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The use of the Real Options approach in valuing the impact of climate change on the pulp and paper industry in South Africa: A Case Study of Sappi.

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Chapter One: Introduction

Over the past two decades, the world has started to realise the extent and urgency of the challenge posed to human life by climate change. The Stern Review, commissioned by the United Kingdom government and undertaken by Sir Nicholas Stern, an ex-World Bank Chief Economist warns that “climate change threatens the basic elements of life for people around the world – access to water, food production, health, and the use of land and the environment” (Stern, 2006).

A certain level of greenhouse gases is naturally present in the atmosphere, acting like the glass roof of a greenhouse to trap in sufficient heat to make the planet habitable. However, since the industrial revolution, the natural levels of these gases are being supplemented with carbon dioxide from the burning of fossil fuels, methane and nitrous oxide from agricultural activities and waste management, and a number of industrial gases which do not occur naturally (IPCC, 2001)¹. Simultaneously, deforestation is reducing the planets ability to absorb these excess emissions (IPCC, 2001). This increased level of greenhouse gases in the atmosphere is resulting in a rise in the global temperature, confirmed by scientific consensus to be caused by human activity (Oreskes, 2004).

Computer climate models estimate that the average global temperature will rise by 1.4 to 5.8 degrees C by the year 2100 ([http://unfccc.int/essential background](http://unfccc.int/essential_background)). This rise threatens to change the weather patterns and climatic conditions of the planet irrevocably (IPCC, 2001). The direct physical impacts are complex due to the myriad of interdependencies and relationships that exist in nature. However, we can expect sea level rise, flooding, generalized temperature increases, wider temperature ranges, a greater number of extreme weather events such as hurricanes and droughts, and changes in precipitation patterns (IPCC, 2001). Different regions and sub-regions are uniquely affected.

¹ The six main greenhouse gases are identified in Annex A of the Kyoto Protocol as being carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF₆), and hydrochlorofluorocarbons (HCFCs)

Humankind is now presented with the double challenge of adapting to the physical impacts of climate change, and avoiding further greenhouse gas build up by reducing our greenhouse gas emissions. Neither challenge is small. The first falls disproportionately on poorer countries with substantial implications for global equity, justice and social dislocation (IPCC, 2001). The second requires both industrialized and developing countries to end their reliance on fossil fuels, and with that the economic and political systems which support this reliance. Climate change is therefore “not only a topic for environmentalists” (Gars and Volk, 2003). Global market value at risk from climate change, modelled by Gars and Volk (2003) in their study entitled “Carbonomics” was estimated to be between \$192 and \$915 billion, dependent on various macro-economic models of economic development.

As global society comes to grips with this challenge, business will increasingly feel the impacts of regulation and consumer pressure to reduce its greenhouse gas generation profile. It will have to adapt to the direct physical impacts of climate change, and knock on effects such as changes in agricultural output, insurance premiums and water scarcity. As noted in Carbonomics “climate change is an extraordinarily complex economic problem, marked by a wealth of feedback mechanisms, irreversibilities and a high degree of uncertainty” (Gars and Volk, 2003). How well and how rapidly companies adapt to this major economic shift is anticipated to become an increasingly significant driver of shareholder value. “Of all the environmental challenges facing us today, climate change has the greatest potential to influence corporate competitiveness and profitability, the market’s valuation of the company’s stock and, by extension, the creation and erosion of shareholder value.” (Cogan, 2004). Understanding, describing and measuring this driver is an area of study still in its infancy.

Over the years, the financial community has developed a number of valuation techniques to describe and quantify the value of assets; be they projects, financial instruments or companies (Damodoran, 2002). The accurate determination of value is central to the capitalist economic system, promoting efficiency and optimality in capital allocation decisions. These techniques have evolved, and this ‘toolbox’ of techniques has expanded (Damodoran, 2002; Reed, 2001) as the business environment has changed, and valuations have become more sophisticated.

The phenomenon of climate change represents a significant change in the international business environment, with profound strategic implications for companies (Cogan, 2004). A literature review of studies undertaken recently which utilise various valuation techniques to understand the impact of climate change on value, reveals shortcomings in many of the traditional valuation techniques currently in use in the financial mainstream when applied to climate change. This is largely due to the high level of uncertainty associated with climate change impacts, demonstrated by both the wide range of potential temperature changes identified by the UNFCCC, and value of economic impacts forecast by Gars and Volk (2003).

An emerging valuation technique, real options analysis, has been found to provide insight on value in situations of high uncertainty (Mauboussin, 1999; Mun, 2002; Kodukula and Papudesu, 2006). Based on financial options theory, it values options relating to real assets. For example, if a company has the option to delay the manufacture of a patented product until the demand for the product is known with greater certainty, this option enables the company to time the investment in order to maximise returns to the new product, and prevents a costly investment mistake should market demand not ever materialise. This option therefore represents a source of value to the company; the value of being able to retain flexibility in an uncertain environment.

According to the real options approach, the uncertainties of climate change could represent sources of value for companies, depending on their ability to remain flexible and to identify, maintain and develop their options. This perspective has implications for both companies' strategic response to challenges arising from climate change and for the valuation of companies by the investor community. This thesis is aimed at answering the following research question:

“Does the real options approach to valuation enhance the understanding of the impact of climate change on company value?”

The objective of this research is to assess the potential of the real options approach in enhancing the understanding of the impact of climate change on company value. Understanding this potential will indicate whether further research into this area is warranted in order to develop a body of theory and empirical insights which will assist

companies with their investment decisions and strategic choices in a carbon constrained future.

Given the emerging nature of this area of study, an exploratory case study method has been chosen, within an interpretive paradigm. Sappi, the South African pulp and paper company, has been chosen for the case study. It is anticipated that this research will be valuable to companies, the investment community and climate change project developers both in South Africa and internationally in understanding, quantifying and managing the impact of climate change on company value.

The thesis is structured as follows. Chapter Two outlines the various mechanisms and linkages through which climate change impacts company value. Chapter Three considers approaches undertaken to date to understand and quantify these impacts, and their successes and shortcomings. Chapter Four introduces real options analysis and discusses its application to the valuation of climate change impacts, and particularly its potential to address the shortcomings of the approaches considered in the previous chapter. Chapter Five describes the case study method and research design utilised for this research. In Chapter Six, Sappi is introduced, and the potential impacts from climate change to the company's value are discussed. A real options valuation on a Sappi project is conducted, and the results considered against the research objective. Finally Chapter Seven draws conclusions and recommendations for further research.

Chapter Two: Climate Change Impacts on Businesses

This chapter will describe the impacts of climate change on business, the mechanisms through which these impacts occur, and the uncertainty of these impacts. It will also discuss the inherently strategic nature of the challenge climate change presents, and provide context to the South African situation. The objective of this chapter is to supply background, context and texture to the discussion in Chapter Three where approaches undertaken to date to understand and quantify the impacts of climate change are considered, and Chapter Five, where the specific climate change impacts on Sappi are identified and assessed.

2.1. Mechanisms through which Climate Change Impacts Business

2.1.1. First Order Impacts

As discussed in Chapter One, climate change is anticipated to have significant impacts on the physical environment, depending on the speed and extent of global warming. These physical effects are described by Gars and Volk (2003) as being 'first order risks', defined as direct risks resulting from the physical impact of climate change as experienced by the whole business value chain. These physical impacts will in turn disrupt current economic relationships. When applied at a company level, first order impacts would include: changes to a company's supply chain such as increased costs of agricultural commodities; changes to demand for products, for example an increased demand for air-conditioning; devaluation of land due to water scarcity and the destruction of assets or disruption of operations as a result of extreme weather events. Operating in geographically sensitive areas will also affect a company's risk profile and hence its credit rating.

The uncertainty surrounding the timing and extent of first order impacts is substantial. The range of IPCC forecasts of temperature rise (http://unfccc.int/essential_background) is indicative of this. Scientists have more recently identified a number of tipping points,

which if triggered, could catapult the earth's climate systems into accelerated and irreversible climate change (Jha, 2006).

The insurance industry is facing the brunt of first order impacts at the moment, with inflation adjusted economic losses having increased by a factor of six, and insured losses by a factor of ten since the 1960's (Innovest, 2004). The industry is adjusting to deal with this, either by excluding climate change risks or by developing innovative products for insuring them. Weather derivatives are an example of such a product, which whilst not specifically developed for climate change, could play an important role in managing the risk it presents. Insurance affordability and availability may change as part of the insurance industry's response.

First order impacts not only present risks to companies, but they also present benefits or opportunities, such the cost saving from reductions in heating requirements in offices, opportunities to enter new markets, or boost existing ones.

2.1.2. Second Order Impacts: Regulation and the Kyoto Protocol

Regulatory impacts have been described as second order impacts (Gars and Volk, 2003). Regulation restricts companies' ability to emit greenhouse gases. Regulatory costs have been defined as "costs incurred by a firm in response to or as a result of proposed or enacted government regulations" (Blacconiere and Dennis, 1994).

The United Nations Framework Convention on Climate Change (UNFCCC) was established in 1992 at the Earth Summit in Rio as the global response to the threat of climate change (www.unfccc.int). A few years later, in 1997, the Kyoto Protocol was drafted under the Convention. The Protocol is a progressive international treaty, which outlines the principles and financial mechanisms whereby nations agree to report on and reduce their greenhouse gas emissions. It also covers issues surrounding adaptation to climate change. The Protocol is a first of its kind in that it makes use of market mechanisms to tackle an environmental issue. It took until 2005 to enter into force, and in the interim the world's largest emitter, the United States, together with Australia announced that it would not ratify the Protocol and is therefore neither bound by its obligations nor able to take advantage of its mechanisms.

Under the Kyoto Protocol industrialized nations have individual targets for reducing their greenhouse gas emissions by an average of 5% below 1990 levels as measured between 2008 and 2012, a timeframe referred to as the 'First Commitment Period' (United Nations Framework Convention on Climate Change, 1997). The Protocol binds signatory Parties, which are by their nature national governments, to these targets. Each nation is allocated allowances representing their target emissions level, and has to hold allowances equivalent to their actual emissions between 2008 and 2012. This can be achieved either by reducing emissions internally, or through purchasing additional allowances from nations in surplus. Each government can pass its obligations on to its citizens, public sector, agriculture, industrial and business sectors as it sees fit. Greenhouse gas regulations in place internationally are therefore predominantly a result of obligations under the Kyoto Protocol. However, non-Parties, such as the United States and Australia, do also incentivise and regulate emissions reductions, although this largely occurs at the state level and through voluntary initiatives. Developing nations do not have targets in the First Commitment Period.

The Kyoto Protocol allows three 'flexible mechanisms' to help industrialized countries (termed Annex B countries, as they are identified in the Protocol) meet their targets: Emissions Trading, Joint Implementation and the Clean Development Mechanism (CDM). All three are market mechanisms. Emissions trading enables the least cost emissions reductions to be undertaken first, as industrialized countries buy and sell emission allowances from each other to assist them in meeting their targets. Joint Implementation and the CDM are project mechanisms; enabling industrialized countries to undertake emission reduction projects outside their borders and claim what are termed 'emission reduction credits' to count as additional allowances towards their targets. CDM is the mechanism for projects being undertaken in developing countries, whilst JI refers to projects being undertaken within other industrialised countries. These project mechanisms are very complex in their eligibility requirements and process, particularly the CDM which needs to ensure that any emission reduction credits generated outside the industrialized country target cap are additional to what would have happened without the mechanism. The reason for this 'additionality', as it has become known, is because the credits generated by the projects will be used to allow continued emissions within the capped industrialized countries. The mechanism is therefore globally neutral in terms of emission reductions. The CDM has also demonstrated high

costs of project design, validation and development. This is in part due to the institutions supporting and governing the CDM project cycle being in a developmental stage.

Emissions trading and carbon markets have matured rapidly over the past two years (IETA, 2005) with the EU Emissions Trading Scheme (EU ETS) the most advanced and representative of emissions trading schemes in operation. The EU ETS is a mandatory scheme designed to assist the EU in meeting its target under Kyoto Protocol. Power generating and energy intensive sectors fall under the scheme, representing 46% of the EU's emissions. The value of the credits traded in the EU ETS in 2005 was US\$8.2b (Ambrosi and Kapoor, 2006).

Projections of the value of the international carbon market in the future vary widely given the uncertainty surrounding the development of international climate change policy. Table 2.1 below gives some estimates of total future market value and highlights the extent of the range.

Table 2.1. Projection of Size of Greenhouse Gas Emissions Trading Market

| Source | Projection of Size of Greenhouse Gas Emissions Trading Market |
|--|--|
| <i>World Bank</i> | \$10 billion by 2005 |
| <i>U.S. Council on Foreign Relations</i> | \$2.3 trillion of trades completed by 2012 |
| <i>Energy Policy Journal</i> | \$24–37 billion of trades completed annually during the period 2008–2012 |
| <i>Resource and Energy Economics</i> | \$46.6 billion of trades annually (unspecified time frame) |
| <i>The Economist</i> | \$60 billion – \$1 trillion of trades annually (unspecified time frame) |

Source: *Innovest (2002, pg30)*

Whilst absolute targets or other forms of emission reduction regulations will make it more costly for the polluter to emit greenhouse gases, where the market structure permits these costs will be passed on to consumers. Goods which involve greenhouse gas emissions, either directly or indirectly are likely to become more expensive. The costs of

greenhouse gas emissions have been shown to have the potential of eroding annual net income by as much as 45% (Innovest, 2005).

As with first order impacts, second order impacts also present opportunities, particularly because climate change regulations are tending to be in the form of market mechanisms. Companies currently using low emissions technologies or inputs will be able to maintain low costs relative to the rest of the economy. Studies have found that energy efficiency, fuel switching and waste management measures undertaken by 22 OECD companies resulted in a combined US\$5.5b in savings (The Climate Group, 2004). A company having the ability to reduce their emissions at low cost will be able to do so beyond what they are required to do under regulations, and sell the emission reductions to those for whom abatement is more expensive. Certain high emissions sectors could actually gain from cap and trade schemes (Citigroup, 2003), depending on the method of emissions trading allowance allocation. Opportunities will also open up to gain a competitive advantage in areas of low emissions such as renewable energy, or to secure additional revenue streams through the CDM. For companies in developing countries, undertaking CDM projects has the additional advantages of mitigating risks of future regulation, and gives insight into the complexities of reducing an emissions profile.

The Kyoto target of 5% is dwarfed by the larger target of 70 - 80% global reduction required if climate change is to be stabilized (IPCC in Gars and Volk, 2003 pg12). Negotiations regarding action post 2012 began at the Meeting of the Parties to the Kyoto Protocol (MOP) in Montreal in 1995, but no substantial indication of regulations after the First Commitment Period has yet been agreed upon. Complex economic, political, technological and scientific factors are at play in determining how and when these required targets will be met, leaving high levels of uncertainty around future greenhouse gas regulations. This uncertainty is highly problematic for companies needing to prepare for potentially significant regulatory changes. This issue is most prevalent for emissions intensive companies needing to make long term capital investment decisions which are impacted by the presence of climate change regulations (IEA, 2006).

