	81	84
Net Present Value	32	39	68	74	97

Source: Pike (1988, 1996); Arnold and Hatzopoulos (2000).

A project's NPV is determined by summing the net annual cash flows, discounted at a rate that reflects the cost of an investment of equivalent risk on the capital market, and deducting the initial outlay (Pike and Neale 2004). According to the NPV rule, managers should accept all projects with a net present value greater than zero (Brealey et al, 2001). The DCF approach offers a conceptually sound approach for appraising capital projects and for this reason; it is the methodology of choice.

The extensive use of NPV is more than justified (Trigeorgis, 1996). In the absence of managerial flexibility, net present value is the only currently available valuation measure consistent with a firm's objective of maximizing its shareholders wealth. Managers should undertake all projects up to the point at which the marginal return on the investments is equal to the rate of interest on equivalent financial investments in the capital market. This is exactly the same as the net present value rule: accept all investments offering positive net present values when discounted at the market cost of capital. The result is an increase in the market value of the firm and thus in the market value of the shareholders stake in the firm.

## **2.4 Deficiencies of Discounted Cash Flow Techniques**

### **2.4.1 Estimation of Costs and Revenue**

Discounted cash flows methods require the assumption of perfect certainty of project cash flows, even though this is rarely the case in real world situations (Herath et al , 2001). There is no fixed formula for calculating the profit and cost streams. The profit expectation depends on market response and there is a high degree of optimism in most projects. Where cash flows are certain, such as in cost reduction projects, the popular NPV works best. In projects where cash flows are less certain, such as in strategic projects, the DCF techniques are less reliable.

### **2.4.2 The Discount Rate**

Under DCF methodology an analyst projects all the future cash flows (including investments) associated with an asset, discounts them using an appropriate discount rate reflecting uncertainty, and sums them to compute the NPV. If a project involves high uncertainty, a high discount rate, which reflects a high-risk premium, is used. The risk premium reflects the market's attitude toward the risk inherent in those cash flows and must equal the extra return expected in the market by similar investments of comparable risk (Kasanen and Trigeorgis, 1996). Selecting a low discount rate for the NPV, gives more weight to cash flows that a project is expected to earn in the distant future.

It is generally assumed that the discount rate is simply the opportunity cost of capital for the particular project – that is, the expected rate of return that could be earned from an investment of similar risk (Dixit and Pindyk, 1995). The opportunity cost would reflect the non diversifiable, or systematic, risk that is associated with the particular project. In practice, however, the opportunity cost of a specific project may be hard to measure. As a result, the concept of a company's weighted average cost of capital (WACC) is a good reasonable substitute as long as the company's projects do not differ greatly from one

another in their non diversifiable risk (Mandron, 2000; Feinstein and Lander, 2003).

However, both academic research and anecdotal evidence show that managers do not follow the NPV rule and hesitate to use it as they have been taught: A study of discount rates in the United States (Summers, 1987), found that companies were using discount rates ranging from 8% to 30% with a mean of 17%. Although the discount rate appropriate for investment with a non diversifiable risk usually exceeds the riskless rate, that is not enough to justify the large discrepancies found. Other studies have confirmed that managers regularly and consciously set hurdle rates that are often three or four times their weighted average cost of capital (Dertouzos et al, 1990, and Poterba and Summers, 1990).

### **2.4.3 Irreversibility of Decisions**

Investment decisions are viewed as now or never type of decisions rather than decisions that can be delayed (Dixit and Pindyk, 1995). The NPV approach leads to immediate acceptance of the project if the NPV is positive. This is a passive method that works well in situations of certainty but has limited applications in situations of uncertainty. The NPV approach assumes a fixed scenario in which a company starts and completes a project, which then generates a cash flow during some expected lifetime. The NPV technique ignores the flexibility to modify decisions as new information about the project becomes available. Instead, it compares investing today with never investing. A more useful comparison, however, would examine a range of possibilities: investing today, or waiting and perhaps investing next year, or waiting longer and perhaps investing in two years, and so on.

### **2.4.4 Illusion of DCF**

From the emphasis devoted by most textbooks to advanced capital budgeting methods, one might be forgiven for assuming that successful investment is exclusively attributable to the correct evaluation method (Pike and Neale,

2003). DCF methods often create an illusion of exactness that the underlying assumptions can not support. There is a danger that the unquantifiable aspects of a project, which may be critical to a project's success, may be undervalued. Indeed a project's success often depends on the enthusiasm and commitment of the person sponsoring and implementing it.

## **2.5 Investments as Real Options**

While discounted cash flow techniques are very useful tools of analysis, they are generally more suited to financial assets, because they assume the assets are held rather than managed. The main difference between evaluating financial assets and real assets is that investors in shares are generally passive. Unless they have a fair degree of control, they can only monitor performance and decide whether to hold or sell their shares. Corporate managers on the other hand, play a far more active role in achieving the planned net present value on a capital project. Managers can take action to mitigate losses or exploit new opportunities: they can create real options. NPV ignores an important reality, in other words: business decisions in many industries and situations can be implemented flexibly through deferral, abandonment, expansion, or in a series of stages that in effect constitute real options (Copeland and Keenan, 1998).

Investment expenditures are irreversible when they are company or an industry specific. These are sunk costs because once spent, they cannot be recovered. This recognition that capital investment decisions can be irreversible gives the ability to delay investments added significance (Dixit and Pindyk, 1995). The irreversible investment opportunity can be viewed as a financial call option. The holder of the call option has the right, for a specified period to pay an exercise price and to receive in return an asset that has some value.

Exercising the option is irreversible; one cannot retrieve the option or the money that was paid to exercise it. Similarly, a company with an investment opportunity has the option to spend money now or in the future in return for an asset of some value. As with a financial call option, the option to make a capital investment is valuable. This is because as it is impossible to know the future value of the asset obtained by investing. This can increase the project's value. In addition certain investment decisions give rise to follow-on opportunities that are wealth creating. Real options are important in investment decisions when conventional NPV analysis suggests that: the project is marginal; uncertainty is high; and, there is value in retaining flexibility.

In financial terms, a business strategy is much more like a series of options than a series of static cash flows. (Luehrman, 1998). Executing a strategy almost always involves making a sequence of major decisions. Some actions are taken immediately, while others are deliberately deferred, so managers can optimize as circumstances evolve. The strategy sets the framework within which future decisions will be made, but at the same time it leaves room for learning from ongoing development and for discretion to act based on what is learned.

## **2.6 History of Real Options**

First coined by Myers (1977), the real options framework views decision makers as having the option to invest, grow, or abandon a project contingent upon the arrival of new information. The real options framework is the application of options pricing theory to capital budgeting (Feinstein and Lander, 2002). Real options attempt to quantify uncertain environments in a world of competition and real-time technology. Scholes (1998) defines any security as a derivative "if its price (or value) dynamics depends on the dynamics of some other underlying asset or assets and time". Using this

concept, the value of a project can be viewed as a derivative of input costs, output yield, time, and uncertainty.

The seminal work of Black and Scholes (1973) and Merton (1973), provided a method for the proper valuation of financial options. Their work led to vast amount of research into the pricing of financial derivative products. Companies have since used the concepts developed by them to hedge risks unique to their business. Due to its success in the financial derivative field, it is a natural progression to assess whether it can be applied to the assessment project valuation at the firm level. To understand how this valuation technique can be utilized in assessing capital projects under uncertainty, it is first necessary to understand the basics of financial options.

## **2.7 Basics of Options Pricing**

Arnold (2002) defines an option as a contract giving one party the right, but not the obligation, to buy or sell a financial instrument, commodity or some other underlying asset at a given price (called the strike price or an exercise price) at or before the expiration date of the option. Since it is a right and not an obligation, the holder can choose not to exercise the right and allow the option to expire.

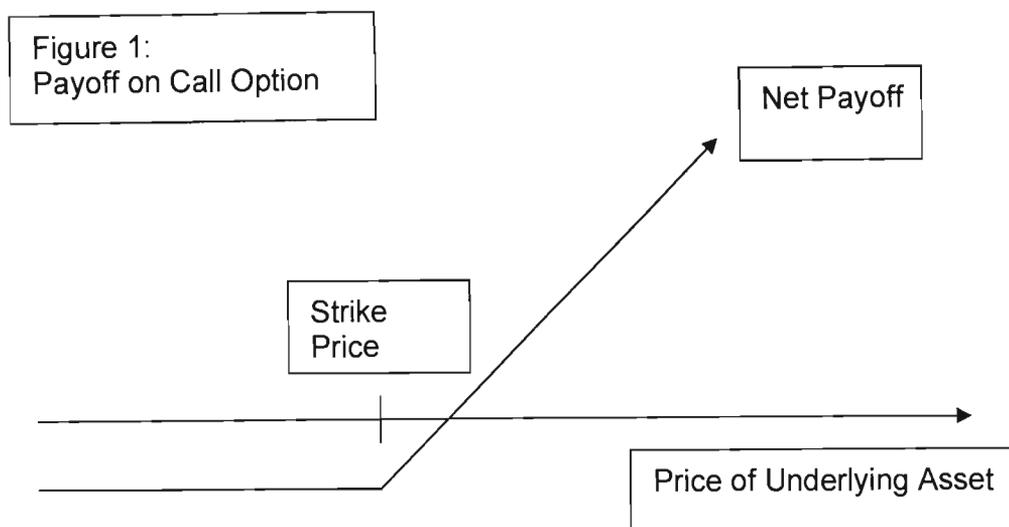
### **Call Options**

A call option gives the buyer the right to buy the underlying asset at a fixed price, called the strike or exercise price, at any time prior to the expiration date of the option: the buyer pays a price for this right. If at expiration, the value of the asset is less than the strike price, the option is not exercised and expires worthless.

If, on the other hand, the value of the asset is greater than the strike price, the option is exercised – the buyer of the option buys the stock at the exercise price and the difference between the asset value and the exercise price comprises the gross profit on the investment. The net profit on the investment

is the difference between the gross profit and the price paid for the call initially.

**Figure 2.1: Payoff on Call Option**



Source: Damodaran (2003).

The payoff diagram, Figure 2.1, illustrates the cash payoff on an option at expiration. For a call, the net payoff is negative (and equal to the price paid for the call) if the value of the underlying asset is less than the strike price. If the price of the underlying asset exceeds the strike price, the gross payoff is the difference between the value of the underlying asset and the strike price, and the net payoff is the difference between the gross payoff and the price of the call.

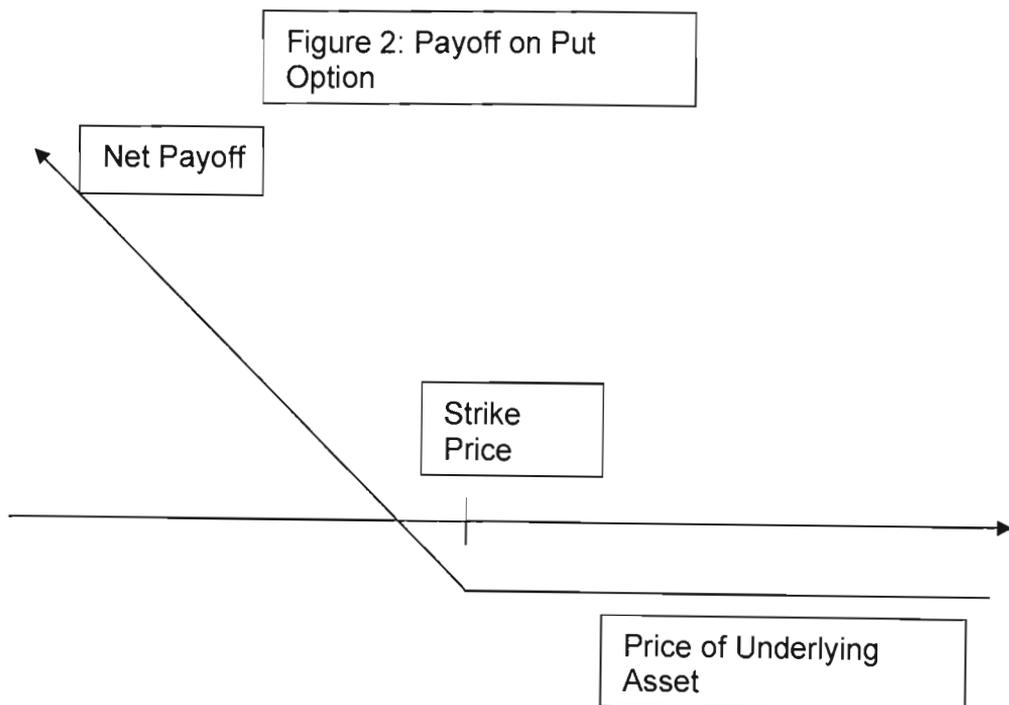
### **Put Option**

A put option gives the buyer of the option the right to sell the underlying asset at a fixed price, again called the strike or exercise price, at anytime prior to the expiration date of the option. The buyer pays a price for this right. If the price of the underlying asset is greater than the strike price, the option will not be

exercised and will expire worthless. If on the other hand, the price of the underlying asset is less than the strike price, the owner of the put option will exercise the option and sell the stock at the strike price, claiming the difference between the strike price and the market value of the asset as the gross profit. Again, netting out the initial cost paid for the put yields the net profit from the transaction.