Increasingly, however, companies are coming to accept the inevitability of a carbon constrained future. A report by America Electric Power to its shareholders, notably a company operating in the country most resistant to greenhouse gas regulations on a

national level, concluded that “mandatory carbon constraints in the long-term appear probable” and “... initial mandatory reduction of greenhouse gas emissions are likely in the next decade” (as cited in Sauer and Wellington, 2005 pg 6)

2.1.3. Additional Second Order Impacts

Additional second order impacts exist in the form of reputation and litigation risks. As awareness of climate change and greenhouse gas emissions becomes more widespread in the future, the importance of these second order impacts is likely to increase.

A company’s response to climate change is anticipated to influence its reputation and branding amongst consumers and shareholders (Lippencot Mercer, 2004; Northrup and Sasson, 2005), and thereby shareholder value (Innovest, 2002). This impact will be different across sectors, with studies suggesting that consumer awareness and response on the issue could become significant in as little as five years in the UK (Carbon Trust, 2004). Litigation relating to climate change is also on the rise. In 2004 eight US states and New York City joined to sue “the five largest global warming polluters in the US: American Electric Power, Southern Company, Tennessee Valley Authority, Xcel Energy and Cinergy” (Innovest, 2005 pg 36). Whilst this risk remains relatively remote for most companies, tobacco-style lawsuits are referred to as a possibility for the future (CDP, 2005).

Financial and investment institutions are slowly waking up to the relevance of climate change to their sector. Whilst they are not direct emitters, their loan portfolios and investments could be significantly at risk if not screened for climate change exposure (Sauer and Wellington, 2005). The CDP² was initiated in 2003 by a group of investors in the Fortune 500 companies, now representing assets of \$31 trillion (Innovest, 2006) to request disclosure on climate change issues. Shareholder resolutions regarding climate change increased by 53% from 2003 to 2006 (CDP, 2006). Credit risk ratings will be influenced by climate change risk (among other factors), and high climate risk companies are likely to be increasingly sanctioned by financiers, and experience higher costs of capital (Northrup and Sassoon, 2004; Innovest, 2002). Again, the extent and

²The CDP issues a simple questionnaire annually to the FT500, comprising of questions around the company’s awareness and management of climate change issues. The response rate is documented, and responses analysed and released in a report.

timing of reputation, legislative and cost of capital impacts is highly uncertain, depending on progress regarding both the scientific forecasts and regulatory decisions.

First and second order impacts will affect company value as a result of their impact on earnings (physical impacts, regulation, litigation and consumer activism), competitive advantage (physical impacts, regulations) and access to capital (shareholder activism, and changes to cost of capital). From the discussion in this section it is clear that climate change impacts are neither restricted to the high emission sectors, nor to those exposed to the physical impacts such as extreme weather events. The Carbon Disclosure Project identifies fifteen sectors which it refers to as being 'high impact' in its 2005 report. This includes such diverse sectors as automotive, financial, integrated oil and gas, paper and forest products, transportation and food products³. The more obviously impacted sectors, such as the automotive and oil and gas sectors have been actively considering the issue of climate change for some years; Shell and BP were experimenting with emissions trading systems at the turn of the 21st century (Nicholls, 2005). The development of hybrid and fuel cell vehicles in the automotive sector is ongoing (Austin et al, 2003). However those affected by indirect regulatory effects such as increased energy prices, the indirect physical effects of high cost agricultural inputs or second order impacts are generally less aware.

2.2. Climate Change: Strategic Implications

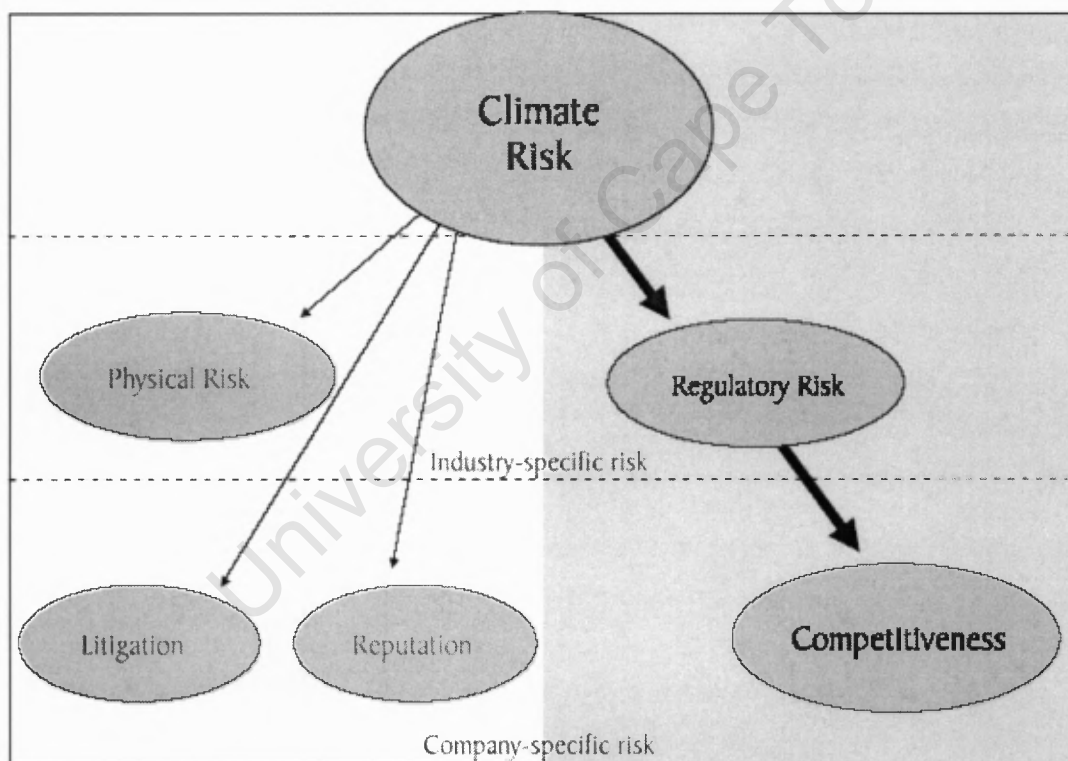
Over the past few years, as the potential economic and financial impacts of climate change have started to become a reality, many papers about the impact of climate change on profits, costs, shareholder value, markets, fiduciary duty and the financial sector have emerged (see for example Innovest 2003; Sauer and Wellington 2005; Innovest, 2006; Environment Agency, 2004; Freshfields Bruckhaus Deringer, 2005; The Climate Group, 2004; UNEP FI, 2004; Allianz and WWF, 2005). These papers highlight the potential extent of the climate change impact, and that both shareholders

³ The full list is automobiles, banks, chemicals, diversified financials, electric power international, electric power North America, food products (beverages and tobacco, food and drug retailing), industrial conglomerates, insurance and reinsurance, integrated oil and gas, metals and mining, paper and forest products, pharmaceuticals, telecommunications and transportation.

and company management need to start considering this as part of their ongoing activities.

Climate change impacts are not uniform within sectors (Innovest, 2005; Sauer and Wellington, 2005 and Gars and Volk, 2003). Whilst first order impacts and regulation determine sector level differences, other second order impacts and competitiveness are differentiators at company level, as demonstrated in Figure 2.2 below. For example, Austin et al (2003) report a difference in the cost of climate change in the automotive sector of between \$25 for Honda and \$650 for BMW. The extent of impact on companies within sectors will depend on factors such as location, asset profile, vertical integration, age and nature of technology base, source of competitive advantage and quality of management (Austin et al, 2003; Gars and Volk, 2003).

Figure 2.2. How Climate Change Influences Corporate Value



Source: WRI Resources in Sauer and Wellington, 2005

The risks and opportunities presented by climate change can be effectively managed (Innovest, 2005), with management quality being a key determinant of how climate

change will impact company value (Austin et al, 2003). The link also stands in reverse, with Gars and Volk (2003) finding that “corporate climate policies are particularly good signals of management quality and responsibility”. There are therefore important strategic implications to responding to the challenge of climate change.

Kolk and Pinkse (2004) find that climate change “poses strategic dilemmas for companies”. In the early 1990’s, the majority of companies followed what has been termed a defensive strategy (Kolk and Pinkse, 2004), arguing against climate change regulations on the basis of high cost and lack of scientific evidence. Since the drafting of the Kyoto Protocol, most company’s strategic responses have evolved to become more accepting and preparatory in nature. Increasingly companies are following an openly offensive approach, citing their moral responsibility to take first steps to reduce emissions. These companies acknowledge that the potential impacts of climate change are serious enough to warrant following the precautionary principle. They also highlight the market and reputation opportunities of being a first mover (Kolk and Pinkse, 2004).

Recently, corporate climate change strategies have been distinguished by their main aim and their scope (organization) as illustrated in the matrix in Figure 2.3 below

Figure 2.3. Strategic Options for Climate Change

| | | Main Aim | |
|--------------|--------------------------------------|-------------------------------------|--|
| | | Innovation | Compensation |
| Organization | Internal (company) | Process Improvement (1) | Internal Transfer of Emission Reductions (2) |
| | Vertical (supply chain) | Product Development (3) | Supply-Chain Measures (4) |
| | Horizontal (beyond the supply chain) | New Product/Market Combinations (5) | Acquisition of Emission Credits (6) |

Source: Kolk and Pinkse, 2005

On the vertical dimension of the matrix, companies believing that climate change primarily poses risks to their operations are likely to follow a 'compensation' strategy, seeking to reduce the impact of climate change without necessitating significant changes to "business as usual". A compensation strategy makes substantial use of market mechanisms to comply with regulation. Those who view their response to climate change as being a matter of survival, or as offering opportunities, are more likely to follow an 'innovation' strategy, involving fundamental changes to their business, products and markets. On the horizontal, the scope of a climate change strategy could be limited to a company's internal operations, and would be characterized by internally oriented measures such as process, technological or corporate culture. It could also extend to a company's supply chain, or encompass co-operative measures, such as participating in emissions markets, partnering with project developers to do offset projects or entering a strategic alliance with another company for innovative purposes (Kolk and Pinkse, 2005). Which type of strategy a company follows will depend on the

level of their sector's climate change risk, management quality and climate change awareness of the business environment they operate in.

Whilst still in the early stages, leading companies internationally are starting to factor the climate change challenge into their long term business plans and strategies, and to look for the new areas of competitive advantage and risk that this issue brings. This awareness is highest in large international companies based in countries with Kyoto targets and active government policies to reduce emissions, with the vast majority of research in this area having been undertaken in the industrialised world. It is also important however to consider the impact of climate change on company value and strategies in the context of a developing country, without Kyoto targets and with far less well developed environmental legislation, as in South Africa.

2.3. Climate Change and Business within a South African Context

First order physical climate change impacts in South Africa at a very general level are that the country will get warmer and drier. Water scarcity, already a significant issue in the country will intensify (Department of Environmental Affairs and Tourism (DEAT), 2004). On the regulatory side, South Africa has been classified as a developing country under the Kyoto Protocol. It is therefore exempt from receiving binding emission reduction targets until at least 2012. After this date, South Africa's situation is less clear. As one of the top seven emitters amongst developing countries, it is a likely candidate for having to commit to some form of emission reduction strategy. The regulatory impacts on South African companies are therefore even more uncertain than for those operating in industrialised countries, and can be likened to that of companies in the US who are already reporting on the difficulty of operating in an environment of regulatory uncertainty (Sauer and Wellington, 2005)

As a developing country, South African companies can generate emission reduction credits from CDM projects, presenting an opportunity to benefit from international regulations. However, South Africa has been slow in developing CDM projects, compared to countries such as India, China and Brazil (www.unfccc.int/cdm; Little, 2006).

One of South Africa's greatest sources of competitive advantage is its inexpensive electricity generated from coal. This is also the reason for the country being one of the top greenhouse gas emitters internationally. A rise in the price of electricity under a scenario of greenhouse gas regulations looks likely.

The awareness and level of understanding in the South African private sector regarding climate change is also low compared to that of industrialised countries (Dinan, 2004). Whilst the large internationally exposed companies operating in sectors described as high risk with regard to climate change are engaging with the issue, other companies typically are unaware of the impacts climate change could have on company value going forward.

2.4 Conclusion

Climate change affects companies through both first and second order impacts. These impacts are material and far-reaching, and will result in a significant change to the international business environment as it currently exists.

Climate change impacts are also highly uncertain. Climate science, although developing at an increasingly rapid pace, is still a relatively new and very complex area of research. So too, as governments grapple with the implications of climate change mitigation for their countries, economies, and political longevity, regulation and policy remain very unclear. These sources of uncertainty make risk mitigation and investment planning for the private sector extremely difficult. This is especially true for developing countries such as South Africa, which experience even greater policy uncertainty.

At least fifteen sectors have been identified as being at 'high risk' from climate change. Within sectors, risk and opportunities from climate change differ substantially, with climate change presenting a source of competitive advantage and therefore a 'strategic dilemma' for companies. With the international business environment undergoing a significant change as a result of the climate change challenge, a company's strategic response to this will be an important determinant of its value in the future.

In order to inform company and investor strategy on climate change, the affects of climate change impacts on company value need to be fully described and measured. This in turn requires financial valuation techniques able to incorporate the particular dimensions and challenges that climate change presents to the valuation of assets and companies.

University of Cape Town

Chapter Three: Valuation of Climate Change Impacts on Companies: a Literature Review

3.1. Early Approaches to Valuation of the Impact of Environmental Issues

In the twentieth century, the relationship between environmental strategies (climate change was not yet significant enough an issue to warrant independent analysis) and shareholder performance was largely explored using techniques such as event studies, regression analysis and model portfolios (Reed, 1998). Whilst the results of these studies showed a moderately positive relationship between environmental and financial performance (Reed, 1998), the techniques used have been critiqued as being severely limited in their ability to address the critical issues required to make progress in understanding the impact of environmental issues on company value (Austin and Repetto, 2000; Reed, 1998):

- i) The techniques are retrospective, whereas any analysis of environmental impacts has to be forward looking as financial markets are more concerned with the future than the past.
- ii) They are insensitive to sector and company differences, which have been shown to be significant in the discussion in the previous Chapter of this research.
- iii) The research focused on issues for which data was available, as opposed to those which had a large potential impact on a company.

Only one study (Feldman et al. 1996), by incorporating environmental variables into an existing valuation model, albeit a retrospective and portfolio based one, started asking what Reed (1998) termed the appropriate question: "What does environmental performance tell us that we don't already know about financial performance?" (Reed, 1998, pg 5). Feldman et al. (1996) found that good environmental management and performance, when effectively communicated to the investor community, could result in a lower beta and therefore higher stock price of up to 5%.

The finding of a link between environmental management and performance and company value was an important step. However, in order for environmental issues to be incorporated into the financial valuation and analysis of companies in a forward looking manner with useful outputs for the formulation of strategy, they needed to be analysed using techniques closely aligned to those used conventionally by the financial community. Acknowledging this, Austin and Repetto (2000) undertook a groundbreaking valuation of environmental impacts on the United States' pulp and paper sector using Discounted Cash Flow analysis (DCF). DCF is the foundation on which all other valuation approaches are built (Damodaran, 2002) and the traditional approach to valuing investment projects (Schwartz and Trigeorgis, 2004a).

3.2 Discounted Cash Flow Valuation with Scenario Analysis

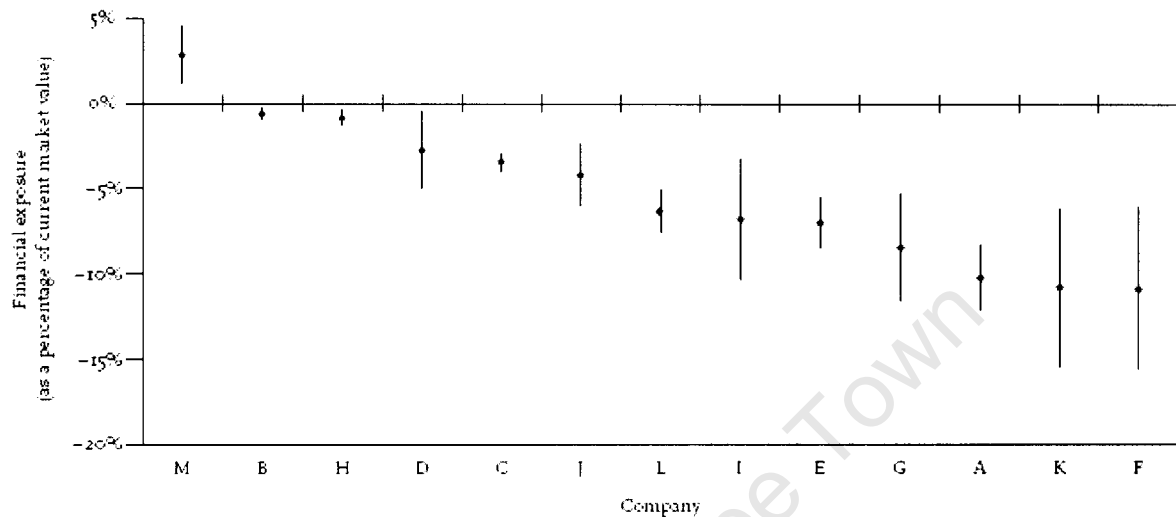
In order to conduct a DCF analysis, Austin and Repetto (2000) constructed probability weighted scenarios around possible paths of development of each of three environmental issues: the future impact of air and water regulations, fibre supply and climate change. Whilst Austin and Repetto (2000, pg16) found that the scenarios qualitatively describing possible impacts of climate change were "highly significant to the paper industry's financial fortunes over the next 15 years", they acknowledged that publicly available data were insufficient to enable an analysis to be conducted. The study will still be briefly discussed here due to its seminal nature, implications for use of the DCF methodology for environmental issues and relevance to the Sappi case study.

For each of the 13 companies assessed and for every scenario developed, financial impacts on revenues, input costs, investment expenditure, and asset values were estimated for each year of the forecast period, and then reduced to discounted present values using an estimate of the company's weighted average cost of capital. These net present value (NPV) figures were summed to arrive at an impact measure expressed as a percentage of a company's shareholder value.

The results of the DCF analysis, shown in Figure 3.1 below, show the percentage of each company's market value exposed to environmental issues, given as a range of potential values. The most likely outcome for each company is represented by a dot. If this dot is positive, the environmental issues are expected to have a positive impact on a

company's market value. If the dot is negative, the impact on market value is expected to be negative. The difference in both the impacts and the extent of the impact range is clearly demonstrated for individual companies.

Figure 3.1 Financial Exposure to Pending Environmental Issues of 13 US Pulp and Paper Companies



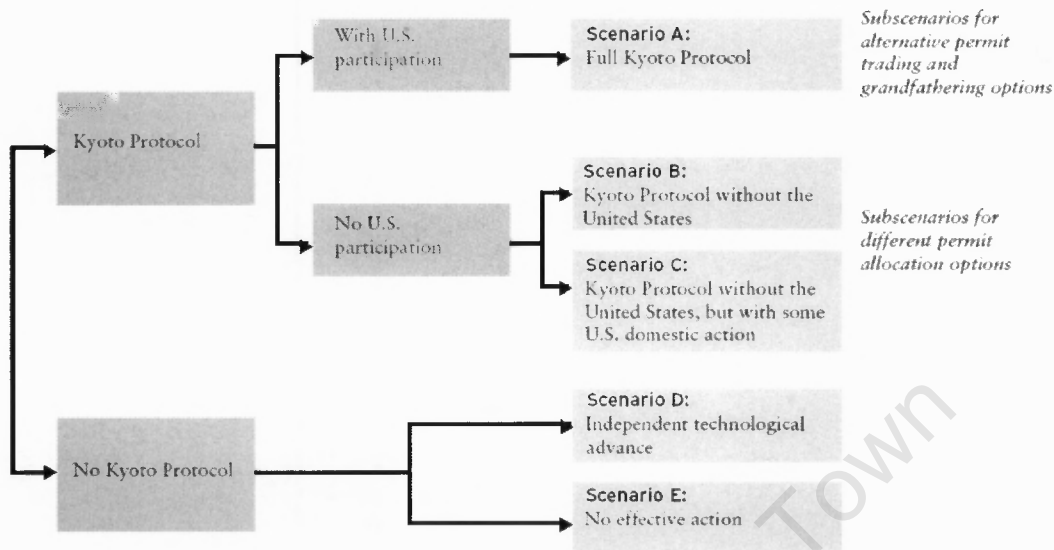
Source: Austin and Repetto, 2000, pg 46

Austin and Sauer (2002) again used DCF and scenario analysis in a study of two primary areas of environmental risk to the oil and gas industry: climate change, and restricted access to reserves. The study considers 16 companies, and with regard to the climate change impact is narrowly focused on a fundamental analysis of the regulatory risks from their primary business segments: proven developed reserves, undeveloped reserves and acreage, and refining (and other downstream) operations, as it is here where the material climate change impacts are expected to occur.

Five climate change scenarios developed by the IPCC in their special report on emissions scenarios and termed the Special Report on Emissions Scenarios (SRES) (IPCC, 2000) are used to model possible future international actions on climate change. Each scenario comprises a number of sub-scenarios, dependent on the degrees of carbon trading assumed (global and only developed country), and whether or not

grandfathering⁴ of emission reduction allowances is considered. The scenarios are depicted in Figure 3.2 below, and each is assigned a probability in the study.

Figure 3.2. Scenarios for future pressures to reduce greenhouse gas emissions



Austin et al, 2002, pg 15

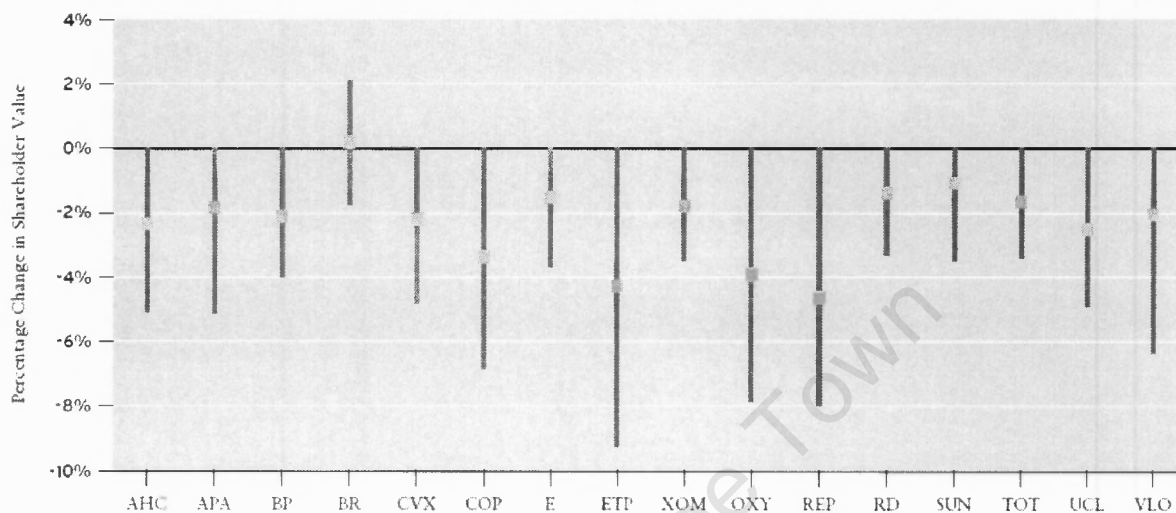
How these scenarios would impact on the sector was explored through the study of existing research, a workshop with company and industry representatives, and consultation with government and academic experts. These impacts were then modeled by making changes to the producer prices of oil and gas as a result of carbon taxes or emission reduction targets, and to the volumes sold.

The net present value of each scenario was applied to a base net present value excluding climate change variables in order to find a percentage differential. Percentage average net worth changes to companies was used as a metric for comparative purposes, shown in Figure 3.3 below. The figure shows Burlington Resources having potentially above 2% positive change in shareholder value, whilst all the other companies have a negative percentage change. Enterprise Oil potentially stands to lose the most, with a potential decline in shareholder value of over 9% negative impact. The

⁴ 'Grandfathering' is the term referring to the allocation of emission reduction allowances to companies based on historical emissions levels. Under an emissions trading scheme, this allocation is likely to be made at no cost, as opposed to an auction allocation method, where companies bid and pay for the allowances they currently need.

rest are clustered around -2%, with significant result ranges of up to 9% in size. Again, the difference between companies in both impact and the extent of the range of impacts is clear.

Figure 3.3. Financial Impacts of Prospective Climate Mitigation Policies



Austin et al, 2002, pg 22

Austin and Repetto (2000) note that the measure of value defined for each company through the DCF method should be changing all the time, like a share price, as different scenarios play themselves out. The results endorse the author's claim that the environment presents "a new dimension in which differences in the relative value of companies can be discerned, and exploited by investors" (2000).

3.2.1 Addressing the Shortfalls of Twentieth Century Techniques

The DCF plus scenario methodology goes a long way to address the critiques of the twentieth century approaches to valuation of environmental issues. It incorporates these issues into the financial community's traditional valuation technique, making consideration of environmental factors more accessible and understandable to those in financial departments, and to investment analysts. DCF is a forward looking approach, focusing on future free cash flows as a basis of value. It is also a bottom-up technique, thereby invoking a deep understanding of sector and company differences.

However, DCF analysis is also widely recognized to have its shortfalls (Ross, 1995; Damodoran, 2002; Mun, 2002; Wang 2002). These are found to be exacerbated in circumstances of high uncertainty, strategic importance and where management flexibility is a key element.

3.2.2 Data Availability

Whilst Austin and Repetto (2000) responded to the criticism that past research focused on issues for which data was available as opposed to issues with the greatest potential impact for the company in their study's scope, they were unable to construct a DCF analysis for climate change due to a lack of data. Austin and Sauer (2003) also acknowledged that data availability restricted the scope of their study of the oil and gas sector. Data availability on climate change impacts and indicators is an issue of relevance for the use of all valuation techniques. The extent of this is determined both by the company or companies being analysed, their value drivers, sector and location. Developed countries lead developing nations in environmental regulation and management, and therefore companies situated in these countries tend to have greater data resources than those in developing nations. Environmental disclosure in South Africa is not high up the priority list of all but the large international companies and a few local exceptions. Substantial further work is required to provide the depth and breadth of data required to facilitate analysis in the area of climate change impacts on company value.

3.2.3. Dealing with Uncertainty

Researchers (Reed, 1998; Austin and Repetto, 2000, Earle and Rhodes, 1995) highlight the concept of uncertainty as being central to the analysis of environmental impacts, which are characterized as having an "unpredictable speed of issue evolution; [and] historical trends which do not provide clear guidance for the future" (Earle and Rhodes, 1995).

Uncertainty is acknowledged by Austin and Sauer (2003) to be a significant factor in their research. As in Austin and Repetto (2000), in a DCF framework, this uncertainty is primarily dealt with through scenario analysis. Whilst a critique of scenario analysis as a way of dealing with uncertainty is beyond the scope of this research, the technique is acknowledged to be limited from a valuation and strategic perspective in that it assumes

a set of possible scenarios given information available today, and disregards management flexibility in responding to the arrival of new information and a changing environment over time (Mun, 2002). Scenario analysis is a static analysis, assuming that the uncertainty will resolve itself. Without the use of quantified uncertainty levels this technique also tends to overemphasise the extreme scenarios (Ha-Duong, 2006). Whilst Austin and Repetto (2000) use probabilities to weight each scenario, the significant uncertainty involved in deciding upon climate change scenario probabilities has led other authors (Austin et al, 2003) to choose an equal weighting of occurrence. Further, scenario analysis relies on extensive data availability to accurately estimate cash flows into the future.

3.2.4 Risk and the Discount Rate

In DCF analysis, risk is dealt with primarily through the application of a discount rate, required to be estimated by the analyst. Risk can also be accounted for in the forecasted cash flows, but in order to estimate future cash flows one needs to accurately assess the mean of all possible outcomes (Myers, 2004). This is exceedingly difficult to do with any accuracy, particularly when there is a high level of volatility and uncertainty surrounding these cash flows, and when the forecast period extends far out into the future, as in the case of climate change impacts. The concept of uncertainty is different to that of risk. Sauer and Wellington (2005) describe uncertainty as involving “a lack of information for determining the parameters with which to assess investment risk”.

The DCF technique is based on a neoclassical model, with perceived risk being translated into an increase in the discount rate. The higher the level of uncertainty surrounding an asset's future cash flows, the less accurate the estimation of risk, and therefore the less accurate the discount rate becomes. The DCF technique is therefore more reliable for companies containing low risk, and environments characterized by low levels of uncertainty (Myers, 2004). This would imply that it is inappropriate for valuing the impact of climate change. In addition, as a high discount rate results in a low investment NPV, DCF analysis could also lead to underinvestment in instances of high uncertainty, and a potential misallocation of resources in the economy. (Schwartz and Trigeorgis, 2004).