A put has a negative net payoff if the value of the underlying asset exceeds the strike price, and has a gross payoff equal to the difference between the strike price and the value of the underlying asset if the value is less than the strike price. This is summarized in Figure 2.2.

**Figure 2.2: Payoff on Put Options**



Source: Damodaran (2003).

### 2.7.3 Determinants of Option Value

The value of an option is related to a number of variables relating to the underlying asset and financial markets (Damodaran, 2003):

1. Current Value of the Underlying Asset: Since calls provide the right to buy the underlying asset at a fixed price, an increase in the value of the asset will increase the value of the calls. Puts, on the other hand, become less valuable as the value of the asset increases.
2. Variance in the Value of the Underlying Asset: The higher the variance in the value of the underlying asset, the greater the value of the option. This is true for both calls and puts. While it may seem counter-intuitive that an increase in a risk measure (variance) should increase value, options are different from other securities since buyers of options can never lose more than the price they pay for them; in fact they have the potential to earn significant returns from large price movements.
3. Dividends Paid on the Underlying Asset: The value of the underlying asset can be expected to decrease if dividend payments are made on the asset during the life of the option. Consequently, the value of a call on the asset is a decreasing function of the size of the expected dividend payments, and the value of a put is an increasing function of expected dividend payments.
4. Strike Price of Option: In the case of calls, where the holder acquires the right to buy at a fixed price, the value of the call will decline as the strike price increases. In the case of puts, where the holder has the right to sell at a fixed price, the value will increase as the strike price increases.
5. Time to Expiration on Options: Both calls and puts become more valuable as the time to expiration increases. This is because the longer time to expiration provides more time for the value of the underlying asset to move, increasing the value of both type of options. Additionally, in the case of a call, where the buyer has to pay a fixed price at expiration, the present value of this fixed price decreases as the life of the options increases, increasing the value of the call.
6. Riskless Interest Rate Corresponding to Life-Of-Options: Since the buyer of the option pays the price of the option up front, an opportunity

cost is involved. This cost will depend upon the level of interest rates and the time to expiration on the option. Increases in the interest rate will increase the value of calls and reduce the value of puts.

**Table 2.2: Summary of Variables Affecting Call and Put Prices.**

Factor	Effect on	
	Call Value	Put Value
Increase in underlying asset's value	↑	↓
Increase in Strike Price	↓	↑
Increase in variance of underlying asset	↑	↑
Increase in time to expiration	↑	↑↓
Increase in interest rates	↑	↓
Increase in dividend paid	↓	↑

Source: Damodaran (2003).

#### **2.7.4 American vs. European Options**

Options can be designed to provide a choice of when the contract can be exercised. European options can only be exercised at maturity, while American options can be executed any time up to expiration. For a European-style call option, the buyer will only exercise when the expiration date market value of the underlying asset that could be purchased is greater than the exercise price. On the other hand, a European style put option will only be rationally exercised when the maturity price of the asset that could be sold is lower than the exercise price.

#### **2.8 Options Pricing Models**

There are three models of option valuation – the two-state, the binomial, and the Black-Scholes. This dissertation will only discuss the Black-Scholes Model. Since 1973, when Black and Scholes published their innovative work providing a model for valuing dividend-protected European options, option pricing theory has undergone some development. Black and Scholes used a

“replicating portfolio”- a portfolio composed of underlying asset and the risk-free asset that had the same cash flow as the option being valued – to come up with their final formulation.

The Black-Scholes model assumes that stock price movements can be described by a statistical process known as geometric Brownian motion (Reilly and Brown, 2003). Ultimately, this process is summarized by a volatility factor,  $\sigma$ , which is analogous to the investor’s stock price forecasts in previous model. Assuming the continuously compounded risk-free rate and the stock’s variance (i.e.,  $\sigma^2$ ) remain constant until expiration date  $t$ , Black and Scholes used the riskless hedge intuition to derive the following formula for valuing a call option on a non-dividend - paying stock:

$$\text{Value of call} = SN(d_1) - Xe^{-rt}N(d_2) \dots\dots\dots (1)$$

Where

$$d_1 = \frac{\ln\left(\frac{S}{X}\right) + \left(r + \frac{\sigma^2}{2}\right)t}{\sigma\sqrt{t}} \dots\dots\dots (2)$$

$$d_2 = d_1 - \sigma\sqrt{t} \dots\dots\dots (3)$$

The variables in the equation have the following meaning:

- S = Current Value of the underlying asset
- X = Strike price of the option
- T = Life to expiration of the option
- R = Riskless interest rate corresponding to the life of the option
- $\sigma^2$  = Variance in the value of the underlying asset

The Black-Scholes model is extremely flexible (Reilly and Brown 2003). Although originally created for European-style call options on non-dividend - bearing stock, it extends easily to valuing put options and options on dividend-paying stocks as well.

**Table 2.3: Factors affecting Black-Scholes Option Values**

	Will Cause an Increase/Decrease in the:	
An increase in the	Call value	Put Value
Security price (S)	↑	↓
Exercise price (X)	↓	↑
Time to expiration (t)	↑	↑ or ↓
Risk-free rate (RFR)	↑	↓
Security volatility ( $\sigma$ )	↑	↑

Source: Reilly and Brown (2003)

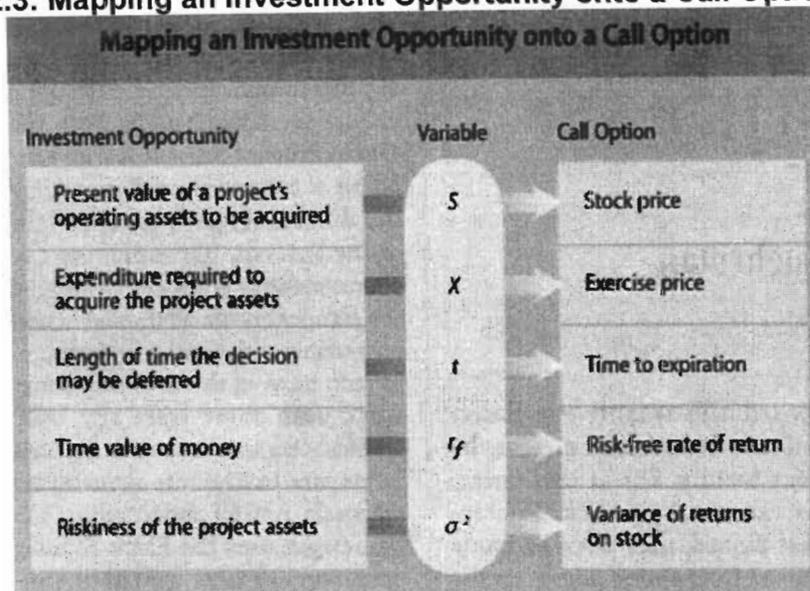
### 2.9 Mapping an investment project onto an Option

A corporate investment opportunity is like a call option because the firm has the right, but not the obligation, to acquire the operating assets of a new business (Luehrman, 1998). If it is possible to link a call option sufficiently similar to the investment opportunity, the value of the option would tell us something about the value of the opportunity. Unfortunately, most business opportunities are unique, so the likelihood of finding a similar option is low. The only reliable way to find a similar option is to construct one. In doing this, a correspondence is established between the projects characteristics and the five variables that determine the value of a simple call option on a share of stock.

Many projects involve spending money to buy or build a productive asset. Spending money to exploit such a business opportunity is analogous to exercising an option on a share of stock. The amount of money expended corresponds to the option's exercise price, X. The present value of the asset built or acquired corresponds to the stock price, S. The length of time the company can defer the investment decision without losing the opportunity corresponds to the option's time to expiration, t. The uncertainty about the future value of the project's cash flows (that is, the risk of the project)

corresponds to the standard deviation of returns on the stock,  $\sigma$ . Finally, the time value of money is given in both cases by the risk-free rate of return ( $r_f$ ).

**Figure 2.3: Mapping an Investment Opportunity onto a Call Option**



Source: Luehrman (1998).

## 2.10 Linking NPV and Option Value

Traditional DCF methods would assess an investment opportunity by computing its net present value. When NPV is positive, a business will increase its own value by making the investment. When NPV is negative, the business is better off not making the investment.

The project's option value and NPV are the same when the project can no longer be deferred; that is, when the company's "option" has expired. At that time, either

$$\text{Option value} = S - X$$

or

$$\text{Option value} = 0$$

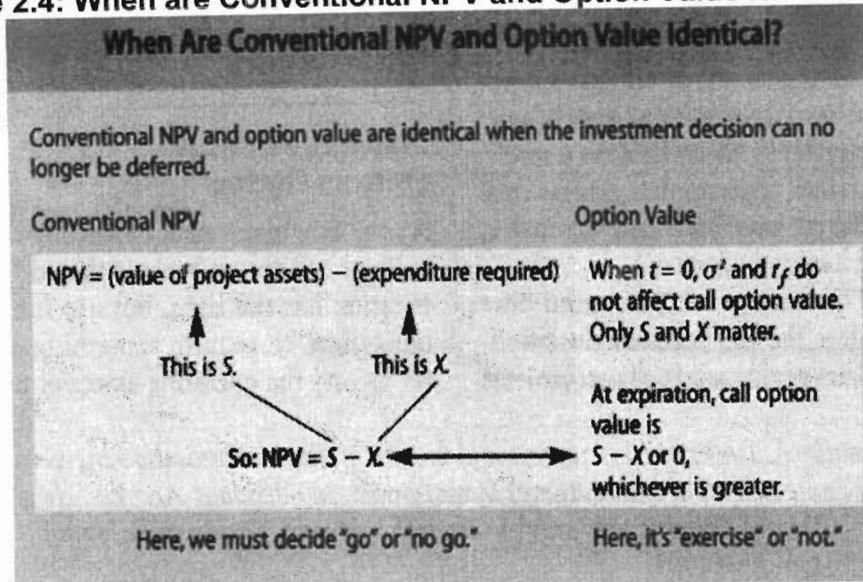
whichever is greater. But note that

$$\text{NPV} = S - X$$

as well, because from the map,  $S$  corresponds to the present value of the project assets and  $X$  to the required capital expenditure. To reconcile the two

completely, it should be noted that when NPV is negative, the company will not invest, so the project value is effectively zero rather than negative. So both approaches boil down to same number and same decision (Luehrman, 1998).

**Figure 2.4: When are Conventional NPV and Option Value Identical?**



Source: Luehrman (1998).

This common ground between NPV and option value has great practical significance. It means that NPV is highly relevant for option pricing. Any NPV computation already contains the information necessary to compute  $S$ , and  $X$ , which are two of the five option-pricing variables.

NPV and options pricing diverge when the investment decision may be deferred. The possibility of deferral gives rise to two additional sources of value. First, it is preferred to always pay later rather than sooner, because the time value of money can be earned on the deferred expenditure. Second, while the project is deferred, the circumstances can change. Specifically, the value of the operating assets may change. If their value goes up, the company can still acquire the assets by making the investment (exercising the option). If their value goes down, the company may decide not to acquire them. Because by waiting, the company avoids making what would turned out to be

a poor investment. The company has preserved the ability to participate in good outcomes and insulated itself from some bad ones.

For both these reasons, being able to defer the investment decision is valuable. Traditional NPV misses the extra value associated with deferral because it assumes the decision cannot be put off. In contrast, options pricing presumes the ability to defer and provides a way to quantify the value of the deferring. To value the investment, two metrics need to be devised to capture the extra sources of value: NPVq and Cumulative Volatility.

## 2.11 Quantifying Extra Value: NPVq

The first source of value is the interest that can be earned on the required capital expenditure by investing later rather than sooner. Here the money is placed in a bank account so that when it is time to invest, the money plus the interest it has earned is sufficient to fund the required expenditure. It is the discounted present value of the capital expenditure. In option notation, it's the present value of the exercise price, or  $PV(X)$ . To compute  $PV(X)$ ,  $X$  is discounted for the requisite number of periods ( $t$ ) at the risk-free rate of return ( $rf$ ):

$$PV(X) = X / (1 + rf)^t \dots\dots\dots(4)$$

The extra value is the interest rate ( $rf$ ) times  $X$ , compounded over however many time periods ( $t$ ) are involved. Alternatively, it is the difference between  $X$  and  $PV(X)$ .