Barker (2004) uses a Weighted Average Cost of Capital (WACC) adjusted for climate change risk in his free cash flow analysis of Sasol, the South African petrochemicals company. However he cautioned that the purpose of the valuation was to gauge the sensitivity of Sasol's value to climate change-driven impacts rather than to quantify these impacts. An adjusted WACC suffers from the inaccuracies of estimation and lack of clarity discussed in this section.

Further, it has been argued (Sorensen, 1997) that inherent in a discount rate is a value judgment of the importance of the present over the future. A high discount rate 'discounts' future value in favour of value today whilst a low or even negative discount rate puts more weight on value generated in the future. Gars and Volk (2003) discuss the ethics of the discount rate chosen when valuing climate change impacts, suggesting that a low rate may be more appropriate given the long term and inter-generational nature of the challenge.

3.2.5. Acknowledging a Flexible Management

A major critique of DCF analysis is that it assumes a passive management, unable to react to changing circumstances or the arrival of new information. The importance of a strategic management response to climate change has been discussed in Chapter Two of this thesis. Both in the pulp and paper, and oil and gas sector studies described above, the DCF analysis was unable to value flexibility. Depending on its existing asset base, location, corporate culture and management, each company will have a different ability to respond to additional information about climate change as it emerges over time.

Similarly, DCF can't cope with time-series links between projects and company decisions (Myers, 2004). For example, should a South African company undertake a renewable energy project, this may enable it to enter European Renewable Energy Certificate (REC) markets should these become open to developing world credits in the future. The additional value of the REC income stream would not be considered in the initial renewable energy project valuation under DCF.

DCF is static; whereas in reality the global response to the climate change challenge is dynamic, largely resulting from its high levels of uncertainty. Management flexibility and

strategic interactions are not catered for in the DCF, thereby ignoring important strategic considerations (Schwartz and Trigeorgis, 2004).

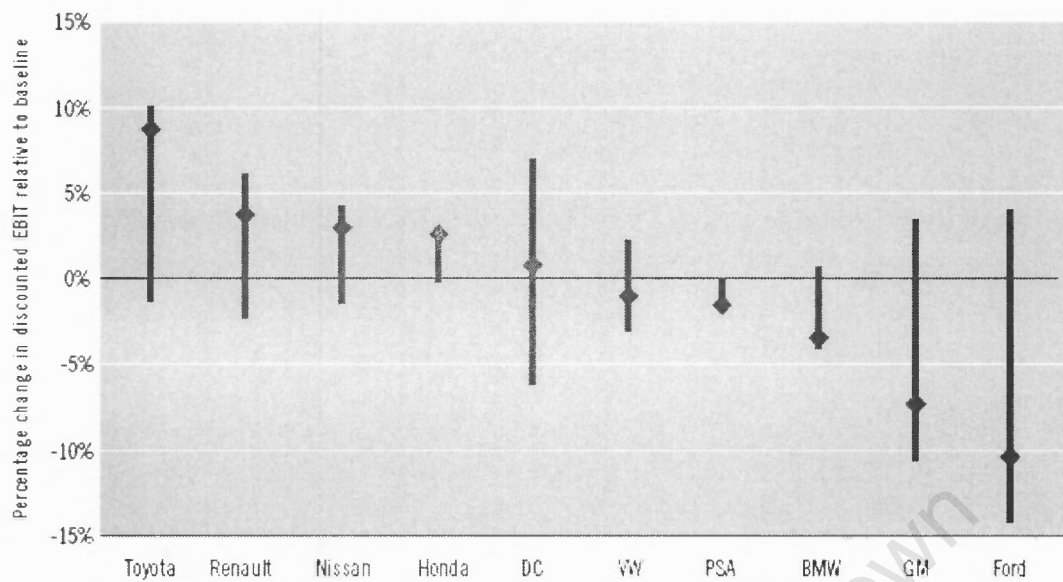
The impacts of climate change are also felt on a company's intangible assets, such as brand value and reputation. The Lippincot Mercer (2004) undertook a valuation of the impact of climate change on consumer brand in the United Kingdom using an established brand valuation technique and a simulated choice methodology with individual companies. The study found that up to 50% of a sector's brand value could be at risk from climate change. The effect on intangibles is therefore not insignificant, and DCF analysis, based on actual cash flows, is not helpful in considering this asset class (Myers, 2004).

3.3 Incorporating a Management Quality Indicator

The CDP acknowledges the importance of management response to climate change throughout its reports, and has established a Climate Leadership Index ranking companies in the sectors identified as being at high risk from climate change. The companies are evaluated according to six factors (Innovest, 2005) including strategic awareness of the relevance of climate change. A number of valuation studies have also started to incorporate an indication of management quality in the methodology.

Austin et al (2003) considered climate change risks and opportunities facing ten Original Equipment Manufacturers (OEMs) accounting for 70% of global automotive sales and operating in the Japanese, EU and US markets. Their methodology comprised a Value Exposure Assessment, to estimate the costs to OEMs of meeting carbon constraints, and a Management Quality Assessment. The Management Quality Assessment rated management's competencies in areas related to their ability to adapt to carbon constraints, including the ability to market and commercialise technological opportunities. The two were then combined to describe the effect on a discounted EBIT of each company's risks and opportunities from climate change. The results are shown below.

Figure 3.4 Potential impact of carbon constraints on discounted EBIT (2003 – 2015) based on Value Exposure and Management Quality Assessments



Source: Austin et al, 2003, pg vii

Whilst this study does capture the value of the important intangible asset of current management quality in its results, the predominance of the DCF and scenario technique renders similar shortcomings as discussed in the section on the DCF. The analysis is static, and does not capture the value of flexibility.

Gars and Volk (2003) also include a variable for management quality in their sectoral analysis. The management score is made up of industry specific components, for example management's attention to renewable energy is allocated 40% of the total in the energy sector. This score feeds into a top-down analysis of the sector value at risk, using the results from their regression analysis of the global market value at risk from climate change, which utilises the SRES scenarios. This top-down approach gives a useful sectoral comparative analysis for the investment community, and highlights areas of advantage, opportunity and risk for companies. Again, though, it is a static analysis, which doesn't value flexibility in the face of the significant uncertainty of climate change.

The valuation of management quality in the above two studies does provide investors with information about the impact of climate change to individual companies and sectors. However, the results are less useful to company management wishing to understand and manage the climate-change-specific strategic implications of their investment and

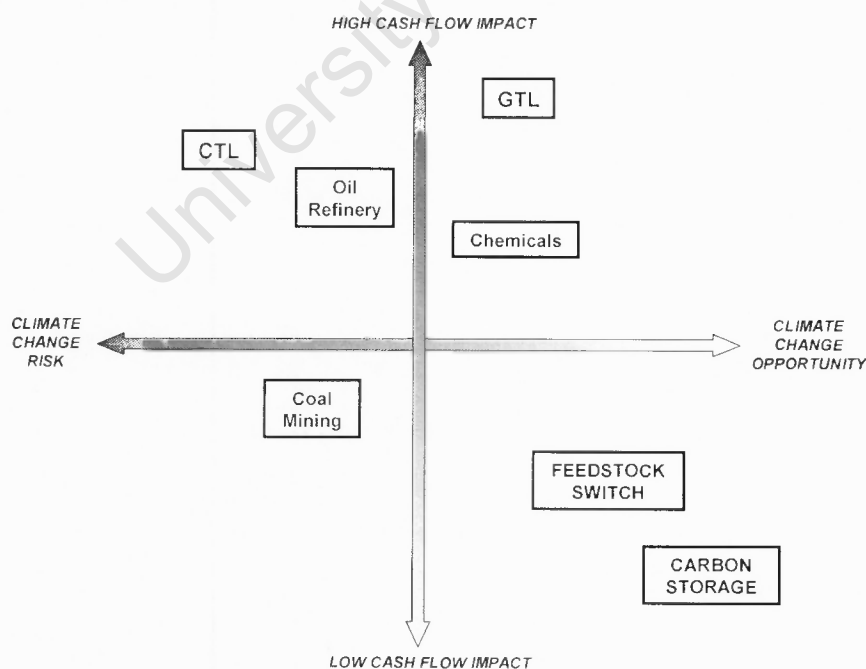
operational decisions. Similar to scenario analysis, these techniques are static, assuming a fixed set of competencies over time. What comprises an effective climate change strategy for managing the impact of climate change on value is also not made clear.

3.4. Understanding the Strategic Implications for Value

Apart from incorporating the strategic implications of climate change through management quality assessments, none of the valuation methods used in the literature capture this vital element quantitatively, or apply analytical techniques to enhance the understanding of strategic opportunities and risks from a value perspective.

Barker (2004) goes some way to address this by undertaking a strategic analysis of Sasol's growth areas and projects in his report on the petrochemicals company, plotting each on a matrix showing their ability to generate cash flows (and thereby increasing their potential for increasing shareholder value) together with their inherent climate change risk or opportunity (which could either decrease or increase shareholder value, respectively, as future cash flows are either reduced or enhanced), as depicted in the Figure below.

Figure 3.5. Summary of Sasol's climate change risks and opportunities



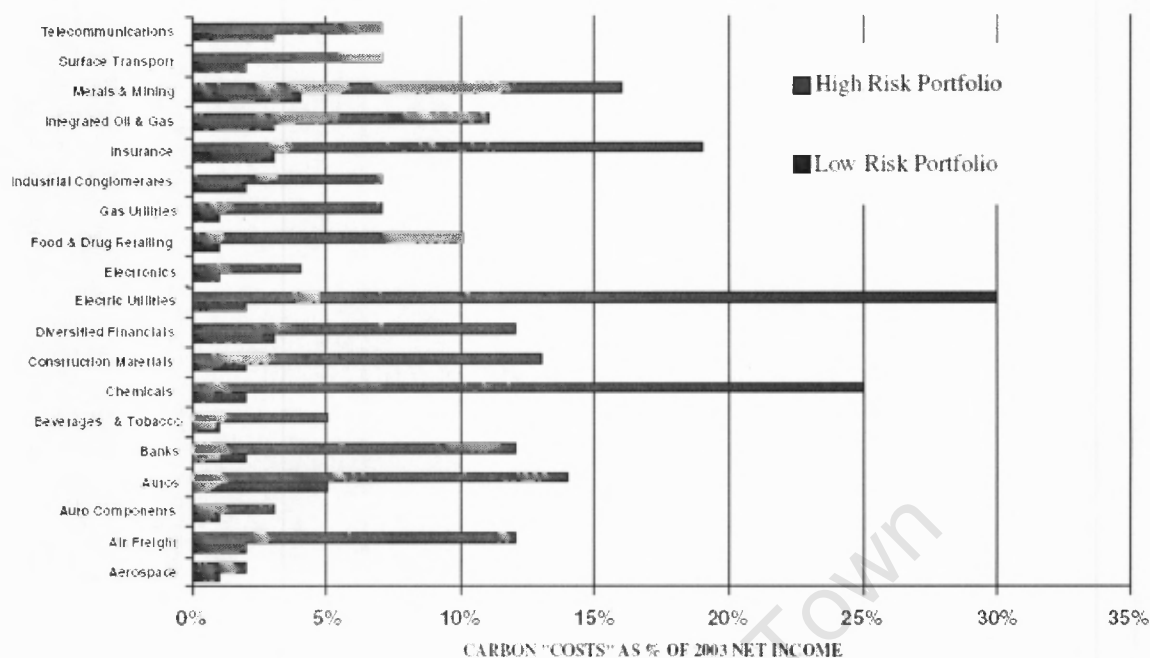
Of the projects and operations areas depicted in the graph above, Gas to Liquids (GTL) and Chemicals have a positive (climate change opportunity) cash flow impact. Coal to Liquids (CTL) and Sasol's Refinery represent climate change risks which have high cash flow implications. This matrix is an important component of Barker's (2004) discussion on the impact of climate change on Sasol's value, and a useful guide to management and investors in monitoring the company's response to climate change.

3.5 Other Valuation Metrics

Various other valuation metrics have been developed by Innovest during the CDP, mostly to improve understanding of particular impacts of climate change. None offer a comprehensive framework for valuing the impact of climate change on a company as a whole, but do assist companies and analysts in understanding the range and complexities of the issue.

Innovest Strategic Value Advisors (Innovest, 2003-2006) derived the concept of a carbon betaTM to measure individual company's risk from climate change relative to their sector. Portfolio carbon risk is found to be a function of three variables: carbon intensity of different sector exposures, geographic distribution of production facilities and sales, and individual security selection (Innovest, 2006). The Figure (3.6) below shows an example of two carbon beta portfolio analyses, one a high risk, and one a low risk portfolio, highlighting the potential intra-sectoral differences. In the Electric Utilities sector this is particularly significant, with the low risk portfolio companies having carbon costs below 5% of their 2003 income; whilst the high risk portfolio companies have costs equal to 30% of their income in this year.

Figure 3.6. Sample carbon beta™ portfolio analysis



Source: Innovest, 2006, pg 6.

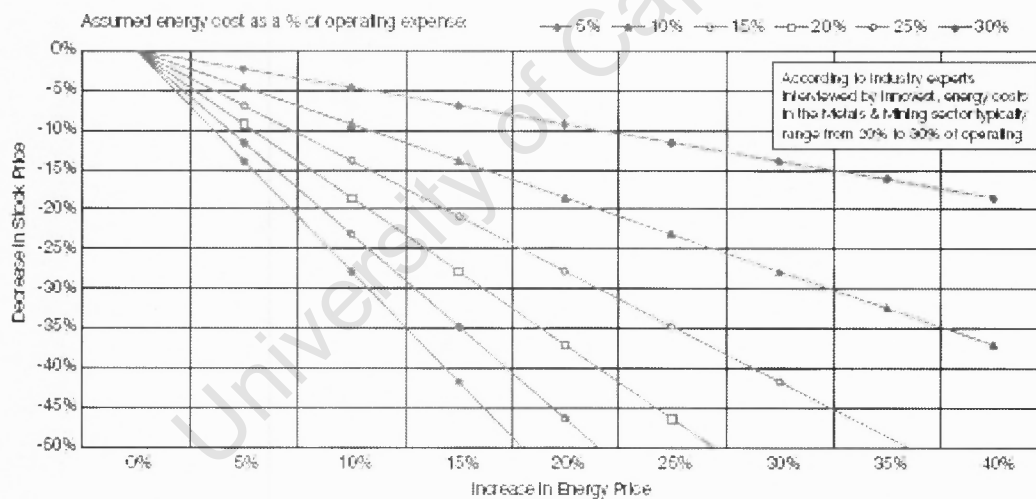
A Weighted Average Country Carbon Reduction Target (WACCRT©) was used in the first CDP Report (Innovest, 2003) to measure a company's exposure to emission reduction regulations across the various countries it operates in. The calculation of this first disaggregates a company's emission generating activities according to the countries it operates in, expressing each country's emissions as a percentage of the company's total. Each percentage is then multiplied by the relevant country's Kyoto target, and summed to arrive at the WACCRT.