Conventional NPV is missing that extra value. NPV can be expressed as

$$NPV = S - X \dots\dots\dots (5)$$

Rewriting using  $PV(X)$  instead of  $X$ . Thus:

$$\text{"modified"NPV} = S - PV(X) \dots\dots\dots(6)$$

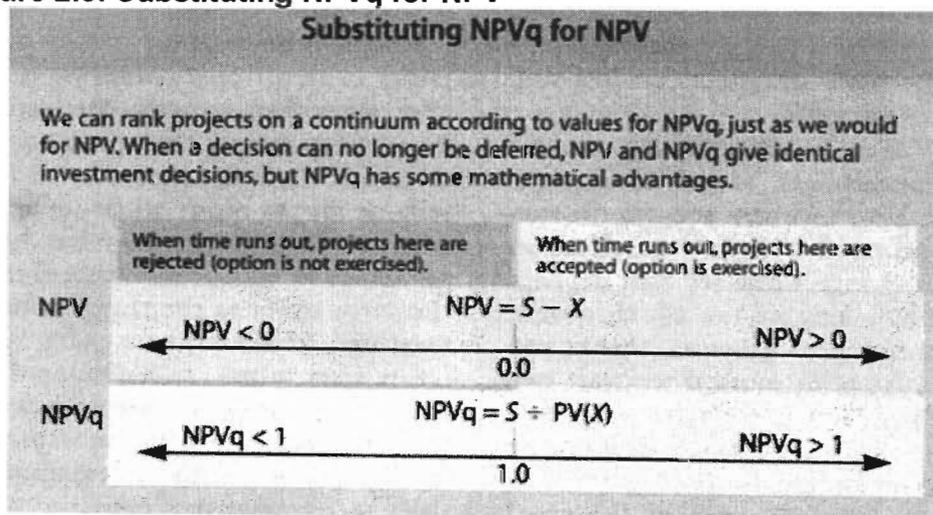
Modified NPV, then, is the difference between S (value) and PV(X) (cost adjusted for the time value of money). Modified NPV can be positive, negative, or zero. However, it is more convenient to express the relationship between cost and value in such a way that the number can never be negative or zero.

Instead of expressing modified NPV as the difference between S and PV(X), a new metric is created: S divided by PV(X). By converting to a ratio, negative values are converted to decimals between zero and one. This new metric is termed NPVq (Luehrman, 1998):

$$\text{NPVq} = S/\text{PV}(X) \dots\dots\dots (7)$$

Modified NPV and NPVq are not equivalent; that is, they don't yield the same numeric answer. For example, if S = 5 and PV(X) = 7, NPV = -2 but NPVq = 0.714. No information or value is lost from the project by substituting one metric for another. When modified NPV is positive, NPVq will be greater than one; when NPV is negative, NPVq will be less than one. Anytime modified NPV is zero, NPVq will be one. There is a perfect correspondence between them, as is shown in Figure 2.5 "Substituting NPVq for NPV".

**Figure 2.5: Substituting NPVq for NPV**



Source: Luehrman (1998).

## 2.12 Quantifying Extra Value: Cumulative Volatility

The second source of additional value is that while the company delays the investment, the asset value may change and affect the investment decision for the better. This possibility is very important, but it is more difficult because it is not certain that the asset values will change or, if they do, what the future values will be. Instead of measuring the added value directly, the *uncertainty* is measured and the option pricing model is used to quantify the value associated with a given amount of uncertainty.

The only way to measure uncertainty is by assessing probabilities. A project's future value can be drawn from a limited range of possibilities, weighted according to their likelihood of occurring. The most obvious measure is simply the range of all possible values: the difference between the lowest and the highest possibilities. As very high and very low values are less likely than medium values, the measure of uncertainty should reflect this. The most common probability-weighted measure of dispersion is *variance*, denoted as *sigma squared* ( $\sigma^2$ ). Variance is a summary measure of the likelihood of drawing a value far away from the average value. The higher the variance, the more likely it is that the values drawn will be either much higher or much lower than the average. In other words high variance assets are riskier than low variance assets.

Variance is an appealing measure of uncertainty, but it is incomplete because it lacks a time dimension (Luehrman, 1998). How much things can change while the company waits depends on how long the company can afford to wait. For business projects, things can change a lot more in two years than in two months. In options valuation, this is termed *variance per period*. Thus the measure of the total amount of uncertainty is variance per period times the number of periods, or  $\sigma^2t$ .

This is sometimes called the *cumulative variance*. An option expiring in two years has twice the cumulative variance as an otherwise identical option

expiring in one year, given the same variance per period. Cumulative variance is a good measure of the uncertainty associated with business investments. Two assumptions are made for mathematical convenience (Luehrman, 1998): First, instead of using variance of project values, the variance of project returns is used. That is, the percentage gained (or lost) per year is used rather than the actual rand value of the project. There is no loss of content because a project's return is completely determined by the project's value:

$$\text{Return} = \frac{(\text{future value} - \text{present value})}{\text{present value}}$$

The probability distribution of possible values is usually quite asymmetric; value can increase greatly but cannot drop below zero. Returns, in contrast, can be positive or negative, sometimes symmetrically positive or negative, which makes their probability distribution easier to work with.

Second, it helps to express uncertainty in terms of *standard deviation* rather than variance. Standard deviation is simply the square root of variance and is denoted by  $\sigma$ . It indicates just as much about uncertainty as variance does, but it has the advantage of being denominated in the same units as the object being measured. Future asset values are denominated in units of currency and returns are denominated in percentage points. Standard deviation, then, is likewise denominated in rands or percentage points.

To make these refinements to the measure of total uncertainty, the following steps are followed:

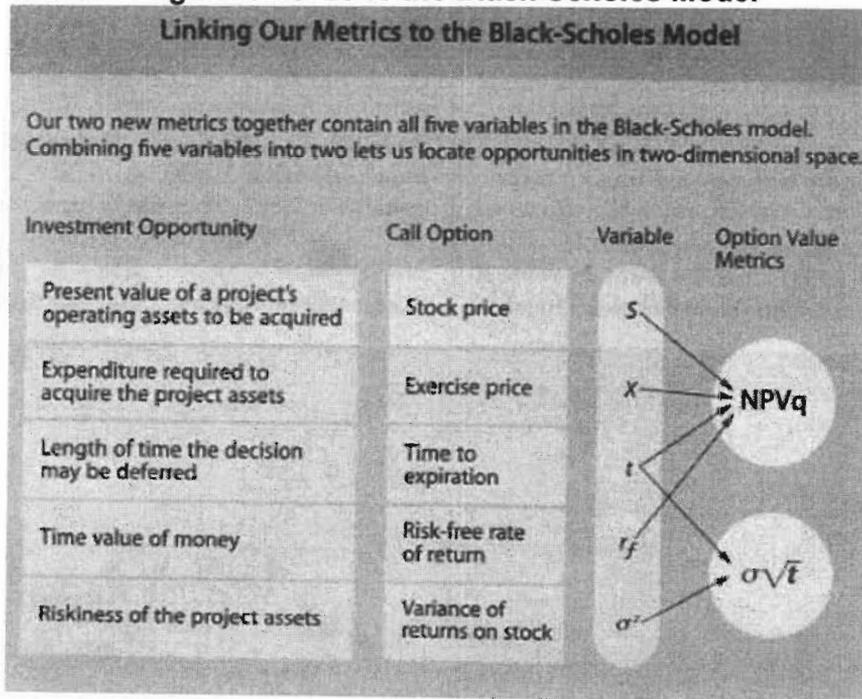
1. First stipulate that  $\sigma^2$  denotes the variance of returns per unit time of the project.
2. Second, multiply the variance per period by the number of periods ( $t$ ) to get cumulative variance ( $\sigma^2t$ ).
3. Third take the square root of cumulative variance to change units, expressing the metric as standard deviation rather than variance. This

is called *cumulative volatility* ( $\sigma\sqrt{t}$ ) to distinguish it from cumulative variance (Luehrman, 1998).

## 2.13 Valuing the Option

Together, the two new call option metrics, NPVq and  $\sigma\sqrt{t}$ , contain all the necessary information to value the project as a European call option using the Black-Scholes model. They are composed of the five fundamental option pricing variables onto which the business opportunity had been previously mapped. NPVq is actually a combination of four of the five variables: S, X, r<sub>f</sub> and t. Cumulative volatility combines the fifth,  $\sigma$ , with t. This is illustrated in Figure 2.6

**Figure 2.6: Linking the Metrics to the Black-Scholes Model**



Source: Luehrman (1998).

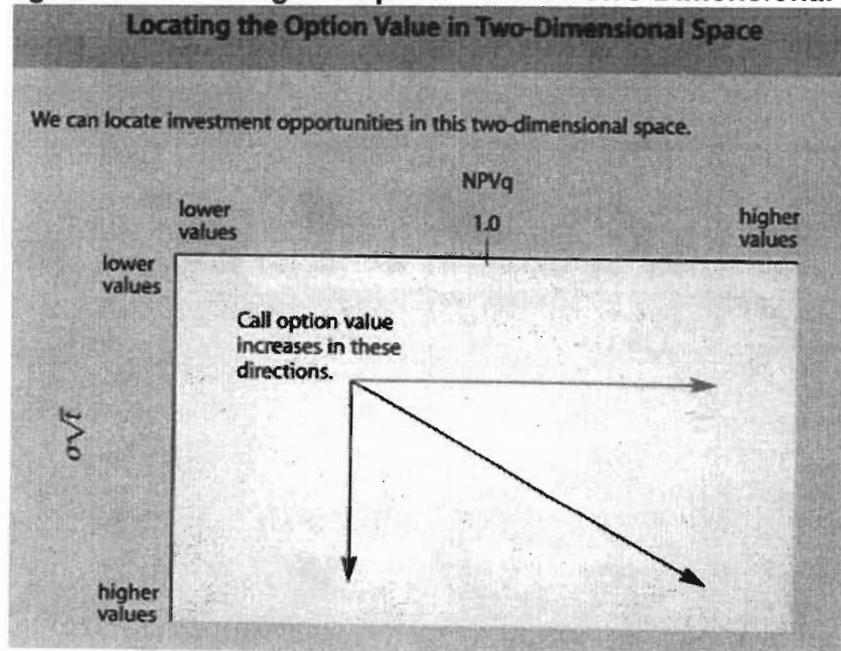
By combining variables in this way, there are two metrics instead of five. Not only is it easier to grasp, it also allows for plotting these variables as two-dimensional pictures instead of mathematical equations. Each of the metrics

has a natural business interpretation, which makes option-based analyses less opaque (Luehrman, 1998).

Figure 2: "Locating the Option Value in Two-Dimensional Space" shows how to use  $NPVq$  and  $\sigma\sqrt{t}$  to obtain a value for the option.

$NPVq$  is on the horizontal axis, increasing from left to right. As  $NPVq$  rises, so does the value of the call option. Higher values of  $NPVq$  are caused by higher project values ( $S$ ) or lower capital expenditures ( $X$ ).  $NPVq$  values are also higher whenever the present value of  $X$  is lower. Higher interest rates ( $rf$ ) or longer time to expiration ( $t$ ) both lead to lower present values of  $X$ . Any of these changes (lower  $X$  or higher  $S$ ,  $rf$  or  $t$ ) increases the value of the call option.

**Figure 2.7: Locating the Option Value in Two-Dimensional Space**



Source: Luehrman (1998).

Cumulative volatility is on the vertical axis of the graph, increasing from top to bottom. As  $\sigma\sqrt{t}$  increases, so does call value. Higher values are caused by greater uncertainty about a project's future value and the ability to defer a

decision longer. Either of these changes (higher  $\sigma$  or  $t$ ) increases the value of a European call option.

Plotting projects in this two-dimensional space creates a visual representation of their relative option value. The call value increases as one moves down, to the right or in both directions at once. Projects in the lower-right corner of the graph are high on both NPV<sub>q</sub> and  $\sigma\sqrt{t}$  metrics and their option values are high compared with projects in the upper-left corner. Locating various projects in space reveals their value relative to one another.

Because NPV<sub>q</sub> and  $\sigma\sqrt{t}$  contain all five Black-Scholes variables, a table can be created with Black-Scholes call values that correspond to every pair of NPV<sub>q</sub> and  $\sigma\sqrt{t}$  coordinates. This equates to “pricing the space” discussed above. Table 2.4: shows part of the filled-in Black-Scholes table. Each number expresses the value of a specific call option as a percentage of the underlying project’s (or asset’s) value.