Various emissions-intensity measures are used to describe a company's exposure to climate change regulatory risk. These include Carbon Dioxide (CO₂) per square footage, total revenue, tonnes per product, million dollars per sales, or electricity generation (mega, giga or kilowatt hours). The actual unit of CO₂ used can also differ, including kilograms, tonnes or grams. It is important that this is specified and considered. The CDP warns that the implementation of emissions-intensity measures in business situations 'has given rise to much debate and controversy', and that there is no consensus on implementation and choice of measure. Their greatest value is derived from use as a comparative tool with which to benchmark corporate performance.

Climate change will have a significant impact on energy pricing. Energy price sensitivity for companies is measured in the CDP report (Innovest, 2004) as the impact of an increase in wholesale power prices on the share price at various assumed levels of energy cost as a percentage of operating expense. The effect of an increase in energy costs on operating expense is determined by identifying current energy costs as a percentage of operating expenses, and applying a percentage increase in energy costs going forward. The corresponding increase to expenses is then deducted from net income. The implied forward price/earnings ratio is then used to determine the adjusted stock price and capitalization, and the results averaged across the sector (Innovest, 2004, Appendix B).

The results of this analysis for the metals and mining sector are shown graphically in Figure 3.7 below, showing the wide range of potential outcomes dependent on the scenario considered.

Figure 3.7. The Effect of an Increase in Energy Costs on Share Prices



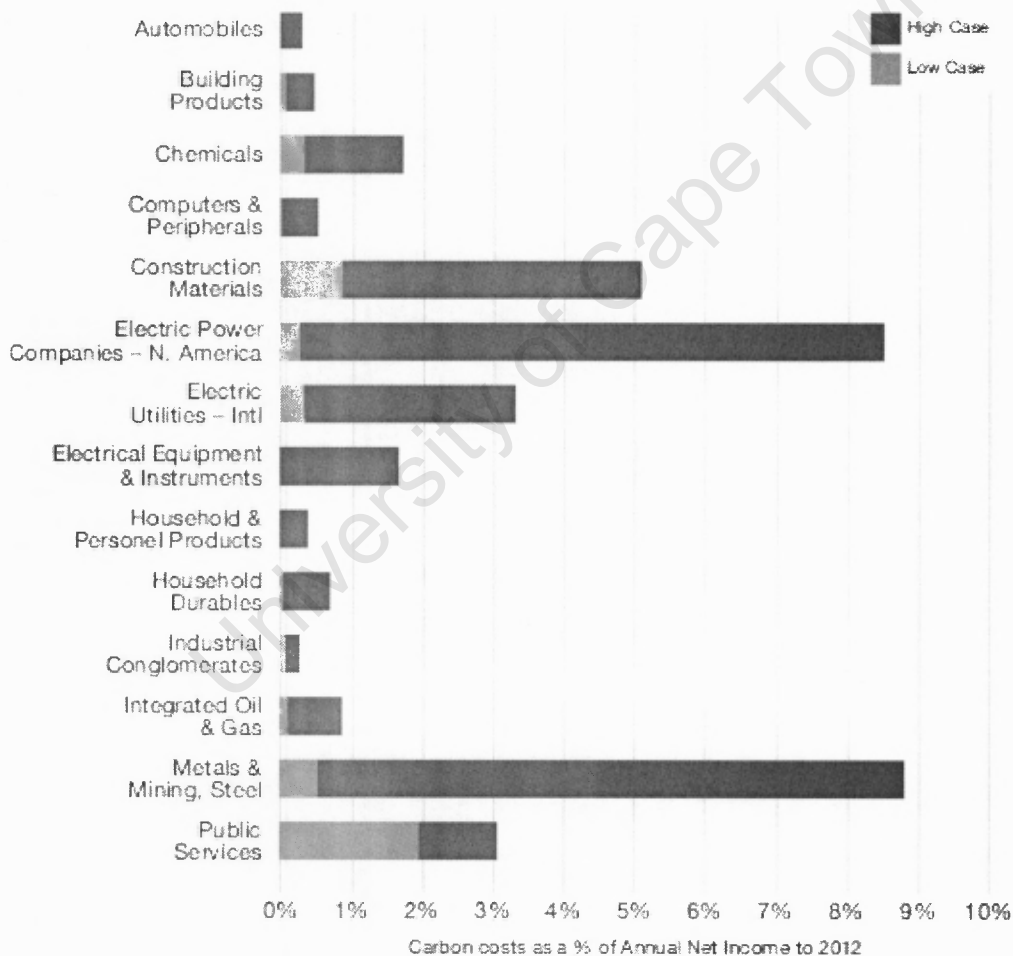
Source: CDP, 2004, pg 22.

Carbon costs are held to be central to any climate change risk analysis (Innovest, 2005). An analytical technique applied in the report involves the use of two hypothetical emissions constraints (5% and 20%), applied to a company's current emissions level. A

high and a low carbon market price (\$5 and \$20), are factored in as a proxy for the cost of mitigation, and the effect on annual net income is calculated.

Scenarios involving different combinations of carbon constraint and cost are modeled and the impact on Annual Net Income graphically depicted for certain high impact sectors. The sectors are shown on the vertical axis, with carbon costs as a percentage of annual net income to 2012 shown on the horizontal axis (see Figure 3.8 below where a carbon cost of \$20, an emissions constraint of 20% and seven year compliance period are assumed). A high and a low case are reported for each sector given the wide intra-sector differential.

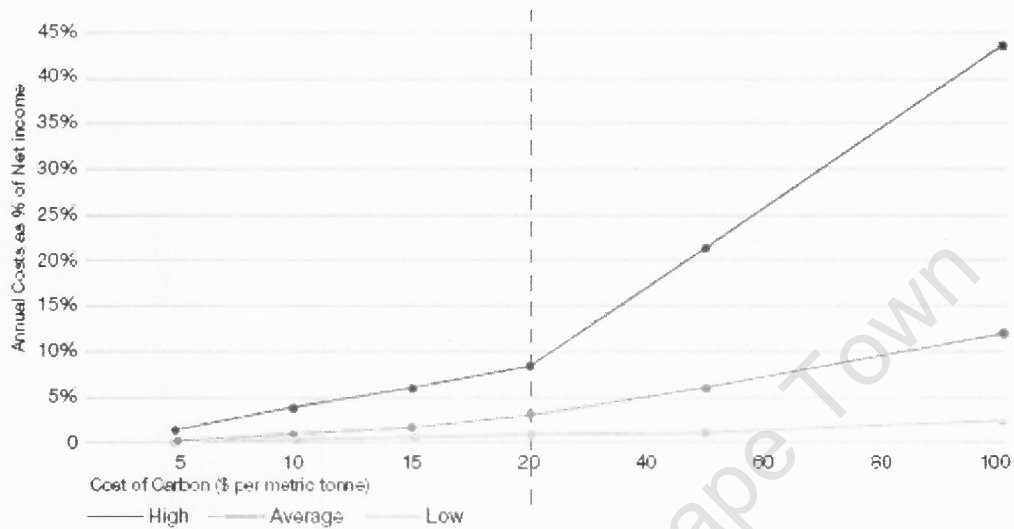
Figure 3.8. Intra-sector risk exposure in the FT 500 – High case vs. Low case by sector



Source: CDP, 2005, pg46

The sensitivity within a given sector to changes in the variables is also shown graphically (see Figure 3.9 below where again a seven year compliance period and 20% emissions constraint are assumed). This graph shows how the carbon price assumption impacts the output (annual cost as a percentage of net income).

Figure 3.9. Sensitivity of Metals, Mining and Steel Sector to Carbon Costs



Source: CDP, 2005, pg47

The CDP techniques assist in the description of the impact of climate change on the value of a company or sector, particularly in instances of low data availability. All of the techniques are, however, subject to similar critiques as applied to those discussed in sections above.

3.6. Conclusion

Two aspects of the impact of climate change on company value have been argued throughout the literature review to be central to any analysis: the *uncertainty* of impacts, and their *strategic* implications. Uncertainty has typically been dealt with through scenario analysis, leading to results which are expressed as a range of possible shareholder value outcomes. The strategic implications of climate change have been captured through the use of valuation techniques assessing management capability (Austin et al, 2003; Gars and Volk, 2003) and brand value impacts (Lippencot Mercer,

2004), putting a value to the risk or opportunity of a company given its current intangible asset base, and the exposure of these assets to climate change impacts. However, given the centrality of these aspects to the impact of climate change on shareholder value, and the interaction between the uncertainty of climate change impacts and strategy, this author suggests that they deserve additional, specific consideration from a valuation perspective. Traditional DCF based valuation methods are not good at dealing with dynamic uncertainty, nor therefore good in providing insight and guidance to the manager or investor.

Real options analysis has emerged recently as a technique for use in conjunction with DCF, and is particularly applicable to situations of high uncertainty and where there are strategic implications to investment decisions (Mun, 2002; Mauboussin, 1999; Wang, 2002, IEA, 2006; Reed, 2001). This technique can be used both to value a company through its strategic business options, and as a strategic business tool in capital investment decisions (Mun, 2002). The following chapter considers this technique, and its potential applicability to valuing climate change impacts on shareholder value.

An aspect impacting all valuation techniques noted in this chapter and which applies equally to real options analysis, is that of the poor state of data on climate change impacts. Data is incomplete and irregularly recorded, if at all. Until companies start routinely generating and organizing data relevant to measuring the impact of climate change on company value, quantitative analysis in this area will be restricted.

Chapter Four: Real Options Analysis and Climate Change

4.1. An Overview of Real Options Analysis

The real options analytical technique extends financial options theory, developed by Black and Scholes (1973), Merton (1973) and Cox and Ross (1976), to options on real assets. Owning a financial option gives the investor the right, but not the obligation to purchase or sell a security at a given price. Similarly, the owner of a real option has the right, but not the obligation to take up or divest an investment opportunity in a non-financial, or real asset at some time in the future (Mauboussin, 1999). A typical example of a real option is that belonging to a mining company through its ownership of the mining rights to a piece of land. The company owns the option to mine the land in the future should the economics of this activity, determined by the price of the mined commodity and the extraction costs, prove attractive. This option is valuable, in that it enables the mining company to wait until more favourable circumstances arise before implementing the mining project. It also avoids costly errors if there are unfavourable developments in the economics of the activity.

The example cited above constitutes an *option to delay* an investment until circumstances are favourable. The option only exists as a result of the company's ownership of an underlying asset: the mining rights to the land. Should these rights expire at some point in the future, the option will also expire. Real options thinking was originally applied to the natural resource sector, as in the example above. However, it has since been expanded to applications across the economic spectrum (Mun, 2002). Real options are embedded throughout the assets of a company, and come in a variety of forms (Mun, 2002):

- By constructing a warehouse with a capacity greater than is currently required, a retailing company has purchased the *option to expand* its operations in the future. The cost of the option is the additional cost of the extra space.
- The *option to abandon* exists in any project. A company can terminate the project and sell its assets at any point, should circumstances render it unfeasible.

- A company can create an *option to switch* product types or process technology by ensuring that the original manufacturing set-up has the flexibility to convert. The additional cost incurred for this flexibility is the cost of the option.
- A *compound option* is where the option's value is dependent on the value of another option, rather than on an underlying asset (Kodukula and Papudesu, 2006). Compound options are common in the pharmaceutical sector where the option to continue the development of a drug depends on successful trials, the trials themselves representing an option to expand.

The drivers of a real option's value are similar to those of a financial option, derived from financial option theory (Mun, 2002). i) The real option is more valuable the longer the time until the option expires. Holding the option allows a company to wait until the arrival of additional information before making a potentially costly and irreversible investment decision. ii) The greater the risk of the project, the more valuable the option is. Owning an option hedges against all downside losses, as the investor can simply decide not to implement the project in unfavourable circumstances. However the option holder still has access to all potential upsides. This is contrary to conventional finance thinking, which holds that the higher the risk, the lower the value (Mauboussin, 1999) iii) Exclusive ownership of an option renders it more valuable than shared ownership. Consider a number of competitors who have developed a new product. All these companies share the option to delay the products launch until a more certain demand environment exists. However, given market leadership considerations, a patented product representing the exclusive ownership of the option by one company would be far more valuable than the shared option. iv) The greater the importance the uncertain portion of the cash flows is to the overall value of the project, the greater the option value.

The concept of real options has been evident in the academic literature for the past 15 years, with practical applications occurring in the past few years (Schwartz and Trigeorgis, 2004). Unlike traditional valuation methods, it accommodates a world where change and uncertainty are pervasive, and business strategies and investments are constantly re-evaluated (Mun, 2002). Real options analysis explicitly incorporates management flexibility, which has been held to represent a substantial part of the value of many projects (Schwartz and Trigeorgis, 2004).

Some of the most valuable applications of real options thinking lie in its input to strategy and the capital budgeting process. Awareness of its options will prevent a company from losing them unknowingly through premature asset disposal. Conversely, an appreciation of options can provide support for technical managers proposing more costly projects which create significant options for the company.

Real Options valuation solutions are theoretically very complex (Kodukula and Papudesu, 2006), with a discussion of the theoretical underpinnings being beyond the scope of this thesis. In summary, arbitrage principles and the concept of futures markets for commodities are used to enable the valuation to be undertaken in a risk-neutral environment. The option is valued relative to the underlying asset, and therefore has the same value in the actual world as in the risk-free one (Schwartz and Trigeorgis, 2004). This risk neutrality enables all flexibilities to be properly incorporated into the analysis. The most common methods for real option valuation are closed form solutions such as the Black-Scholes, partial-differential equations, and binomial lattice approaches (Mun, 2002). A binomial lattice approach is generally favoured, given its transparency and intuitive appeal (Mun, 2002; Mauboussin, 1999).

Real options analysis is most usefully conceptualised as a complement to DCF analysis; it captures the additional value arising from the optionality embedded in an asset (Mauboussin, 1999; Mun, 2002). The first step in a real options valuation is to create a conventional DCF of the underlying asset which contains the embedded option. In the example of the mine, this would be the mining project under today's economic circumstances. This DCF can be conceptualised as a special case, it ignores the potential for management flexibility as additional information about the uncertain variables is received. The more accurate value is argued to be the DCF value plus the value of the real option, or options, embedded within the asset.

Considering real option value in addition to conventional DCF value of assets and companies is held to be more appropriate to the increasingly uncertain and changeable nature of today's business environment. As such, real options analysis is anticipated to become an important component of the valuation 'toolbox' if not the dominant valuation paradigm in the twenty-first century (Schwartz and Trigeorgis, 2004; Kodukula and Papudesu, 2006; Mauboussin, 1999; Mun, 2002). A real options perspective can both

be used to conceptualise and value existing options, or to help management create options within projects that hedge risks, reduce maximum regret or leverage an investment in an option many times over (Mun, 2002).