For Example, for a project whose NPV<sub>q</sub> equals 1.0 and  $\sigma\sqrt{t}$  equals 0.5, the value given in the table is 19.7%. Any European call option for which NPV<sub>q</sub> is 1.0 and  $\sigma\sqrt{t}$  is 0.5 will have a value equal to 0.197 times S. If the assets associated with a particular project have value (S) of R100, then the project viewed as a call option has a value of R19.70. If S were R, the call option value would be R1.97, and so forth. Option values are expressed in relative terms, as percentages of S, rather than in absolute currency terms, to enable us to use the same table for both big and small projects. It is also convenient not to have to manipulate the Black-Scholes equation every time we want to value a project. The Black-Scholes model is used once, to generate the table itself. After that it is only required to locate the project in the table and multiply by a factor of S.

**Table 2.4: Black and Scholes Options Pricing Model (A Portion)**

**NPVq**

	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.08
0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.6	1.2	2.0	3.1	4.5	6.0	7.5
0.10	0.0	0.1	0.2	0.3	0.5	0.8	1.2	1.7	2.3	3.1	4.0	5.0	6.1	7.3	8.6
0.15	0.5	0.7	1.0	1.3	1.7	2.2	2.8	3.5	4.2	5.1	6.0	7.0	8.0	9.1	10.2
0.20	1.5	1.9	2.3	2.8	3.4	4.0	4.7	5.4	6.2	7.1	8.0	8.9	9.9	10.9	11.9
0.25	2.8	3.3	3.9	4.5	5.2	5.9	6.6	7.4	8.2	9.1	9.9	10.9	11.8	12.8	13.7
0.30	4.4	5.0	5.7	6.3	7.0	7.8	8.6	9.4	10.2	11.1	11.9	12.8	13.7	14.6	15.6
0.35	6.2	6.8	7.5	8.2	9.0	9.8	10.6	11.4	12.2	13.0	13.9	14.8	15.6	16.5	17.4
0.40	8.0	8.7	9.4	10.2	11.0	11.7	12.5	13.4	14.2	15.0	15.9	16.7	17.5	18.4	19.2
0.45	9.9	10.6	11.4	12.2	12.9	13.7	14.5	15.3	16.2	17.0	17.8	18.6	19.4	20.3	21.1
0.50	11.8	12.6	13.4	14.2	14.9	15.7	16.5	17.3	18.1	18.9	19.7	20.5	21.3	22.1	22.9
0.55	13.8	14.6	15.4	16.1	16.9	17.7	18.5	19.3	20.1	20.9	21.7	22.4	23.2	24.0	24.8
0.60	15.8	16.6	17.4	18.1	18.9	19.7	20.5	21.3	22.0	22.8	23.6	24.3	25.1	25.8	26.6
0.65	17.8	18.6	19.3	20.1	20.9	21.7	22.5	23.2	24.0	24.7	25.3	26.2	27.0	27.7	28.4
0.70	19.8	20.6	21.3	22.1	22.9	23.6	24.4	25.2	25.9	26.6	27.4	28.1	28.8	29.5	30.2
0.75	21.8	22.5	23.3	24.1	24.8	25.6	26.3	27.1	27.8	28.5	29.2	29.9	30.6	31.3	32.0
0.80	23.7	24.5	25.3	26.0	26.8	27.5	28.3	29.0	29.7	30.4	31.1	31.8	32.4	33.1	33.8
0.85	25.7	26.5	27.2	28.0	28.7	29.4	30.2	30.9	31.6	32.2	32.9	33.6	34.2	34.9	35.5
0.90	27.7	28.4	29.2	29.9	30.6	31.3	32.0	32.7	33.4	34.1	34.7	35.4	36.0	36.6	37.3

**Source: Brealey and Myers (1981).**

$\sigma\sqrt{t}$

## **2.14 Conclusion**

Managers with capital responsibilities are called upon regularly to invest in projects that seek to grow the company and shareholder value. The lack of a capital projects pipeline creates a negative sentiment in the market place. Having a viable capital projects list presupposes that all projects will create value over and above the internal hurdle rate. The current method of determining value creating potential of a project is the discounted cash flow methods, of which the Net Present Value (NPV) is probably most commonly used.

However, the DCF methods are unable to price the strategic value of a project. Real Options Analysis is a promising valuation tool for strategic investment decisions whereby projects are viewed as real options that can be valued using financial option pricing technique. Under the real options approach, the decision to invest is simply an option. Option holders have the right but not the obligation to make an investment, similar to a financial call or put option on a common stock. It may be that the mathematics of the Black-Scholes formula to real asset valuation makes the technique inaccessible to most financial managers. The result being that real option valuations are not widely used. The real option model as outlined here is an attempt to bridge this gap.

## **Chapter 3: Resorcinol Investment - A Case Study**

### **3.1 Introduction:**

The South African Chemicals Industry is a substantial and complex operation making a substantial contribution to the economy. It presents both challenges and opportunities. The Industry is involved in basic chemicals manufacture and lacks a meaningful presence in the higher-value chemicals sector. With more than R4 billion worth of chemicals being imported into the country, there are many opportunities to engage in the local manufacture of these chemicals. One such chemical imported in relatively large amounts, is called Resorcinol. Resorcinol enjoys widespread usage in the rubber (tyre), wood and fibre industry. From the marketing research conducted, it would appear that a viable and sustainable resorcinol manufacturing plant is possible in South Africa.

The chemical manufacturing industry is capital intensive. It requires up-front outlays of capital. Evaluating the return on investment is the most important factor for potential investors. Unless the investor is convinced that the capital invested in the project will give one superior returns over alternative investments, the investor is unlikely to commit his capital. Realistic appraisal of the investment is therefore imperative. The business plan for the setting up of a resorcinol manufacturing plant will be examined in this section. The marketing and economic rationale will be presented. The financial projections of this enterprise will also be presented.

### **3.2 The South African Chemical Industry**

The South African chemical industry is of substantial economic significance to the country, contributing more than 5% to GDP and approximately 22% to its manufacturing output. The industry employs approximately 175 000 people. Through isolation of the industry from international competition (during Apartheid) and high raw material prices as a result of import tariffs, locally produced goods have generally not been competitive in export markets. The

industry is the largest of its kind in Africa. It is highly complex and widely diversified, with end products often being composed of a number of chemicals which have been processes in some way to provide the required properties and characteristics.

South Africa imported more than R4 billion worth of chemicals in 2004 (Department of Finance, Chemical Import Data, 2004). The chemicals sector represents an area where substantial growth in the economy can be realized in the medium to long-term. A competitive import substitution strategy, where certain chemicals, currently imported, are manufactured locally, seems a feasible strategy to grow both the chemical industry and the South African economy. The chemicals that should be the focus of the import substitution strategy should be intermediate chemicals, currently imported into South Africa and used in relatively large amounts. Intermediate chemicals are manufactured by reacting two or more basic chemicals to give the intermediate chemical. Very few chemical companies in South Africa are engaged in intermediate chemical manufacture. As South Africa imports many intermediate chemicals, an opportunity exists for starting a chemical enterprise, that manufacturers intermediate chemicals. The chemical chosen for this case study is resorcinol, a derivative of the base chemical benzene.

### **3.2 Resorcinol Project Description**

This project involves a two stage investment proposal:

**First Stage Investment:** Resorcinol is not produced in South Africa and is currently imported into the country. Resorcinol is used in the rubber and wood processing industries, as an adhesive. Two products will be manufactured in this plant: (1) resorcinol, which is the primary product and (2) sodium sulfite which is a by-product. The sodium sulfite will be sold to a local paper mill. The quantities consumed in the South African economy indicate that a commercially viable chemical manufacturing plant can be setup in KwaZulu Natal.

**Second Stage Investment:** Aramid fibre is widely used as a fire resistant textile material. This fiber has excellent heat resistance and does not support combustion, and it is used in special textile application, electric goods, fire blocking in car engine compartments, thermal insulation for pipes and fire-resistance protective fabric. The second stage of the investment will involve expanding the resorcinol production capacity and building a fibre spinning plant to produce aramid fibre. This fibre will be sold to the automobile industry for use as fire blocking in car engines.

### **3.2 Resorcinol Manufacture in South Africa**

This investment project proposes to initially build a 1000 tons per annum resorcinol manufacturing facility in Umbogintwini, in KwaZulu Natal. Resorcinol is a chemical compound used mainly as an adhesive in both the rubber (tyre) and wood industries. It also finds uses as an intermediate in the production of flame-retardants, dyes, UV stabilizers, medicines, cosmetics and explosives. In South Africa, its major usage is in the rubber and wood industries.

South Africa imported more than 500 tons in 2004. From the market research conducted, a viable resorcinol producing facility in South Africa looks extremely feasible. South Africa has a significant tyre and rubber processing industry as well as a growing wood composite market. As the economies of Africa and other developing countries grow, the demand for resorcinol is expected to grow simultaneously.

### **3.3 South African Market**

The estimated current consumption of resorcinol for the South Market (based on import statistic) is between 450 to 550 tons in 2004. This information was obtained from import statistics and from local consumers. The main industry users of resorcinol in South Africa are:

- The Rubber Processing Industry.

- The Wood Adhesives Industry
- Fire Retardants

### **3.3.1 The South African Rubber Processing Industry**

Nearly 70% of resorcinol demand is in adhesive resins for rubber products, including tyres. The largest use among rubber products is in the manufacture of tires for cars and trucks, off-road vehicles, aircraft, racing cars, motorcycles and bicycles; small amounts of resin are used in the reinforcement of other rubber products such as belting, rubberized hose and rubberized textile sheets. The resorcinol is used as resorcinol-formaldehyde resins. They are used in two main ways:

- As a rubber compounding additive, it increases the adhesion of the rubber in the carcass and tread to the reinforcing fabric and belt
- As a latex dip, it is applied directly to the tire cords to increase the adhesion of the cords to the rubber in the tread

Reinforced rubber products represent the largest outlet for resorcinol. Tyres are composite structures produced by combining an inexpensive structural material (rubber) with a more costly reinforcing material (steel cord and/or polyester fabric). The major role of resorcinol is in providing strong adhesion between the steel cord and the rubber under service conditions, such as moisture and speed that cause heat buildup.

### **3.3.2 Major Users in Rubber Industry**

Industex of Port Elizabeth operates two tyre-cord dipping plants, one in Port Elizabeth and one in Utenhage. In the past, tyre companies used to manufacture their own tyre cord dips. However due to high capital costs, most tyre companies have out-sourced tyre cord dipping to Industex. Although exact usage is confidential, Industex usage of resorcinol is estimated at more than 100 tons per annum. Dunlop Tyre in Durban and Ladysmith also uses a significant amount of resorcinol in rubber compounding. Their usage is estimated at about 80-100 tons per annum of resorcinol. Discussions have been held with Dunlop Tyre in Durban and Industex in Port Elizabeth and both

these companies have indicated a willingness to use a locally produced product, provided the quality was comparable to the imported product. Price had to be competitive. .

### **3.3.3 The South African Wood Adhesives Industry**

In the Wood Adhesives industry, resorcinol brought into the country is also used to produce resorcinol-formaldehyde resins and phenol-modified resorcinol formaldehyde resins. These resins are used as wood adhesives. In comparison with the more widely used phenol-formaldehyde resins, resorcinol-based resins offer certain performance advantages-particularly where a durable, waterproof, structural bond is required without application of heat. Straight resorcinol-formaldehyde resins are recommended for bonding dense hardwoods such as oak and maple. Resorcinol resins dominate in the production of structural laminated beams. Resorcinol-based resins are also used in other specialty wood laminates that require an adhesive of strong physical resilience. These specialty laminates include plywood (used for industrial construction) and laminated arches, balsa insulation laminates used in liquefied natural gas tanks and specialty laminates used in marine and sporting goods products. The demand for wood products in external construction will increase demand for resorcinol.

### **3.3.4 Main Users in Wood Industry**

The industry leader in the wood adhesives market is Zeta Resins of Johannesburg, and their usage is estimated at more than 150 tons per annum. Zeta Resins supply Global Forest Products, the leading manufacturers of plywood. Discussions were held with Zeta Resins and they have expressed a willingness to support the local manufacture of resorcinol provided that quality, price competitiveness and supply are attractive.

The other significant user of resorcinol as wood adhesives is Rystix Adhesives, based in Port Elizabeth. Rystix Adhesives is currently exporting 30% of its products and hopes to increase this sector of their business. Their

usage is estimated at about 50 tons per annum. There are a number of other smaller users of resorcinol in South Africa. They include conveyor belt manufacturers, reinforced hosing manufacturers, and textile rubber sheeting manufacturers. Together they represent a significant consumption of resorcinol.

### **3.3.5 Fire Retardant Industry**

The use of resorcinol in flame-retardants represents a large growth area for resorcinol. Consumed primarily in business machine and electrical/electronic applications, flame retardant compounds represent a significant portion of the total consumption of these alloys. A South African company Chemicals and Research has developed an insulating material containing resorcinol that is highly resistant to combustion. This substance is expected to be in high demand especially in the mining sector where non-combustible insulating materials are needed. Chemicals and Research are currently patenting the formulation. A potential 300 tons will be required for this venture. A consistent supply of reasonably priced resorcinol is needed for this venture

The fibre, meta-aramid, which is produced from resorcinol and the fiber has excellent heat resistance and does not support combustion. It is used in special textile application, electric goods, fire blocking in car engine compartments, thermal insulation for pipes and fire-resistance protective fabric. The use of resorcinol in flame-retardant insulations represents a substantial growth market for South Africa and other developing countries. The aramid fibre will be supplied to the large number of car manufacturers located in South Africa, who would use it primarily for fire blocking.

### **3.4 Future Trends in Resorcinol Market**

As the consumption of resorcinol worldwide is expected to grow at 3-4% average annual growth rate (SRI International, 2005I), the possibility of exporting to both the developing and first world countries is very attractive.

The local production of resorcinol will give impetus for the upstream usage of resorcinol in the manufacture of flame retardants, dyes, UV stabilizers and medicinal (anti-tuberculosis drugs). As there are no manufacturing facilities in South America, Africa, Middle East or Europe, exports to these regions has promising prospects. Growth in the tyre and construction industries is related to population and economic activity and both of the latter are increasing on a worldwide basis.

### **3.5 Raw Materials Suppliers for Resorcinol and meta Aramid**

All raw materials are sourced locally and this represents a major advantage of this process. The raw materials and suppliers are listed below:

- Benzene, Engen, Durban
- Sulfuric Acid, Polifin, Durban
- Caustic, Polifin, Sasolburg
- Oleum, Chemical Initiatives, Umbogintwini, Durban
- Ethyl Ether, Illovo Chemicals, Durban
- Resorcinol, in house
- Ammonia, Polifin

### **3.6 Barriers to Entry into Resorcinol Business**

There is a significant barrier to new entrants. The Benzene sulfonation process is an old and relatively simple process, but the big drawback of this process is that it produces 2.45kg of sodium sulfite waste for every kilogram of resorcinol. An outlet has to be found for this by-product. For anyone contemplating producing resorcinol by this route, the waste remains a major obstacle. The advantage of using the benzene sulfonation route lies in finding a ready outlet for this waste by-product. This is indeed the case for this project. There exists a ready market for the by-product in South Africa: Kraft paper mills use sodium sulfite in the pulp preparation process. All sodium sulfite produced will be sold to the paper mills at a competitive price as it is currently imported into South Africa, there being no local production.

The alternative process for manufacturing resorcinol is practiced only in Japan. This process is technically complex and requires delicate control and are prone to explosions. This process will not be used in South Africa.

### **3.7 Competitors**

Only three companies produce resorcinol in the developed regions of the world and they all market their resorcinol in South Africa.

- INDSPEC Chemical Corporation (United States)
- Sumitomo Chemical Company, Ltd (Japan)
- Mitsui Chemicals, Inc (minor player in Japan)

In addition, three small capacity plants located in China and four in India. These smaller companies supply mainly the internal market in those countries. In India and China, resorcinol is mainly used for producing dyes.

With over 50% share of the world market, INDSPEC is the dominant player in the global resorcinol industry. Japanese resorcinol production is primarily for export; 80% of production was exported in 2000 (SRI International, 2005).

### **3.8 Employment Creation**

As employment is a major concern in South Africa, any enterprise that engages people in employment will be received positively by the South African government. Twenty-Six full time jobs will be created in the first phase and 20 new jobs will be created in the second phase. These jobs include managerial, technical and operational jobs. More employment may be possible if there is an increase in production.

### **3.9 Intended site of project**

Chemical Plant will be built the Umbogintwini Chemical Complex, in KwaZulu Natal. The Umbogintwini Chemical Complex is located south of Durban and is zoned as a heavy industrial site. The main advantage in setting up the resorcinol plant in this complex is that it is a fully serviced chemical site. It has a central steam generating plant as well as providing warehousing, effluent handling, rail facilities and security control. One of the raw materials, oleum is manufactured on this site. A further advantage of this site is that a skilled labour force is readily available from the surrounding areas.

Umbogintwini is close to the port at Durban Harbour providing easy access to exporting overseas. It is located close to the major road network that serves the entire country. Major users are located in Durban, Johannesburg and Port Elizabeth.

### **3.10 Marketing Strategy**

The marketing plan of resorcinol will focus on four strategies

1. Internationally acceptable quality
2. Price competitiveness of the locally synthesized resorcinol.
3. Local Manufacture and Consistent Delivery
4. Price Protection.

#### **3.10.1 Quality**

In this enterprise, the benzene-sulfonating process will be used to produce resorcinol of acceptable quality. INDSPEC Chemical Corporation in the USA uses such a process. This is relatively old and simple technology. The quality of resorcinol produced in this process will be equivalent to that produced by INSPEC. In order to ensure internationally acceptable quality, the company will apply for ISO 9000 accreditation as soon as production commences. This quality system is regarded as a standard in the Chemical Industry and is a requirement for entry in the international market

### **3.10.2 Price Competitiveness and Price Sensitivity**

All chemicals imported into the country are quoted in US dollar terms. The world price for resorcinol is quoted at USD5.2-5.7/kg (R32.24 to R35.34 based on an exchange rate of R 6.2 to US dollar). It is planned to offer the resorcinol at ZAR29 to local users. With this strategy, it is intended to supply all of South Africa's resorcinol requirements within two years of commencement of operations.

### **3.10.3 Local Manufacture and Consistency of Delivery**

The company will have to ensure delivery on customer's requirements. To do this, the best practices of the chemical industry will be adopted through a process of continuous improvement. The advantage to the local manufacture of resorcinol is that delivery times will be less than a week compared to that of 6 to 8 weeks if it is imported. There may be more efficient use of working capital as users can carry less stock of resorcinol, as it will be readily available.

### **3.10.4 Import Duties on foreign resorcinol**

The company intends seeking the establishment of import duties on foreign manufactured resorcinol should foreign producers dump resorcinol in South Africa. The Department of Trade and Industries provides this type of protection. This is a standard measure operating in most countries in order to give developing countries a chance to establish indigenous industries.

### **3.11 Manufacturing Process Description: Resorcinol**

Even though the process described here is an old one, it is still the main route for the synthesis of resorcinol. The equipment required for this process is fairly simple. Sulfuric acid corrosion requires due consideration in material of construction. The simplified process is explained below. A basic process flow diagram is also attached.



### **3.11.1 Process Description**

1. Benzene is added to sulfur trioxide to form m-benzenedisulfonic acid.
2. m-Benzenedisulfonic is then converted to its disulfonate sodium salt by treatment with sodium sulfite or oleum.
3. In the next step, this salt is heated to 350°C in the presence of sodium hydroxide yielding the sodium resorcinate and sodium sulfite.
4. After sulfuric acid work-up, the resorcinol is extracted with ethyl ether.
5. The ether extract is distilled, the ether is recycled, and the light ends (phenols) and the bottoms (heavy phenols) are incinerated,
6. Molten resorcinol is cooled and flaked.
7. The sulfite-sulfite solution is transferred to a dryer. The dry products will be sold to kraft paper mills.
8. The resorcinol yield is 94% yield based on m-benzenedisulfonic acid.
9. Resorcinol is used to produce meta-aminophenol in a clean one step process. In this process, ammonia reacted with resorcinol is used to produce meta-aminophenol. The meta aminophenol is then drawn into the meta aramid fibres.

### **3.11.2 Plant Capacity: Resorcinol and Meta Aramid**

The design capacity of the first-stage resorcinol plant will be 1000 tons per annum. In phase 2 the expansion in year 3 will see a doubling of plant capacity to 2000 tons per annum. In the third year after commencing production of resorcinol, the meta aramid plant will come on stream. The increased capacity from the resorcinol plant will be used to produce the meta Aramid fibre. The meta aramid plant will have a capacity of 1000 tons per annum.

### **3.12 Strategic value of the Resorcinol Enterprise**

The setting up of a resorcinol manufacturing plant in South Africa will be the first on the African continent. It is of strategic significance as it allows the development of a value added chemical industry in South Africa. The local availability of competitively priced resorcinol will add impetus to the

development of additional resorcinol based industries such as medicines and dyes. This will increase economic activity which will add to the industrial development of the country.

### **3.13 Financial Projections**

#### **Phase 1: Resorcinol Plant**

The cost of the intended resorcinol enterprise is comprised as listed below:

- Plant and Equipment: R28 million
- Land and Buildings: R1 million
- Technology package: R1 million
- Working Capital: R7.5 million
- Total Capital Required: R37.5 million

#### **Phase 2: Resorcinol Expansion and Meta Aramid Plant**

Plant and equipment: R50 million

Working Capital: R12.5 million

Total investment required for phase 2 is R62.5 million

### Resorcinol Cost and Revenue Structure

Note:

1. Detail in variable cost structure has been omitted due to confidentiality reasons
2. All costs are expected to rise by 5% per year
3. Revenue is expected to rise by 5% per year
4. New manpower levels from year 4 as follows: 2 technical managers, 2 supervisors, 20 operators, 2 logistics, 2 accounts and 3 laboratory

**Table 3.1: Resorcinol Variable Costs**

<b>RESORCINOL VARIABLE COSTS</b>									
Price per kilo			<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>Year 4</b>	<b>Year 5</b>	<b>Year 6</b>	
	Usage	Price/kg	<b>600000</b>	<b>800000</b>	<b>1000000</b>	<b>1800000</b>	<b>2000000</b>	<b>2000000</b>	
			<b>6118737</b>	<b>9448552</b>	<b>12325485</b>	<b>21312503</b>	<b>24710148</b>	<b>25739738</b>	
<b>Variable Cost increases by 5% per year</b>									