4.2. Potential Application of Real Options to the Valuation of Climate Change Impacts

Options thinking is held to be most appropriate in areas of high uncertainty, where learning can occur (Mun, 2002), and for large, strategic projects as opposed to routine maintenance projects (Brigham and Daves, 2002). Uncertainty in climate change is well documented (IEA, 2006; Wellington and Sauer, 2005; Austin and Repetto, 2000; Gars and Volk, 2004; Heal and Kristrom, 2002; Toman, 1998) and business is constantly learning to monitor, disclose and manage climate change impacts (CDP, 2003-6). The strategic nature of the climate change challenge is the subject of a growing area of research (Kolk and Pinkse, 2004, 2005; Sauer and Wellington, 2005). Theoretically therefore, scope exists to explore real options analysis as potentially providing additional insights into the impact of climate change on company value.

The scope for a real options approach to climate change impacts is extensive, with types of climate change related real options including:

- *Options to switch* (Mauboussin, 1999) from carbon emissions intensive technologies and products to cleaner fuels, processes and outputs as emissions taxes and regulations become increasingly expensive.
- *Options to 'scope up'* (Mauboussin, 1999) by moving into related industries with a lower climate change exposure as opportunities in these areas open up in response to climate change policies and consumer preference.
- *Options to contract* (Mun, 2002) by reducing the size of high emitting operations as these become unfeasible due to high carbon taxes or emissions trading prices.
- *Options to abandon* (Brigham and Daves, 2002) high emission operations altogether in the longer term.
- *Options to delay* (Brigham and Daves, 2002) investment in a clean technology until market forces have proven its value or to delay projects until prices for

carbon credits or the extent of the physical climate change impacts justify investment.

In addition to capturing the value from opportunities created by climate change and identifying the potential for creating risk hedges, real options analysis can also put a value to the climate change risks themselves by modelling a climate change insurance solution which would then price the risk. For example, weather derivatives can be used by farmers to hedge the risk of unexpected frosts.

Real options thinking focuses on the value of a company's ability to respond flexibly to climate change impacts as they emerge, as opposed to the NPV of the impacts as best understood today. This is arguably more appropriate and useful to companies and analysts, given the current uncertainty surrounding these impacts, and the wide ranges of outputs DCF analyses provide. A real options perspective may offer a strategic tool for companies to incorporate the impacts of climate change into their investment and strategic decision making processes, ensuring that potentially valuable climate change related options are appropriately considered in capital budgeting exercises.

Real options valuation lends itself to applications where volatilities of uncertain future outcomes can be quantified. Market data is a valuable source of these volatilities. Climate change policy has a strong tendency towards the use of market mechanisms. A two year trading history of carbon market prices already exists.

Considering the nature of the drivers of option value and the characteristics of climate change impacts on companies, climate-change-related options may have a high value. Firstly, the longer the timeframe until the option expires, the greater its value. Climate change is a long term phenomenon, and many uncertainties will only be resolved over decades. Secondly, the greater the uncertainty levels, the higher the option value. Climate change uncertainties have been shown to be significant. The third option value driver, that of an exclusively owned option being more valuable than when ownership is shared, is less appropriate to climate change options. Whilst some relate to changes in processes and energy use and therefore are exclusive, others have a first mover competitive advantage aspect, resulting in their ownership being shared. Finally, the

greater the portion of uncertain climate change related cash flows are of the project's value, the greater the option value.

Combining the values of all climate change related real options embedded in a company's assets in a portfolio of options could theoretically provide a measure of the impact of climate change on a company's shareholder value today. However, due to the complexity of the actual real options valuation processes, this may be a less practical application until these processes are further developed and refined. Whilst the quantification of real options is analytically robust, authors on the topic emphasise that real options are best understood as a way of thinking. "From management's perspective, that means appreciating what types of options exist, how they can be created, how and why option values change, and how to capture their value" (Mauboussin, 1999). The more important result of real options valuation lies in its thinking and strategic approach. "The journey is more important than the destination" (Mauboussin, 1999, pg13).

Options thinking has been applied extensively to climate change issues from an economic and policy perspective, to inform international policy development in response to the many uncertainties surrounding the science of climate change (Heal and Kristrom, 2002; WWF, 1997; Toman, 1998; IEA, 2006). Climate change has also been incorporated into real options analysis for energy sector investments (IEA, 2006; Majmin, 2006). However, there appears to be a dearth of research demonstrating the potential application of real options in conceptualising and quantifying the impact of climate change on company value.

4.3. Conclusion

The emerging technique of real options analysis has specific applicability in areas of high uncertainty, where management learning can occur, and where investment decisions are strategic in nature. Theoretically therefore, the technique may have the potential to deal with the shortcomings of other valuation methodologies in providing insight into the impact of climate change on company value, and in use as a strategic decision making tool for companies to incorporate climate change impacts into their investment and strategic processes. This warrants further research attention and testing.

Chapter Five: Methodology

5.1. Research Method

As described in the preceding chapter, the study of climate change effects on shareholder value is in its infancy and plagued by data limitations and both regulatory and scientific uncertainty. The size and nature of climate change impacts also varies significantly both between and within sectors, and these impacts are still in the process of being described and quantified by researchers. This situation is exacerbated in South Africa by a greater degree of regulatory uncertainty, and by high levels of data scarcity and uncertainty. The knowledge base in this field is therefore poor, with no clear conceptual framework, which does not lend itself to the development of good theoretical statements or hypotheses (Yin, 2002).

In fields such as this, where there is little empirical or theoretical work to serve as a guide, exploratory case studies are proposed as a useful method of gaining insight and identifying hypotheses for further research (Guari et al, 1995; Ryan et al, 2002). Case studies also provide a way of thinking about different approaches to problems (Yin, 1994; Ryan, 2002), and are useful in the valuation of climate change impacts where traditional approaches are found lacking. Case studies highlight the importance of contextual conditions, demonstrated by the literature review to be particularly relevant to climate change impacts. An exploratory case study method has therefore been used to test the usefulness of real options analysis in enhancing the understanding of climate change impacts on company value

5.2. Research Design

As stated in Chapter One, this study's research question is:

“Does the real options approach to valuation enhance the understanding of the impact of climate change on company value?”

The objective of the case is therefore to apply real options analysis to a South African company, to test whether the technique enhances understanding of the impact of climate change on company value.

A five step research plan was designed to translate the research question into an operational research undertaking. These steps are shown below, and described further in sections 5.3 'Choice of Company', 5.4 'Data Collection' and 5.5 'Data Analysis'.

1. Choice of case study company
2. Identification of the material impacts of climate change on the company's shareholder value
3. Exploration, description and quantification of material climate change impacts on the company
4. Data analysis and application of the real options valuation technique
5. Interpreting the case study results

The research design allows for a 'thick' (Yin, 2002) qualitative and quantitative description of climate change impacts, meaning that many methods are employed to bring out as many aspects of the climate change impacts as possible. Alternative valuation techniques are considered and utilised throughout the research. The resulting discussion provides a comprehensive context against which to assess the research question.

The research was conducted over six months, from April to September 2006.

Choice of Company

Ryan et al (2002) argue that the choice of the case in exploratory interpretive research is relatively unimportant. What is important is that the case enables theory development by being sufficiently relevant, and that it is simple. However Ryan et al (2002) admit that simplicity is difficult to determine prior to the study.

Buy-in to the research by the company being studied was considered crucial in generating meaningful results. Therefore, the materiality of the impacts of climate change to the company operations and value was important. The impact of climate change is described as being material when greater than 5% of market capitalisation is affected (Barker, 2004). The company needed to be aware of climate change impacts, which is not always the case amongst smaller South African companies with no international exposure. Small and non-listed companies also tend to have less data pertaining to environmental issues. The pool of companies considered as candidates for the case study was therefore comprised of large, publicly listed companies which have significant South African operations, a global presence, and which are in one of the high impact sectors as defined by the CDP (2005).

Step One: Choice of Case Study Company

Approaches were made to eligible companies where the researcher had a contact through her networks. Of this sub-set (around six companies), Sappi was the first to respond positively, and hence self-selected itself as the case for this research. Sappi is an international company, with operations in North America, Europe and Southern Africa (South Africa and Swaziland) and listings on the Johannesburg, London, New York and Frankfurt stock exchanges. For the purposes of addressing the research question, only Sappi's South African operations were considered⁵.

5.4. Data Collection

Two methods of data collection were employed in the case study: review of secondary sources and interviews.

Secondary data sources included industry reports, both local and global, encompassing primarily those on environmental and sustainability issues in the industry and the impact of climate change; Sappi's financial statements, annual report and sustainability report; and limited confidential data. The researcher worked within a confidentiality agreement signed with the company, and whilst the use of publicly available information was

⁵ In some cases Sappi's plantations and mill in Swaziland have been included in the case data, but this is not held to be material for the purposes of answering the research question.

preferred for reasons of replicability, academic acceptance, and to ensure that the results have value for the investor perspective (Reed, 1998), the confidentiality agreement allowed the researcher freedom to explore the full spectrum of climate change impacts. The integrity of the data presented in the case study was improved through the approval of the case study by Sappi.

Interviews were conducted with the following key Sappi employees, financial analysts, and South African climate change experts. These were followed up with emails and phone calls where necessary.

1. *Grant Little (Sappi CDM Project Leader; Environmental Quality Systems Manager) and Stuart Christie (Sappi Group Sustainable Development Management)*. An initial exploratory interview was held with Christie and Little, to scope out the research and to confirm the set of material climate change impacts on Sappi. Little was designated the lead Sappi contact for the research, and a follow up interview was held with him regarding the Tugela CDM project and other Sappi projects in the pipeline. Additional email and telephone correspondence was conducted with follow up questions throughout the research period.
2. *Sakkie van der Westhuizen (Sappi Environmental Manager)* van der Westhuizen was interviewed regarding Sappi's water use in their milling operations. The impact of climate change on the cost of water, together with various response options under different climate change scenarios was explored.
3. *Henry Coppens (Sappi Technical Specialist, Energy and Emissions)* Coppens was interviewed to explore the impact of climate change on Sappi's energy use, and mitigation options. The link between water and energy was discussed, and insight gained into the types of energy saving and renewable energy projects available to Sappi, and the costs thereof.
4. *Tyrone Hawkes (Financial Director, Sappi Kraft)* Hawkes provided the key link between the operational and environmental aspects of Sappi, and their financial functions. Three interviews were conducted, exploring the valuation techniques currently in use at Sappi, the appropriateness of alternative techniques to the business, the materiality of various climate change impacts, insurance and risks

- in the international operations. Hawkes reviewed the Tugela CDM DCF constructed during the research.
5. *Dr David Everard (Sappi Divisional Environmental Manager) and Dr Andrew Morris (Research and Nurseries, Sappi Forests)* Everard and Morris were interviewed for their insights into the impact of climate change on the forestry side of the Sappi business. Fires, pests, species variety and growth were covered, together with timeframes and their perspectives on the scientific forecasts for the areas where the Sappi forests are located.
 6. *Dr Bob Scholes (Systems Ecologist, Council for Scientific and Industrial Research, Division of Water Environment and Forestry Technology)* A telephonic interview was conducted with Scholes, a leading expert in the physical impacts of climate change on Southern Africa, in order to ascertain the likely impacts, timeframes and severity. Scenarios generated from the interview were emailed to Scholes for review and comment.
 7. *Nicola King (then Environmental and Resource Economist, Council of Scientific and Industrial Research) and Mr Mohammed Vawda (Director, Department of Water Affairs and Forestry, Water Resources Finance and Pricing Department)* were interviewed telephonically regarding the pricing of water in South Africa, and the impact of the forecast water scarcity for the region on forestry and industry.
 8. *Royce Long (Head of Financials, RMB Asset Managers) and James Twyman (Analyst, UBS Investment Bank, London)*. Long and Twyman were interviewed telephonically (Long) and via email (Twyman) in their capacity as analysts of the pulp and paper sector, including Sappi. Questions covered the types of valuation techniques employed to value Sappi, and what the main drivers of value for the sector are.
 9. *Doug Morrow (Analyst, Innovest Strategic Value Advisors, Ontario)* was interviewed telephonically regarding the Innovest Carbon Beta[®] methodology, to understand its potential application to valuation techniques.
 10. *Piet Schoombee (Sappi Harvesting Development Manager) and Jeanette Sullivan (Process Engineer, Utilities, Sappi Kraft)* gave email and telephonic information regarding the Tugela project and the costs of collecting biomass in the field for energy purposes.

11. *Greg Barker (Financial Analyst, Fraters Asset Management)*. Barker was interviewed given his expertise in climate change impacts on South African companies, and his professional interest in the real options technique and the valuation of Sappi.
12. *Steve Thorne (Director, SouthSouthNorth Projects Africa)* Thorne was interviewed on the use of energy in milling operations, given his energy expertise, extensive knowledge of the pulp and paper sector, and CDM project design work on the Mondi Biomass CDM project in South Africa.
13. *Harald Winkler (Senior Researcher and Programme Lead of Energy, Environment and Climate Change, Energy Research Centre University of Cape Town)* Email correspondence occurred with Winkler regarding the status of South African energy and climate change research, and price impact forecasts.

Interviews typically lasted an hour, and a semi-structured interview format was used with a number of prepared questions prompting the discussion. The role of the researcher was one of a 'visitor' to Sappi (Ryan, 2002), and whilst the information exchange was occasionally two way during the interviews, the respondents were sufficiently well versed in climate change issues that the researcher's influence over the resulting data was held to be minimal.

Each interview was written up shortly after the event. Follow up emails or telephone calls were subsequently recorded and used to augment the interview notes. Data verification and triangulation was undertaken where possible, either by cross-checking within Sappi or through confirmation with external experts and secondary sources. The cross checking helped to obtain different perspectives on the extent of uncertain climate change impacts, to better understand the mechanisms through which climate change impacts would be felt and to access additional information and data sources. Information on climate change is not routinely collected by the company, and therefore was not immediately accessible. The draft case study has been reviewed by the designated lead contact at Sappi and other key Sappi informants.

Step Two: Identification of the Material Impacts of Climate Change on Sappi's Shareholder Value

Climate change will impact all companies differently; therefore the second step was to describe comprehensively the ways in which Sappi's company value could be affected. Secondary information sources were consulted to establish a profile of all material climate change impacts on companies in the pulp and paper industry. This profile was then adapted to the South African regulatory and physical environment, resulting in seven material impacts on Sappi being identified. This was confirmed in an interview with Sappi's Group Sustainable Development Manager and CDM Project Leader; Environmental Quality Systems Manager. This profile established the scope of the research.