**Table 3.2: Resorcinol SG&A and Operating Costs**

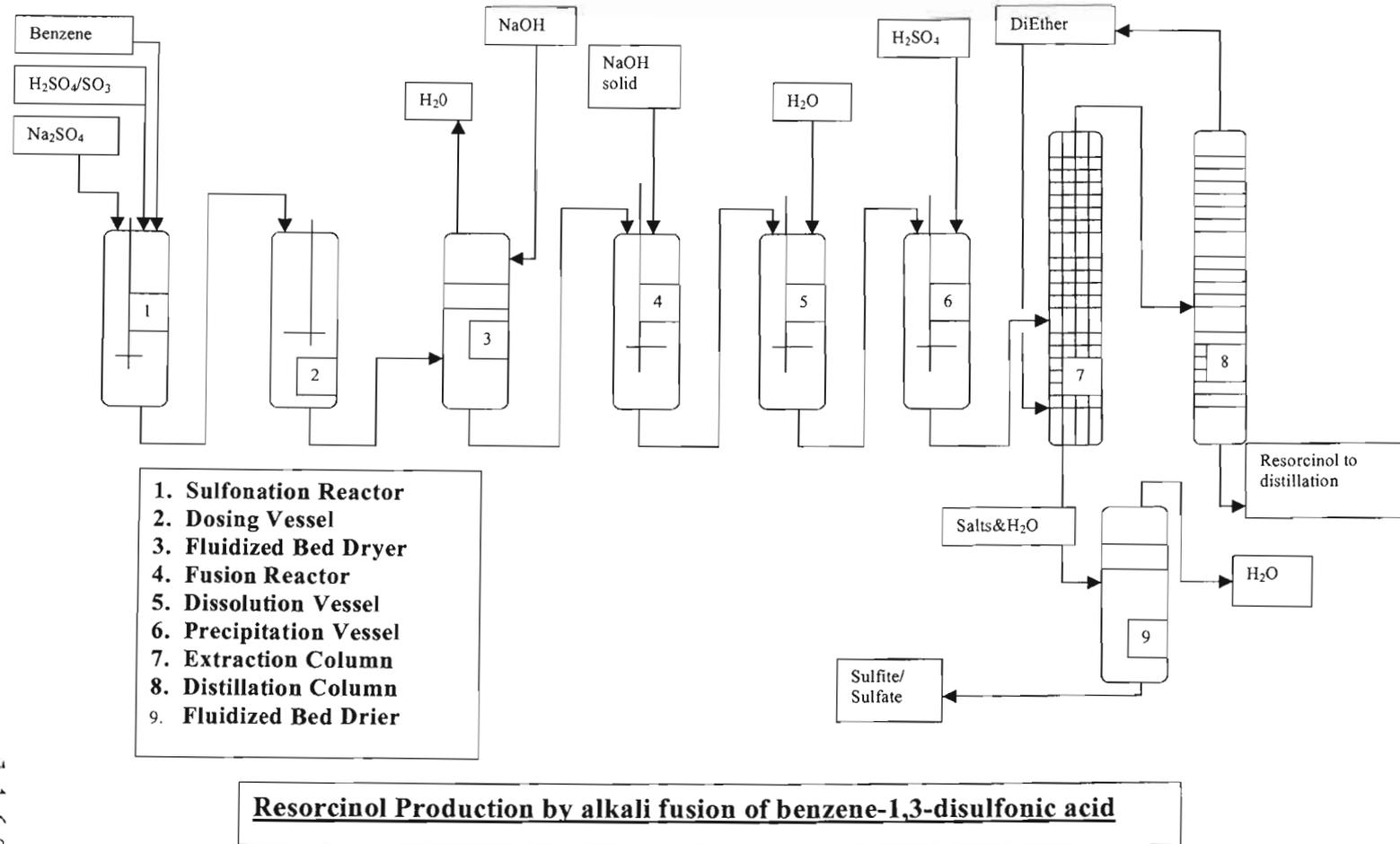
<b>SALES GOODS AND ADMINISTRATION COSTS</b>										
<b>Manpower Costs</b>		<b>Annual Pack</b>		<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>Year 4</b>	<b>Year 5</b>	<b>Year 6</b>	
MD		300000		300000	315000	330750	347287.5	364652	382884	
P. Manager		150000	1	150000	157500	165375	173644	182326	191442	
Technical		100000	1	100000	105000	110250	231525	243101	255256	
Sup		90000	1	90000	94500	99225	208373	218791	229731	
Operator		70000	15	1050000	1102500	1157625	1620675	1701709	1786794	
Secretary		60000		0	0	0	60000	63000	66150	
Logistics		70000	1	70000	73500	77175	162068	170171	178679	
Accounts		80000	1	80000	84000	88200	185220	194481	204205	
Lab		80000	2	160000	168000	176400	277830	291722	306308	
Admin and Sundry Expenses				100000	150000	300000	315000	330750	347288	
<b>Total</b>				<b>22</b>	<b>2100000</b>	<b>2250000</b>	<b>2505000</b>	<b>3581621</b>	<b>3760702</b>	<b>3948737</b>
<b>OPERATING COSTS</b>										
<b>Utilities</b>		cost	usage/ton							
Electricity per kilowatt		0.33	419	82962	110616	138270	248886	261330	274397	
Steam per ton		125	27	2025000	2700000	3375000	6075000	6378750	6697688	
Process Water per kL		2	21	25200	33600	42000	44100	46305	48620	
Cooling Water per kL		1	60	36000	48000	60000	63000	66150	69458	
<b>Total Utilities Costs</b>				<b>2169162</b>	<b>2892216</b>	<b>3615270</b>	<b>6430986</b>	<b>6752535</b>	<b>7090162</b>	
Maintenance				200000	210000	220000	400000	425000	450000	
Depreciation on		30000000		6000000	6000000	6000000	6000000	6000000	6000000	
Loans				0	500000	500000	500000	1000000	1000000	
Transport				100000	200000	300000	315000	330750	347288	
Effluent Disposal				100000	200000	600000	630000	661500	694575	
<b>Total (Operating +Variable)</b>				<b>8569162</b>	<b>10002216</b>	<b>11235270</b>	<b>14275986</b>	<b>15169785</b>	<b>15582025</b>	

**Table 3.3: Final Revenue and Costs Structure**

<b>Costs and Revenue Structure</b>									
<b>Costs</b>				<b>Year 1</b>	<b>Year 2</b>	<b>Year 3</b>	<b>Year 4</b>	<b>Year 5</b>	<b>Year 6</b>
Operating +Variable)				14687899	19450768	23560755	35588489	39879934	41321763
SG&A Expense				2100000	2250000	2505000	<b>3581621</b>	<b>3760702</b>	<b>3948737</b>
<b>Total Costs</b>				16787899	21700768	26065755	<b>39170110</b>	<b>43640636</b>	<b>45270500</b>
<b>Revenue</b>									
Resorcinol Sales @	29	4.83		17400000	24360000	32045000	54810000	63800000	67280000
Sulphite Sales	1.5			2160000	2520000	3150000	3307500	3472875	3646518.8
Total Sales				19560000	26880000	35195000	58117500	67272875	70926519
<b>Gross Profit</b>				<b>2772101</b>	<b>5179232</b>	<b>9129245</b>	<b>18947390</b>	<b>23632239</b>	<b>25656019</b>



Figure 3.1: Schematic of Resorcinol Production Process



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## Chapter 4: Evaluation

### 4.1 Introduction

The economic rationale and financial projections for engaging in resorcinol manufacture in South Africa have been presented in the previous chapter. The next critical step for any investor is to value this enterprise. Investment valuation is the most critical aspect of any potential investment. How risky is this investment? Will investment in an alternative investment(s) possibly result in a better rate of return? Will the investment provide superior returns over the long term? The discounted cash flow model is the general method which most analysts use to value investments. Within this model, the net present value technique is currently the more widely used valuation technique. In this section, the resorcinol project will be valued using the real options framework developed in Chapter 2. The value obtained here will be checked against the normal form of the Black-Scholes options calculation

### 4.2 The Resorcinol Investment Proposal

The resorcinol project involves a two stage investment proposal:

**First Stage Investment:** Resorcinol is not produced in South Africa and is currently imported into the country. Resorcinol is used in the rubber and wood processing industries, as an adhesive. Two products will be manufactured in this plant: (1) resorcinol, which is the primary product and (2) sodium sulfite which is a by-product. The sodium sulfite will be sold to a local paper mill. The quantities consumed in the South African economy indicate that a commercially viable chemical manufacturing plant can be setup in KwaZulu Natal

**Second Stage Investment:** The second stage involves increasing the resorcinol capacity to so as to feed an Aramid fibre plant. Aramid fibre is widely used as a fire resistant textile material. This fiber has excellent heat resistance and does not support combustion, and it is used in special textile application, electric goods, fire blocking in car engine compartments, thermal

insulation for pipes and fire-resistance protective fabric. The second stage of the investment will be used to build a fibre spinning plant to produce the aramid fibre. This fibre will be sold to the automobile industry for use as fire blocking in car engines.

Table 4.1 on the following page shows the cash flow projections and NPV calculations for projected investment.

**Table 4.1: Financial Projections for Resorcinol Project**

Year			0	1	2	3	4	5	6
Revenue				19560000	26880000	35195000	95072250	106075363	115215457
Less Cost of Goods Sold				14687899	19450768	28960755	71667281	77762666	81098631
Gross Profit				4872101	7429232	6234245	23404969	28312697	34116825
Less SG&A Expense				2100000	2250000	2505000	8163243	8571405	8999975
Operating Profit				2772101	5179232	3729245	15241726	19741292	25116851

**Cash Flow Calculation**

EBIT (1-tax rate)				1801866	3366501	2424009	9907122	12831840	16325953
Add Depreciation				6000000	6000000	6000000	16000000	16000000	10000000
Less Capital Expenditure			-30000000	-100000	-200000	-50300000	-2400000	-3000000	-3600000
Less increase in NWC			-7000000	-500000	-500000	-13100000	-1600000	-1800000	-2100000
Free Cash Flow			-37000000	7201866	8666501	-54975991	21907122	24031840	20625953
Terminal Value									50000000

<b>Discount Rate 12%</b>			1	0.893	0.797	0.712	0.636	0.567	0.507
			-37000000	6431266	6907201	-39142905	13932930	13626053	35807358

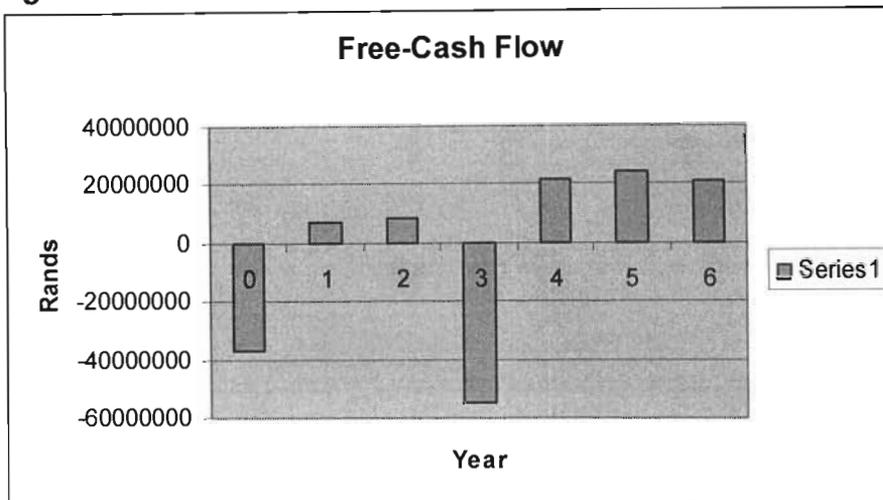
**NPV**

**561903**

### 4.3 Recognizing the Option in the Resorcinol Project

There are two ways to recognize the options in the Resorcinol project. The first way is to examine the description of the project. This project involves a two phased investment program with a large capital investment in year 3. The other way is to examine the pattern of the project cash flow over time.

Figure 4.1: Free Cash Flow



The cash flows in the chart show an uneven bias: year 0 and year 3 stand out net cash outflows. These cash outflows relate to the capital expenditures in year 0 and year 3. The investment in year 3 is discretionary. That is the company can choose not to make the investment, based on how things look when the time comes. This is a classic expansion option, sometimes called a growth option.

The Resorcinol project has two major parts. The first part is to spend R37.5 million now to acquire some operating assets. The second part is an option to spend an additional sum, R62.5 million, three years from now to acquire the additional capacity and enter new markets. The option here is a call option, owned by the company, with three years to expiration that can be exercised by investing certain amounts in net working capital and fixed assets. Viewing the project in this way, the resorcinol project must be evaluated in the

following manner: NPV (entire proposal) = NPV (phase 1 assets) + call value (phase 2 assets).

Phase 1 refers to the initial investment and the associated cash flows. It can be valued using NPV as usual. Phase 2 refers to the opportunity to expand, which may or may not be exploited in year 3. To value phase 2, the framework outlined in Chapter 2 will be used to synthesize a comparable call option and then value it. This step-by-step is outlined below.

#### **4.4 Mapping the project variables onto call option variables.**

This mapping procedure will create the synthetic option that is needed and will indicate where in the DCF spreadsheet, values for the variables can be obtained. The value of the underlying assets ( $S$ ) will be the present value of the assets acquired when and if the company exercises the option (See Table 2). The exercise price ( $X$ ) will be the expenditures required to acquire the phase 2 assets. The time to expiration ( $t$ ) is three years, according to the projections given in the DCF analysis. This time ( $t$ ) may be made sooner or later depending on economic circumstances. The three-year risk-free rate of interest ( $r_f$ ) is 7% (which is the market rate of interest on a three-year SA Government bond). The risk-adjusted discount rate being applied in the NPV calculation is 12%. Finally, the standard deviation of returns on these operating assets ( $\sigma$ ) is assumed to be 40%, a value that is neither particularly high nor low.

#### **4.5 Rearranging DCF projections**

The DCF projections are rearranged to separate phase 1 from phase 2 and to isolate values of  $S$  and  $X$  (See Table 3). This requires making a decision on what spending is discretionary (routine) versus nondiscretionary (extraordinary). This also requires making similar judgment about which cash inflows are associated with phase 1 as opposed to phase 2.

In this project, expenditures on net working capital and fixed assets are quite large. The large sums in year 3 clearly are discretionary and form part of the

exercise price (X). The smaller expenditure sums in other years are plausibly routine and may be offset against phase 2 cash inflows, ultimately to be discounted and form part of S, the value of phase two assets.

#### **4.6 Establishing Phase 2 Options Value**

Tables 2 and 3 show the separated Phase 1 and Phase 2 conventional discounted cash flow NPV for each. Table 2 calculations show that Phase 1 has a positive NPV of R635 705, while Table 3; Phase 2 calculations show a NPV of – R73 176. The sum of these two NPV gives the same value as in Table 1 viz. R561903.

From an options point of view, the value of the whole proposal must be at least R635 705 because the option value of Phase 2, whatever, it turns out to be cannot be less than zero.