Step Three: Exploration and Description of Material Climate Change Impacts on Sappi

The nature, mechanisms and strategic implications of the seven material impacts identified in Step Two were explored through the series of interviews with Sappi employees. Each respondent was questioned on impacts relevant to his or her area of expertise and responsibility. Initially a qualitative understanding of how each impact would affect Sappi was sought, including the expected timeframe and extent of the impact. Often, unexpected interactions between the various impacts emerged, defying the use of a consistent framework for organising the data.

In order to assist with coherence and consistency between the seven impact areas, a framework consisting of two climate change scenarios for South Africa described as 'medium' and 'high' was devised by the author in conjunction with external South African climate change experts, and appears in Figure 5.1 below.

Figure 5.1. South African Climate Change Scenario Framework

| | |
|---|---|
| <p>Medium Climate Change</p> <ul style="list-style-type: none"> - 5% temperature increase - 15% rainfall increase - low level preparatory emissions regulation - CDM opportunities | <p>High Climate Change</p> <ul style="list-style-type: none"> - 5% temperature increase - 15% rainfall decrease - South Africa takes on Kyoto Targets - No CDM opportunities |
|---|---|

The scenarios describe two plausible climate change related futures, based on the current levels of scientific knowledge and international policy negotiation. The medium scenario envisages a future where both the physical impacts of climate change and the international policy environment have evolved in a way which will have a medium intensity of impact on Sappi. The high scenario describes a future where scientific understanding and policy development will have a more significant impact on the company. This framework was also used to analyse the data elicited from both the interviews and the secondary sources, understand the strategic implications of each scenario, and support the qualitative and quantitative description of climate change impacts on Sappi’s value. Secondary sources were also consulted to verify the data arising from the interviews, and to augment their findings.

In addition to gaining a clear and coherent qualitative understanding of each impact, data relating to the quantification of the impact on Sappi’s value was requested. The form of this data varied substantially, from the respondents own head knowledge, to data sets compiled for specific, unrelated internal applications, to that gleaned from the annual reports. Due to the emerging nature of this field of study, relevant data was seldom centrally organised, and was also inaccessible, inconsistent between impacts, and in many cases simply unavailable.

5.5. Data Analysis

Step Four: Data analysis and application of the real options valuation technique

The approach to data analysis was two-fold.

5.5.1 Descriptive Analysis of the Material Impacts of Climate Change on Sappi's Value

The data collected from interviews and secondary sources was organised into seven sections, one for each of the seven impacts of climate change on Sappi. The patchiness of the data meant that a variety of analytical techniques had to be employed to quantify and describe the value implications of each impact. The choice of technique, drawn from the climate change valuation literature, was therefore determined by the data. The high levels of uncertainty around the evolution of future climate change impacts also limited the ability of the analyst to undertake meaningful in-depth quantitative analysis.

The analysis is therefore not consistent across impacts. Descriptive analysis was conducted for each impact, and thereafter available data was analysed to extract quantitative impacts. Techniques utilised included: i) The impact of input price increases and scarcity on operating costs was analysed by considering the impact on earnings per share. ii) Potential additional costs and revenues relating to the CDM and the avoidance of national greenhouse gas regulations were calculated. iii) Break even analysis was used to estimate the fossil fuel costs at which increasing renewable energy becomes feasible. iv) DCF analysis was used to estimate an alternative value of an asset utilising carbon finance opportunities. v) The climate change impact scenario framework developed through the data collection process was used as part of a descriptive scenario analysis for some of the impacts. vi) A table was used to summarise the analysis, and to provide an organising framework.

Whilst not providing consistency, the variety of techniques used do provide an initial indication of the potential effect of climate change impacts on company value.

5.5.2 Real Options Analysis

Secondly, a real options analytical approach was applied to the descriptions of each impact. Existing and potential options embedded in Sappi's assets and related to

climate change were identified using real options thinking. These options were framed according to the various option types identified in the literature.

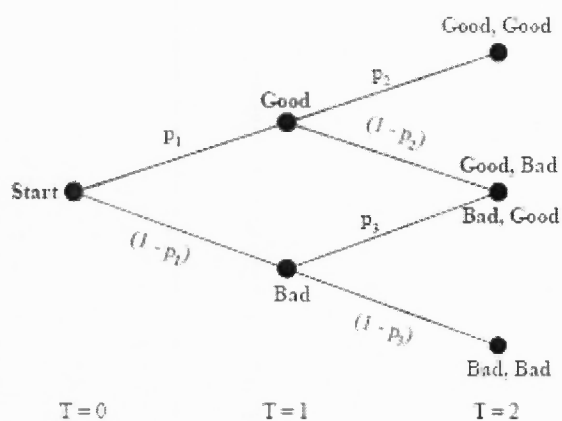
A real options valuation of one of the options identified was then undertaken. A quantitative valuation of only one impact area was held to be sufficient to respond to the research question, given the emphasis in the literature on the value of employing real options thinking above the actual quantification, and given the research project's time and resource limitations.

In approaching the valuation, a framework developed by Mun (2002) was modified for application in this research context. The first phase of real options valuation, referred to by Mun (2002) as 'Qualitative Management Screening', involves a decision regarding which projects, assets, initiatives or strategies are viable for further analysis. The impact of the CDM was chosen for further analysis using the real options technique, and the Tugela mill CDM project was selected primarily for reasons of data availability.

Mun's (2002) second phase involves undertaking a DCF analysis of the underlying asset, in this case the CDM project. The DCF for the Tugela project used data supplied by various Sappi informants, and was verified by both Sappi's CDM project lead and the Financial Director of Kraft.

Thirdly, the type of real option was framed as an *option to delay*, and finally modelled. A binomial lattice modelling approach was selected for its mathematical simplicity, transparency and intuitive nature. The latter two properties of the approach were held to be particularly appropriate, given the research objective of assessing whether real options analysis enhances the understanding of the impact of climate change on company value. A lattice model is shown in Figure 5.2 below.

Figure 5.2. The Binomial Lattice Model



(Source: Mauboussin, 1999, pg 6)

Two lattices need to be calculated to solve the option value. In the first, the NPV of the underlying asset is represented at T_0 in Figure 5.2 above. This value has been discounted using a discount rate consistent with those used to value similar assets by the company or analyst, such as the company's Weighted Average Cost of Capital. Each subsequent node represents a point in time. The size of the time-step in years or months is determined by the analyst up-front as δt . The lattice progresses in a step-wise manner to T_1 , where two potential payoff nodes exist, one good and one bad. These up and down-steps are risk neutral probabilities, determined by the volatility (σ) impacting on the asset's value, and calculated according to the following equations:

$$u = e^{\sigma \sqrt{\delta t}} \quad [1]$$

$$d = \frac{1}{e^{\sigma \sqrt{\delta t}}} \quad [2]$$

The payoff at each node represents the value of the underlying asset were the investment to be made at this point. In T_2 four potential payoff nodes exist, and so on for the life of the option.

The second lattice is calculated from the first, using a technique known as backward induction. Each node in this second lattice represents the value maximisation of either investing at that point, or waiting until the next time period. The end nodes are first considered, T_2 in the figure above. The first lattice value of each end node, less the cost of exercising the option, is compared to a decision rule for exercising the option. This decision rule is most often related to the company's investment hurdle rate. For example, if the returns represented by the asset value at that point less the cost are greater than those required by the investment hurdle rate, the investment would be made. If the return represented by the value of the underlying asset less the cost of exercising the option passes the investment hurdle rate, the net asset value is retained at this node. If the return does not pass the hurdle rate, the option will expire worthless at this point.

Secondly, the values at the intermediate nodes are calculated (T_1). These values are the weighted average of potential future option values, discounted at the risk free rate, and using the risk-neutral probability, represented by the equation [3] below:

$$\text{Intermediate Value} = [p(e^{\sigma \sqrt{\delta t}}) + (1-p) e^{-\sigma \sqrt{\delta t}}] e^{-rf (\delta t)} \quad [3]$$

$$\text{Where: } p = \frac{[(e^{\sigma \sqrt{\delta t}})^{rf} - e^{-\sigma \sqrt{\delta t}}]}{(e^{\sigma \sqrt{\delta t}} - e^{-\sigma \sqrt{\delta t}})} \quad [4]$$

Rf is the risk-free rate, used in the binomial lattice because risk is accounted for in the use of probability adjusted payouts.

Using equation [3] The binomial lattice is completed back to T_0 , which gives the value of the option.

Step Five: Interpreting the case study results

The implications of the application of real options thinking to the impacts of climate change on Sappi's value, and the quantitative valuation of the Tugela CDM project, were then considered against the research question. The initial description of the material

climate change impacts on Sappi's value, together with the literature review's theoretical finding of shortcomings in traditional valuation methods when applied to climate change impacts, provided the template against which the real options results were assessed.

Finally, the potential for generalising the findings of the Sappi case were considered, together with certain key research limitations. The empirical findings of the case study technique can be generalised through a process of analytic generalization, which in turn is intended to lead to theory development (Yin, 2002).

5.6. Difficulties Encountered during the Research

Securing a company's agreement to participate in the research as a case study took a number of months. This was primarily a result of difficulties experienced in getting the attention of the right people, mostly in the sustainability or environmental department, who were typically involved in numerous initiatives simultaneously. Use was made of the researcher's own contact network, together with industry associations and cold calling. The greatest success was had with network contacts.

The problems of data availability have already been discussed in this section, and should not be underestimated in future research into this area. As a result of limited data, the researcher's expectations of the scope of the case study had to be reduced, and the quantitative analysis restricted to one project.

The impact of climate change on company value is an emerging field of study, and requires the combination of two disciplines, environmental management and finance, which have historically been very separate. This presented a number of problem areas to the case research. Difficulty was experienced in communicating key concepts and information requests to Sappi employees, and misunderstanding between the researcher and informants was common throughout the data collection period. This increased the timeframe of the research, and reduced its scope in line with the effect of the data limitations described above.

During the real options valuation, the application of an emerging and mathematically complicated technique to an obscure and complex mechanism arising from international

climate policy (the CDM) held its own communication problems, and it took a number of attempts before the point of interaction between the two areas was sufficiently well understood to enable accurate problem framing and analysis. In order to ensure the validity of the final analysis, the process and results were confirmed with a real options expert (Russell Nel, RessCapital), an options modelling expert (Haim Abrahams, UCT Economics Department), and an analyst who has worked with both real options and climate change (Greg Barker).

Also related to the emerging nature of the field, maintaining an open mind and continuous flexibility as a researcher proved to be very important. Holding to one analytical path too closely and too early on in the data collection stage, without paying heed to what was emerging from the data, was found to be costly in terms of time.

University of Cape Town

Chapter Six: A Case Study of the Climate Change Value Impacts on Sappi Southern Africa

6.1. Sappi Ltd: Introducing the Company

Sappi Ltd is an international vertically integrated pulp and paper company. Headquartered in Johannesburg where it was established in 1936, Sappi now has operations in both Europe and North America. Initially listed on the Johannesburg Stock Exchange, its global expansion programme in the 1990's led to listings in London, New York and Frankfurt.

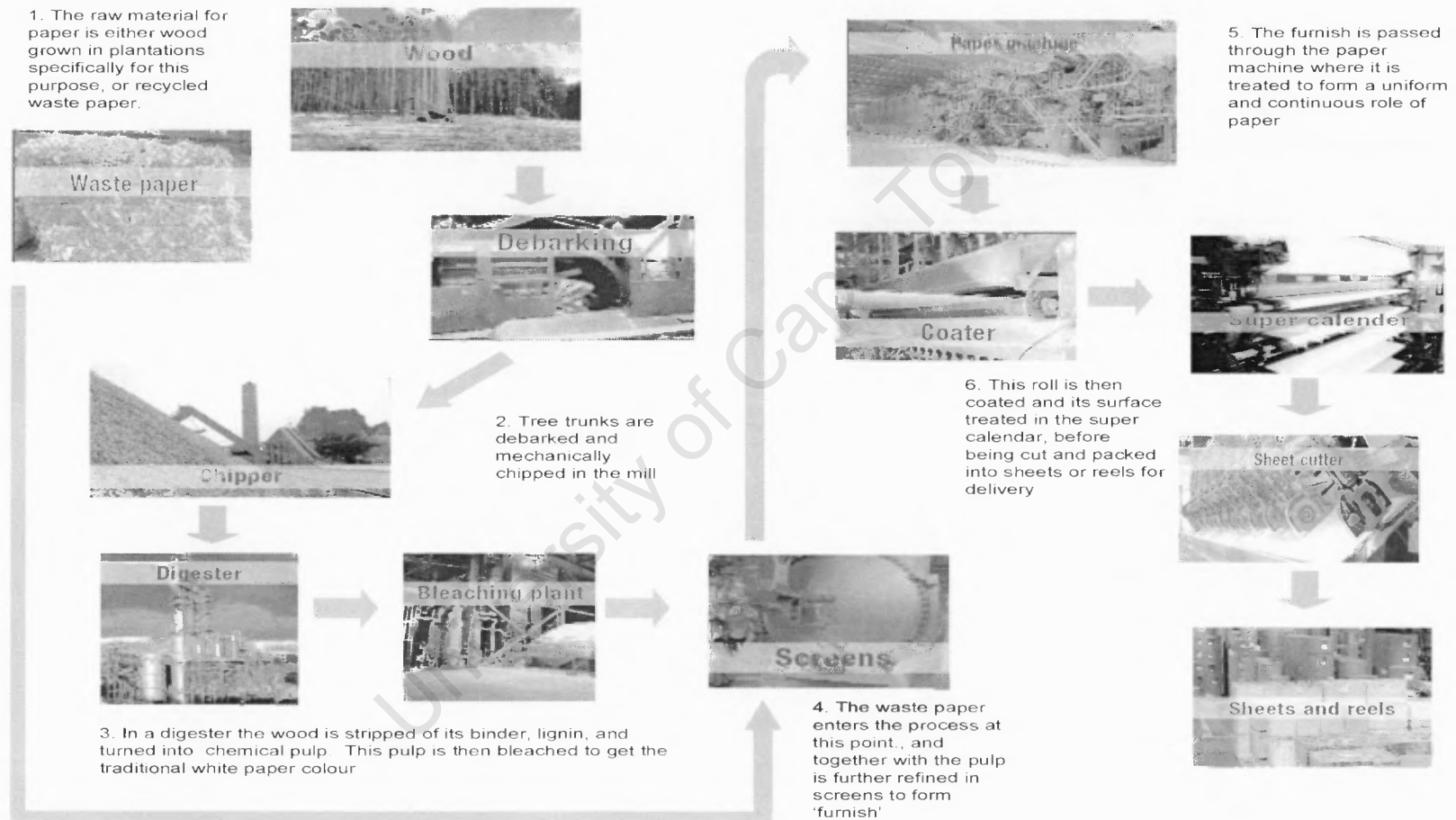
Sappi Ltd consists of two main divisions: Sappi Fine Paper and Sappi Forest Products. Sappi's Fine Paper division produces a range of paper products, with a presence in North America, Europe and Africa (Annual Report, 2005), and is in the process of acquiring an interest in a paper company in South East China through a joint venture. The Fine Paper division accounted for over 80% of Sappi's sales in fiscal 2005, and has the capacity to produce over four million tons of paper. It is 70% self sufficient in pulp.