#### **4.7 Attaching Values to the Option-pricing Variables**

Tables 2 and 3 shows how the original cash flow of Table 1 has been reorganized into phase 1 and phase 2 of the investment project. Values can now be obtained for the variables S and X. X is the amount the company will have to invest in net working capital and fixed assets (capital expenditures) in year 3 if it wants to proceed with the expansion: R62.5 million. S is the present value of the new phase 2 operating assets. In other words, it's the DCF value now (at time zero) of the cash flows those assets are expected to produce in the fourth year and beyond. This value is obtained from Table 3 by adding the present values in year 4, 5 and 6 (R9 527 473 + R9 700 622 + R25 198 729) and this gives an S value of R44 426 844.

The other options pricing variables are  $t = 3$  years,  $r_f = 7\%$  and  $\sigma = 40\%$  per year.

**Table 4.2: Phase 1 Resorcinol Projections Rearranged**  
**Financial DCF Projections for Resorcinol Project**

Year			0	1	2	3	4	5	6
<b>Phase 1</b>									
<b>Based on 1000 tons per annum</b>									
Revenue			19560000	26880000	35195000	36954750	38802488	40742612	
Less Cost of Goods Sold			14687899	19450768	28960755	30408792	31929232	33525694	
Gross Profit			4872101	7429232	6234245	6545958	6873255	7216918	
Less SG&A Expense			2100000	2250000	2505000	3581621	3760702	3948737	
Operating Profit			2772101	5179232	3729245	2964336	3112553	3268181	

**Cash Flow Calculation**

EBIT (1-tax rate)			1801866	3366501	2424009	1926819	2023160	2124318	
Add Depreciation			6000000	6000000	6000000	6000000	6000000	6000000	
Less Capital Expenditure			-30000000	-100000	-200000	-300000	-400000	-500000	-600000
Less increase in NWC			-7000000	-500000	-500000	-600000	-600000	-600000	-600000
Free Cash Flow			-37000000	7201866	8666501	7524009.4	6926818.6	6923160	924318
Terminal Value									20000000

<b>Discount Rate 12%</b>			1	0.893	0.797	0.712	0.636	0.567	0.507
			-37000000	6431266	6907201	5357094.7	4405456.6	3925431.5	10608629

NPV

**635079**

**Table 4.3: Phase 2 Resorcinol Projections Rearranged**

**Phase 2**

**Based on an extra 2000 tons per annum capacity from Year 3**

Year						3	4	5	6
Revenue							58117500	67272875	74472845
Less Cost of Goods Sold							41258489	45833434	47572938
Gross Profit							16859011	21439441	26899907
Less SG&A Expense							4581621	4810702	5051237
Operating Profit							12277390	16628739	21848670

**Cash Flow Calculation**

EBIT (1-tax rate)							7980303	10808680	14201635
Add Depreciation							10000000	10000000	10000000
Less Capital Expenditure						50000000	-2000000	-2500000	-3000000
Less increase in NWC						12500000	-1000000	-1200000	-1500000
Free Cash Flow						62500000	14980303	17108680	19701635
Terminal Value									30000000
Discount Factor 12%						0.712	0.636	0.567	0.507
						44500000	9527472.9	9700621.7	25198729

**NPV**

**-73176**

**Table 4.4: Phase 1 and 2 Resorcinol Projections Rearranged**

**Resorcinol Project Cash Flow Projection  
Phases 1 and 2**

Year			0	1	2	3	4	5	6
Cash Flow			0	7201866	8666501	7524009.4	21907122	24031840	20625953
Add Terminal Value									50000000
Less Investment			37000000			62500000			
Total			37000000	7201866	8666501	54975991	21907122	24031840	70625953
Discount Factor 12%			1	0.893	0.797	0.712	0.636	0.567	0.507
PV each year			37000000	6431266	6907201	39142905	13932930	13626053	35807358
<b>NPV</b>									<b>561903</b>

#### 4.8 Combining the option-pricing variables into NPVq and $\sigma\sqrt{t}$

In the resorcinol investment project:

$$\text{NPVq} = S / \text{PV}(X) = \text{R}44\,426\,844 / (\text{R}62\,500\,000 / (1.07)^3) = 0.871$$

And

$$\sigma\sqrt{t} = 0.4 \times \sqrt{3} = 0.693$$

#### 4.9 Using the Black and Scholes Options Pricing Table

Table 5 shows the Black-Scholes Option-Pricing Model. The table does not show values that correspond exactly to the computed value for NPVq and  $\sigma\sqrt{t}$ , but by interpolation, the synthesized call option value of about 22.4% of the value of the underlying assets (S) is obtained. Accordingly, the value of the option is 0.224 times R44 426 844, which equals R9 951 613. Recall that the value of the entire proposal is given by: NPV (entire proposal) = NPV (phase 1 assets) + call value (phase 2 assets). Filling in the figures gives: NPV (entire proposal) = R635 079 + R9 951 613 = R10 586 692

#### 4.10 Check against full Black-Scholes Calculation

The final real option call value has been calculated at R10.6 million. This value has been calculated using the re-arranged form of the Black-Scholes equation and the Black-Scholes Options Pricing Table. Is the value R10.6 million generated the correct value? The check would be if the same value is obtained if the full form of the Black-Scholes equation is used.

Recall that a call option on a non-dividend-paying stock is given by:

$$C = SN(d1) - X(e^{-rf t})N(d2)$$

Where  $e^{-rf t}$  is the discount function for continuously compounded variables

$$d1 = [(\ln(S/X) + (rf + 0.5\sigma^2) [t])] / (\sigma\sqrt{t})$$

and

$$d2 = d1 - \sigma\sqrt{t}$$

$$d1 = [\ln(44.4/62.5) + (0.07 + 0.5(0.4)^2(3))] / 0.4\sqrt{3}$$

$$d1 = [-0.3419 + 0.45] / 0.693$$

$$d1 = 0.16$$

$$d2 = d1 - \sigma\sqrt{t}$$

$$d2 = 0.16 - (0.4\sqrt{3})$$

$$d2 = -0.533$$

looking at calculated values for the Standard Normal Probabilities,

$$N(0.16) = 0.5636$$

And

$$N(-0.5636) = 0.298$$

Therefore the call value

$$C = R44.4 * 0.5636 - R62.5 (e^{-0.07*3}) * 0.298$$

$$C = R25.1 - R15.1$$

$$C = R10 \text{ million}$$

This value is similar to the call value of R10.6 million obtained in real options model.

#### **4.11 Conclusion**

The final estimate of R10 586 692 is a long way off from the original figure for NPV of R561 903. The option- pricing analysis uses the same inputs from the same spreadsheet as the conventional NPV but obtains a much higher value. This higher value is the inherent strategic value that the static NPV method is unable capture. The real options analysis is able to extract this value using variables that are readily available in the DCF spreadsheets.

**Table 4.5: Black and Scholes Options Pricing Model (A Portion)**  
**NPVq**

	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98	1.00	1.02	1.04	1.06	1.08
0.05	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.6	1.2	2.0	3.1	4.5	6.0	7.5
0.10	0.0	0.1	0.2	0.3	0.5	0.8	1.2	1.7	2.3	3.1	4.0	5.0	6.1	7.3	8.6
0.15	0.5	0.7	1.0	1.3	1.7	2.2	2.8	3.5	4.2	5.1	6.0	7.0	8.0	9.1	10.2
0.20	1.5	1.9	2.3	2.8	3.4	4.0	4.7	5.4	6.2	7.1	8.0	8.9	9.9	10.9	11.9
0.25	2.8	3.3	3.9	4.5	5.2	5.9	6.6	7.4	8.2	9.1	9.9	10.9	11.8	12.8	13.7
0.30	4.4	5.0	5.7	6.3	7.0	7.8	8.6	9.4	10.2	11.1	11.9	12.8	13.7	14.6	15.6
0.35	6.2	6.8	7.5	8.2	9.0	9.8	10.6	11.4	12.2	13.0	13.9	14.8	15.6	16.5	17.4
0.40	8.0	8.7	9.4	10.2	11.0	11.7	12.5	13.4	14.2	15.0	15.9	16.7	17.5	18.4	19.2
0.45	9.9	10.6	11.4	12.2	12.9	13.7	14.5	15.3	16.2	17.0	17.8	18.6	19.4	20.3	21.1
0.50	11.8	12.6	13.4	14.2	14.9	15.7	16.5	17.3	18.1	18.9	19.7	20.5	21.3	22.1	22.9
0.55	13.8	14.6	15.4	16.1	16.9	17.7	18.5	19.3	20.1	20.9	21.7	22.4	23.2	24.0	24.8
0.60	15.8	16.6	17.4	18.1	18.9	19.7	20.5	21.3	22.0	22.8	23.6	24.3	25.1	25.8	26.6
0.65	17.8	18.6	19.3	20.1	20.9	21.7	22.5	23.2	24.0	24.7	25.3	26.2	27.0	27.7	28.4
0.70	19.8	20.6	21.3	22.1	22.9	23.6	24.4	25.2	25.9	26.6	27.4	28.1	28.8	29.5	30.2
0.75	21.8	22.5	23.3	24.1	24.8	25.6	26.3	27.1	27.8	28.5	29.2	29.9	30.6	31.3	32.0
0.80	23.7	24.5	25.3	26.0	26.8	27.5	28.3	29.0	29.7	30.4	31.1	31.8	32.4	33.1	33.8
0.85	25.7	26.5	27.2	28.0	28.7	29.4	30.2	30.9	31.6	32.2	32.9	33.6	34.2	34.9	35.5
0.90	27.7	28.4	29.2	29.9	30.6	31.3	32.0	32.7	33.4	34.1	34.7	35.4	36.0	36.6	37.3

**Source: Brealey and Myers 1981**

$\sigma\sqrt{t}$

## **Chapter 5: Conclusions and Recommendations**

### **5.1 Introduction**

This chapter discusses the main issues in investments: risk and investment valuation. Quantifying the investment risk is and will be an area of considerable academic research. Investment in the chemical industry is capital intensive. Ensuring that there are adequate returns on this investment is vitally important to the investor and entrepreneur. How can the strategic value of an investment and its risks be quantified? This chapter firstly describes the risks involved in the resorcinol project and how this is reflected in the discount rate in the DCF model, and in the volatility factor in the real options model. The Real Options model for the resorcinol project developed in the last section will be critically analysed and recommendations are provided for use of this model in the South African context.

### **5.2 Risks in the Resorcinol Project**

An investment in any new enterprise such as the resorcinol project is an exercise in risk. Risk is an important element in every investment decision because it indicates the possibility of return on investment. Identifying risk and capturing the inherent value in an investment decision is a difficult balancing act. The cost of capital is a function of mainly operating risk in the resorcinol project. Because of the equity nature of the resorcinol project, financial risk (debt financing) is of lesser concern.

#### **5.2.1 Business or Operational Risk**

Business risk refers to the variability of business results deriving from the operational structure of a firm, i.e., from the nature of a firm's business activities. This risk becomes more evident upon breaking down a firm's cost into fixed and variable costs. The mix or balance of fixed versus variable costs is an important indicator of operating risk. High fixed costs tend to render

many corporate decisions difficult to reverse and may require significant “revision costs”.

## **5.2.2 Industry Risk**

### **Competitors**

Competitor Risk originates from the possibility that strategic choices by competitors will have consequences on the industry structure and cost-earnings of a firm. For example aggressive strategies based price competition; the introduction of innovative products to the market, mergers and acquisitions that create vertical integration, and cost cutting investments that improve efficiencies. The resorcinol industry is dominated by two major players: Inspec and Sumitomo. There are significant barriers to entry for new entrants. The most important of these is the environmental concern regarding the generation of 2.45kg of waste for every kilogram of resorcinol produced. In this resorcinol project in South Africa, a captive market exists for the by product. This will prove to be a competitive advantage and significantly reduces the risk of this project.

### **Technological Risk**

Technological risk is partially related to competitor risk, and can be thought of as a combination of factors that can cause a firm's loss of competitiveness. Specific source of risk here is innovation that results in technological obsolescence and loss of competitiveness, in terms of cost as well as quality. The main area of technological risk in the resorcinol project would be a new and different process that could manufacture resorcinol more competitively. Because of its long and safe use in the tyre industry, it would be difficult to displace resorcinol as the adhesive of choice.

## **5.2.3 Other Risk Factors**

### **Market Demand Risk**

Market-demand risk is another variable that impacts on the determinants of volatility. This type of risk is related to the area of customer satisfaction.

Quality, on time delivery and price competitiveness of the product are three main factors that impact on customer satisfaction. Lack of attention to these variables may hamper sales and leave the firm unprepared. Market demand risk underlies the important role that managerial flexibility can have in the formulation of strategic positioning of the product. This resorcinol project will aim to produce resorcinol at the quality and price equivalent to that of the main competitors. The company will not engage in aggressive pricing strategies as this may trigger a price war and will significantly impact the cost structure of the resorcinol project.

### **Country Risk**

Country risk is risk arising from the commercial and industrial relationship between firms and the country's governmental departments. One example might be the risk represented by the possibility of non-recognition of foreign credit due to economic fluctuations in that country, such as changes in the inflation rate, interest rate or GDP. A volatile exchange rate may also increase country risk. The South African economy continues to grow at an impressive rate of 4% and inflation rates are low and the exchange rate is stable. The contribution of country risk to the variance is at par with that of stable economies.

### **5.3 Risk and the Discount Rate in the DCF model**

The DCF approach has traditionally relied on a single discount rate to indicate the risk of the project. The higher the discount rate the higher the risk of the venture. A lower the discount rate indicates more certainty in cash flow projections.

The DCF model discounting at a single rate implies the future cash flow will contain the same risk as the starting period of the venture. In other words, information relevant to the future cash flows comes in regularly and there are no periods in which more is learned than in any other period. In reality, this

seldom happens, as new information provides more certainty and hence reduces risk. The traditional DCF model is ill-suited for projects characterized by varying degrees of risk time. The model also cannot illustrate the resolution of risk over time.

The discount factor reflects the minimum return the company expects on capital invested. A low discount rate gives more weight to cash flows that a project is expected to earn in the distant future. Low discount rates indicate safe investments and should compare favourably with expected returns from alternative investment in securities of comparable systematic risk. On the other hand, a high discount rate indicates that there is more risk associated with the project and this may impact on the revenue stream. High discount rate gives distant cash flows much less weight.

It is important to realize that each project has its own cost of capital or discount rate. The correct discount rate is the opportunity cost of capital for the particular project: the expected rate of return that could be earned from an investment of similar risk. In principle, the opportunity cost would reflect the non diversifiable or systematic risk that is associated with the particular project. That risk might have characteristics that differ from those of the company's other individual projects or from its average investment activity. In practice, however, the opportunity cost of a specific project may be hard to measure.

In the resorcinol project a hurdle rate of 12% was used. While there are certain risks associated with the project, the beneficial aspects of the project more than outweigh the risks. The most important benefit is that a local market exists for the product. With the economy of developing nations, most notably India, China, Brazil and Russia, showing increased economic growth rates, it is reasonable to expect that the demand for resorcinol will be strong in the medium to long term. The South African economy is also growing at comparable rates. Resorcinol is a mature product used in critical applications

such as tyre construction. It is widely accepted in the industry and because of its unequalled safety performance, it will be difficult if not impossible to displace as a product of choice. These considerations indicate that the discount rate of 12% is neither too optimistic nor too risky.

## **5.4 The Real Options Analysis**

### **5.4.1 Estimating Cumulative Volatility**

In the real options pricing model, cumulative volatility is indicated by variable  $\sigma\sqrt{t}$ . The term  $\sigma$ , the standard deviation ( $\sigma^2$  is the variance) of the asset is a measure of its risk. It is a statistical measure of the dispersion of returns around expected value whereby a larger variance or standard deviation indicates greater dispersion. The more disperse the returns the greater the uncertainty of future returns. In understanding the uncertainty of returns associated with the resorcinol project, a discussion of the risks of the project will give greater insight. The risks are similar to risks discussed for the DCF model.

Startup companies are inherently more risky than established ones and therefore will therefore tend to have higher variance values as a norm. Having higher values for the variance  $\sigma$  will increase the value of the resorcinol real option, but it also gives an indication of higher risk. However it can be argued that if a company finds a ready market and if it is run by experienced and astute managers, then it can deliver a consistent and superior performance. Hence the companies ability to deliver should reflect a less risky enterprise and hence a reasonable  $\sigma$  value. In quantifying the value of the cumulative volatility, a  $\sigma$  value of 40% was used. This is neither too high nor too low.

## **5.5 The Duration factor in Cumulative Volatility**

The cumulative volatility term has the time variable  $\sqrt{t}$ . The option (the resorcinol project phase 2) has a higher value if the time to expiration is longer

rather than immediate. This ability to defer the exercise captures the value in the delay. A company may choose to defer an investment for some period of time until it has more information on the market. The NPV rule will value that investment at zero, while real options approach would correctly allocate value to that investment's potential.

Delaying an investment also has other advantages. For example, in this project, the initial investment seeks to build a presence in the resorcinol market. Entry into this market allows the manager to consolidate the resorcinol operation and explore future market opportunities. Investing phase 2 capital together with phase 1 capital at the same time will create enormous pressure on management to satisfy return on investment. It is apparent that because of excess production capacity, the instinctive response will be to produce to capacity and sell the resorcinol at a heavy discount. This may trigger a price war with the established competitors which cannot be sustained by the new entrant. It is more beneficial to build the resorcinol business in stages outlined earlier.

The time to maturity of an option and the volatility of the underlying asset jointly affect the value of an option in a very important way. Relative to deciding today whether or not to invest, an option provides the ability to wait for additional information before making the investment decision. The more informed this decision can be, the better, as the probability of making a decision that would ultimately prove to be a costly mistake is reduced. Thus, what makes an option valuable is the amount of relevant information that can be obtained during the life of the option. While delaying the phase 2 investment as long as possible to obtain the necessary information is an advantage, knowing when to exercise the option (invest in phase 2) is equally important. It may be necessary to exercise the option earlier, or defer the exercise even longer, depending on prevailing market conditions. It is imperative for a business to invest quickly in order to advantage of market demand and preempt investment by existing or potential competitors.

## 5.6 Critical variables in the Black-Scholes Formula

The value of a call option in the Black and Scholes model can be written as a function of the following variables:

S = Current Value of the underlying asset

X = Strike price of the option

T = Life to expiration of the option

R = Riskless interest rate corresponding to the life of the option

$\sigma^2$  = Variance in the value of the underlying asset

The model itself can be written as:

$$\text{Value of call} = SN(d_1) - Kre - rtN(d_2) \dots\dots\dots (7)$$

Where

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)t}{\sigma\sqrt{t}} \dots\dots\dots (8)$$

$$d_2 = d_1 - \sigma\sqrt{t}$$

Notice that the value of the call in the Black-Scholes formula has the following properties: It increases with the level of the stock price S and decreases with the with the present value of the exercise price, X which in turn depends on the interest rate and time to maturity. It also increases with time to maturity and the stock's variability ( $\sigma\sqrt{t}$ ).

In examining real options the model that has been developed, it was observed the model does captures this argument viz. the NPVq is defined by  $S/PV(X)$ . The value of NPVq increases as S, the stock price increases, and decreases with the present value of the exercise price X. The cumulative volatility factor  $\sigma\sqrt{t}$  also influence the value of the option as defined in the model: it increases with time to maturity and the stock's variability.

### **5.7 Analysis of Options Value of Resorcinol Project**

Real options analysis extends the financial option theory to real or nonfinancial assets. Using the real options framework developed for investment in the chemical industry, the two stage investment in a resorcinol production plant has been analysed. The NPV analysis gives a low positive NPV value (R 561 903), while indicating that the second stage investment has a negative NPV value (-R73 176). Unlike net present value, real options analysis using the Black-Scholes framework calculates the resorcinol project to have a value of R10 586 692. This is significantly higher than the NPV value of R561 903.

This framework captures the value of a firm's opportunity to start a chemical investment project and increase production capacity with further investment at a later stage. As time goes by and the prospects for an underlying investment become clearer, the value of the option decreases. The real options framework encourages a phased approach to capital investment decision making. This approach captures the strategic value inherent in the capital investment. The NPV relies on conventional discounted cash flow valuation. This is because the real options framework accounts for the flexibility (able to delay) in a project, whereas an NPV analysis ignores this additional source of value. Since flexibility has value, ignoring it may result in undervaluation of the project. The NPV methodology clearly undervalues the resorcinol project by almost R10 million.

While the real options framework encourages the two stage investment model for the resorcinol project, the timing flexibility needs careful monitoring. After the initial investment in resorcinol, managers cannot afford to sit back and wait 3 years. This might be a mistake. Managers need to interpret market signals and may need to invest earlier to gain a “first mover” advantage. By capturing the value of flexibility, the real options framework allows managers to better value projects and assesses project alternatives

## **5.8 Recommendations**

South Africa faces a chronic unemployment problem. The creating of employment is the single most important challenge facing the South African government. Reducing the unemployment rate by half will greatly reduce the socioeconomic challenges that the unemployed face. And will no doubt contribute to an improvement in the domestic security situation. The critical requirements are entrepreneurs, employment creating investment projects and funding agencies. The entrepreneur remains the engine of employment creation. He has the energy and vision to turn an investment idea into reality by harnessing the available resources. The funding agencies play a crucial role in providing finance for the entrepreneur’s investment plan. Evaluating the investment project potential feasibility remains the critical function of the financier and entrepreneur. Over the past few decades, the DCF valuation has come to dominate the investment evaluation process. However in using the DCF valuation model, many projects that may have strategic value to the country may be routinely rejected due to the criteria of the DCF valuation model.

Evaluating investment in real assets in a similar manner to financial options seems to be better able to capture the strategic value of the investment project. The real options concepts have hitherto been difficult to apply to investment projects. The mathematical manipulations seem daunting to financial managers inexperienced in options analysis. However, the resorcinol

real options investment model developed here illustrates a simplified approach to real options valuation that avoids the complicated mathematics of the Black-Scholes model. The real options model indicates that the resorcinol project is of high strategic value whereas the DCF (NPV) valuation framework shows the project to be of marginal value.

Funding agencies need to apply investment evaluation criteria that can illustrate the strategic value of an investment project. This is of critical importance to the long term growth of the South African economy. The real options model is better able to accomplish this than the DCF model.

Investment in the South African chemicals industry represents an ideal opportunity to grow it, reduce unemployment and increase the chemical engineering capability of the country. The resorcinol investment project is of strategic value and current investment valuation methods used in South Africa fail to highlight the strategic nature of investments in the chemical industry. The real options framework is better able to capture the strategic value of resorcinol project than the DCF framework. It is recommended that entrepreneurs and funding agencies in South Africa use the real options framework outlined here to value potential investments in the chemical industry.

## **5.9 Conclusion**

Executing a business strategy almost always involves making a sequence of major decisions. The sequence of investment decisions relies on the initial and subsequent decisions. The initial decision gives the firm the option to invest further into the project should market conditions prove advantageous. Without the initial option, it is extremely difficult and expensive to take advantage of opportunities that arise at a later date. This "first mover" advantage gives the holder of the option a competitive advantage. However, it is crucial that this option is correctly valued and exercised at the right time.

The overriding consideration for any capital investment project is that it must create shareholder value. Allocation of capital to those investment projects that add the highest value must be the defining criteria for investment project selection. The discounted cash flow model of NPV in particular has been the popular investment valuation technique for many years. However, this technique has an inherent disadvantage in that it is a static methodology and is unable to capture the strategic value inherent in most capital projects. In addition the discount rate cannot be adjusted to reflect any operational flexibility.

The real options framework extends the valuation methodology provided by NPV. The real options framework illustrated here for the resorcinol project, rearranges the variables of Black-Scholes options pricing formula to find the NPVq and Cumulative Volatility concepts. The use of these two new concepts in the Black-Scholes Option Pricing Table is better able to illustrate the strategic value of the phase two investment. Investing in the first phase of the resorcinol project is similar to purchasing a financial call option. This gives the option to invest in further resorcinol production in the future. The use of the real options model developed here alleviates the need for complex mathematical calculations which the Black-Scholes formula normally requires.

The chemical industry is an important facet in growing the South Africa economy. It has the potential to create employment and develop expertise in a technically challenging sector. Investment in this industry has to offer superior returns over the long term. The real options framework is better able to illustrate the long term strategic value of investment in the South African Chemical Industry.

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## **7: Appendix 1: Ethical Clearance**



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11 DECEMBER 2006

MR. T MOODLIAR (203517505)  
GRADUATE SCHOOL OF BUSINESS

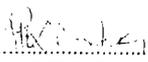
Dear Mr. Moodliar

**ETHICAL CLEARANCE APPROVAL NUMBER: HSS/06838A**

I wish to confirm that ethical clearance has been granted for the following project:

“A real options approach to evaluating investment in the South African Chemical Industry”

Yours faithfully

  
.....  
MS. PHUMELELE XIMBA  
RESEARCH OFFICE

→ cc. Faculty Office (Christel Haddon)  
cc. Supervisor (Dr. A Gani)