Sappi Forest Products is a pulp, packaging, paper and newsprint business, fully integrated, and wholly situated in Southern Africa. It in turn is divided into three operating divisions: Saiccor which specialises in chemical cellulose, Kraft which produces paper, packaging and newsprint, and Sappi Forests producing timber products.

6.1.1. The Integrated Paper Making Process

The paper making process begins in the plantations where the trees are grown, and continues in the paper mills where the wood passes through both mechanical and chemical applications to produce various grades of paper. Producing paper relies substantially on natural resources such as wood and water as inputs, and is very energy intensive. The process is depicted in Figure 6.1 below:

Figure 6.1. The Paper Making Process



Source: Adapted from Sappi Annual Report, 2005

6.1.2. Value Drivers and Financial Characteristics of Sappi and the Pulp and Paper Sector

The primary value drivers for the South African pulp and paper industry are earnings related, as impacted by paper prices, exchange rates and input costs. The international pulp and paper industry is cyclical in nature, and subject to significant paper pricing volatility. Exchange rates are also volatile, impacting both margins on exports and the local market prices.

Rising input costs, such as chemicals and energy, have been squeezing margins in the sector in recent years. Sappi's energy bill rose by 16% in 2005, and their chemicals bill rose 11% (Sappi Annual Report 2005). Both continued to rise in 2006, and are anticipated to be an issue into the future. There is a need throughout the sector for rationalisation and increased efficiencies (Forestry South Africa, 2004).

Earnings are therefore described by analysts as being the most important factor in conducting a valuation of the company, with earnings volatility making forecasted earnings a long way out fairly devoid of meaning (Long interview, June 2006; Twyman interview, June 2006; Barker interview, August 2006). Sappi itself focuses internally on the growth of the net present value per share (www.sappi.co.za). The company relies substantially on DCF as the basis of all their internal valuation approaches, with the cash flow statement viewed as their most important financial statement. Under new international accounting rules asset impairments have become very significant in valuation terms.

6.2. Descriptive Analysis of Climate Change Impacts on Sappi Southern Africa

"To an extent equalled by few others, the environment can significantly affect the financial results of companies in the pulp and paper industry". (Austin and Repetto, 2000)

Chapter Two discussed the various mechanisms through which business is impacted by climate change. The pulp and paper sector is identified as a high impact climate change sector (Austin and Repetto, 2000; CDP, 2003-5), subject to both direct and

indirect impacts. For the purposes of this case study, only Sappi's Southern African operations were considered.

The Carbon Disclosure Project (2005) and Innovest (2005) identify the impacts of climate change on the paper and forest products sector as being:

1. Exposure to national carbon emissions regulations
2. Material increases in operating costs due to higher energy prices
3. Opportunities in biomass-based power production and for bio fuels in agriculture and forestry
4. Possible opportunities to enhance cash flow from carbon sequestration in forest operations
5. Increased risk from fire and pest problems
6. Decreased value of land assets due to climatic extremes and secondary effects

A seventh impact relevant for Sappi's South African operations is that of water scarcity. This has been identified as the most relevant physical impact on South Africa from climate change (Dinan, 2004). Water scarcity will impact Sappi's land assets under six above, but will also have an impact on their mill operations.

Climate change will also impact Sappi through mechanisms such as reputation, the cost of their chemicals (which are 60% derived from fossil fuels), decline in paper demand as a result of consumer awareness around climate change, and an increase in demand for recycled paper. However, guided by the CDP (2003-5) and confirmation by Sappi, the seven impacts identified above are considered to be the most financially material. The scope of the research was therefore restricted to an assessment of these seven, categorized as impacts on either the forestry or pulping and milling activities of the integrated paper making value chain, according to primary impact.

A summary of each impact appears in Table 6.2 below, as a reference and organising framework for the description which follows. It shows the mechanisms through which each impact will translate into value effects, the techniques used to analyse each impact, and the anticipated impact on total company value.

What is clearly evident from the table is the extent to which the uncertainty of climate change impacts has restricted the analysis. Whilst uncertainty is an issue for climate change impacts on companies in general, the uncertainty relating to Sappi in particular is exacerbated due to two factors: Firstly, Sappi's plantations are positioned to the east of the escarpment. This area is not covered by the large climate change models, and therefore it remains uncertain as to whether the area will be wetter or drier in the future. Which scenario is realized is clearly not insignificant to Sappi's operations. Secondly, South Africa's position within the international policy regime is such that it is likely to undertake some form of carbon reduction commitment as early as 2012. What form this commitment will take, and how restrictive it will be is unclear. This results in the climate change regulatory framework being particularly uncertain.

University of Cape Town

Table 6.2. Summary of Climate Change Impacts on Sappi's Value

| Pulp and Milling Operations | | | |
|---|--|---|--|
| <i>Climate Change Impact</i> | <i>Mechanisms through which Value is affected</i> | <i>Techniques used to measure the impact</i> | <i>Value Implications</i> |
| Exposure to National Greenhouse Gas Emission Regulations | <ul style="list-style-type: none"> - Increase in the cost of fossil fuel derived energy - Increase in the cost of chemicals - Costly technology upgrades | Descriptive only, due to the uncertainty regarding South African climate change regulations post 2012 | Reduction in earnings, extent uncertain |
| Material increases in operating costs due to higher energy prices | <ul style="list-style-type: none"> - Increase in the cost of fossil fuel derived energy - Increase in the cost of chemicals - CDM opportunity - Costly technology upgrades | <p>Hypothetical impact on earnings per share analysis</p> <p>Estimation of additional CDM revenue available to the company</p> <p>Regulatory uncertainty and lack of data render valuation results speculative</p> | <p>Reduction in earnings, extent uncertain</p> <p>Opportunities for an earnings increase through CDM, extent uncertain</p> |
| Opportunities for biomass based power and bio fuels | <ul style="list-style-type: none"> - Reduced cost of waste disposal - Hedge against increased fossil fuel derived energy costs - Opportunity to access revenue from renewable energy certificates - Technological immaturity of advanced biomass energy generation presents a cost barrier | <ul style="list-style-type: none"> - Calculation of the cost saved per tonne of biomass diverted from landfill - Estimation of the cost of coal at which collecting slash becomes viable - Estimation of additional CDM revenue available to the company | <p>Increase in earnings, extent uncertain</p> <p>Strategic opportunity to move into renewable energy generation</p> |
| Impact of Water Scarcity on Mill Operating Costs | <ul style="list-style-type: none"> - Change in capital outlay required for water infrastructure - Increased energy costs as a result of increased water recycling | Descriptive only, due to the uncertainty regarding the physical climate change impacts in Southern Africa | Increased capital outlay to maintain costs. Negative value implications, extent uncertain |

| Forestry Operations | | | |
|--|--|--|---|
| <i>Climate Change Impact</i> | <i>Mechanisms through which Value is affected</i> | <i>Techniques used to measure the impact</i> | <i>Value Implications</i> |
| Increase in fires and pests | <ul style="list-style-type: none"> - Fibre loss due to fire and pests results in assets impairment and increased pulp costs - Potential reduction in fires reduces current levels of fire loss | Descriptive only due to scientific uncertainty of physical impacts | Uncertain, potentially positive or negative |
| Decreased value of land assets | <ul style="list-style-type: none"> - change to more lucrative land use as a result of climate change impact could increase revenue - potential increase in fibre growth and therefore reduced input costs due to increase carbon dioxide in the air - Stranding of mill assets should plantations become unviable in close proximity to the mill - Water scarcity reduces yield and therefore increases input costs - once off extreme weather events could significantly affect fibre yield and therefore earnings | Descriptive only due to extent of uncertainties | <p>Uncertain, potentially positive and negative</p> <p>Strategic implications of change in land use</p> |
| Possible opportunities to enhance cash flow through sequestration in forest operations | - Switch to producing emissions credits rather than pulp. Pricing results in increased revenues. | - DCF analysis of converting plantations to sequester carbon | <p>Speculative, potentially positive</p> <p>Strategic implications of change in land use</p> |

6.2.1. Impacts on Pulping and Milling

The key impacts on Sappi's pulping and milling operations are energy and water related. Sappi's pulping and milling activities are extremely water and energy intensive, and both inputs are anticipated to become either scarce or expensive as a result of climate change. Although Sappi is a world leader in water conservation measures in milling due to their primary operations being located in a water stressed region, the company has paid less attention to energy efficiency historically, given the availability of South Africa's cheap grid electricity.

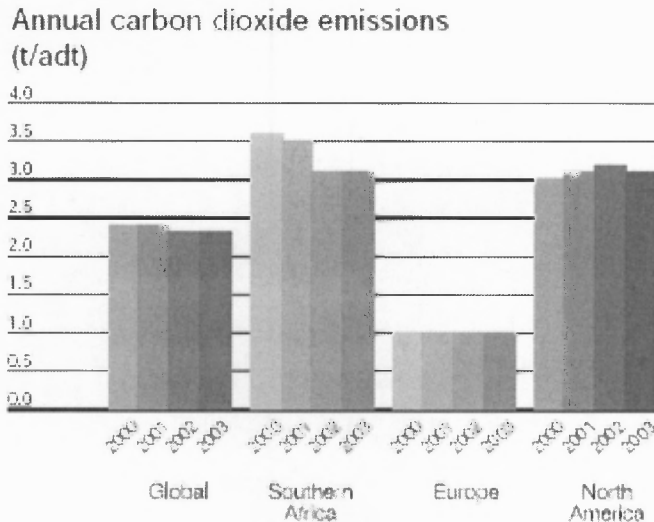
Exposure to National Greenhouse Gas Emissions Regulations

Under the international policy regime established by the Kyoto Protocol, Sappi has emission reduction targets at its mills in Europe which fall under the European Union Emissions Trading Scheme (EU ETS). Its US operations do not currently have targets as the US is not a signatory to the Kyoto Protocol. Sappi's South African operations, the subject of this case study, are not currently subject to targets, but may well face these as early as 2012, or prior to this as a preparatory measure.

Sappi's greenhouse gas emissions profile is dominated by CO₂ emissions from energy use, both direct and indirect, as is typical of companies in the pulp and paper sector (CDP, 2005; ICFPA, 2005; Hyvarinen, 2005). For example, Stora Enso, a large international pulp and paper company, reported its total global greenhouse gas emissions in 2004 as being 98% CO₂ (CDP, 2005; ICFPA, 2005). Other emissions sources for Sappi include the transport of fibre to the mill, non- CO₂ emissions from the combustion of fossil fuels and biomass, emissions from Kraft mill lime kilns and calciners, CO₂ emissions from chemicals, and methane emissions from landfill sites (ICFPA, 2005). For reasons of financial materiality, only CO₂ emissions from energy will be considered in this study.

Sappi neither measures nor discloses the total greenhouse gas emissions from its operations. It does however report its CO₂ emissions intensity as 'tonnes of CO₂ per air dried ton of product' in its Sustainability Report (2004). These intensities are depicted in Figure 6.3 below, disaggregated per region.

Figure 6.3. Sappi's Annual CO₂ Emissions



Sappi, *Towards Sustainability* (2004, pg 45)

Sappi uses a mix of electricity, coal, gas and biomass for its energy purposes (Sustainability Report, 2004). In Southern Africa, biomass accounts for 38% of the total primary fuel consumption. Biomass emissions are considered carbon neutral as the carbon in biomass originates from the atmosphere (ICFPA, 2005). These emissions are therefore not counted towards greenhouse gas emission levels under most greenhouse gas reporting protocols.

As can be noted from Figure 6.3 Sappi's Southern Africa region has a CO₂ emissions intensity which is three times that of its European operations. This is due to the region being water scarce and therefore requiring additional energy use in mills to recycle water, together with South Africa's historically cheap electricity prices and coal based electricity generation mix.

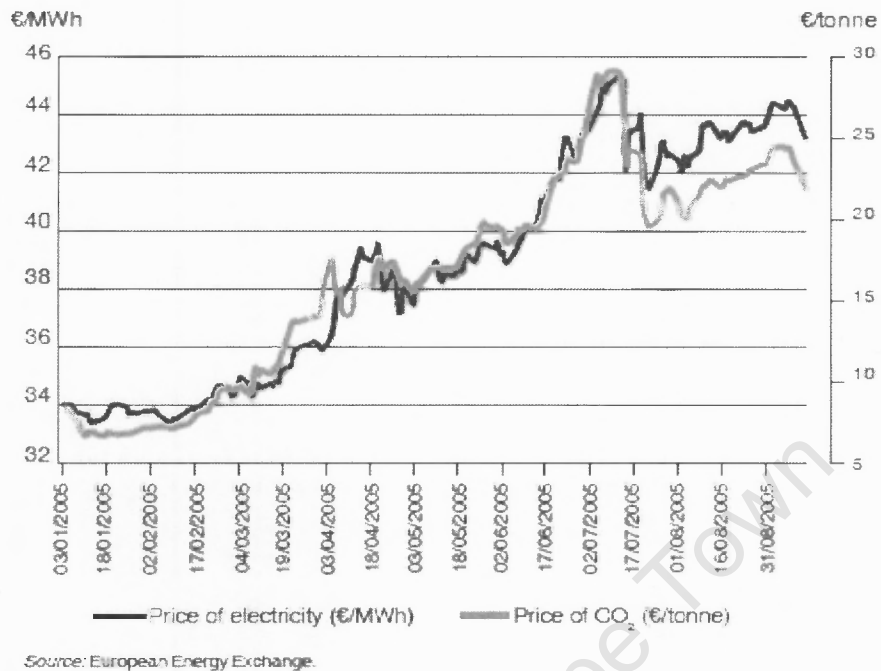
Should South Africa take on greenhouse gas emission reduction targets, the impact to Sappi would be felt primarily as an increase in the price of energy, similar to that on European pulp and paper operations under the EU ETS (Hyvarinen, 2005). This in turn would incentivise a switch to renewable energy sources. Both outcomes are discussed in the relevant sections below.

Increased Energy Prices

The South African electricity price is forecast to rise above inflation over the next few years, largely driven by capacity constraints within the South African electricity sector. If emissions regulations are instigated as well, this increase is likely to be greater. All forms of fossil fuel generated energy are anticipated to experience a cost increase under an emissions regulation scenario.

Establishing the extent to which the electricity price would rise is extremely difficult. Prior to the start of the EU Emissions Trading Scheme (EU ETS), many attempts were made to forecast the impact of the scheme on the electricity price, with estimations ranging between 10% and 40% (Global Insight, 2004). Whilst a correlation in the empirical data has been demonstrated, see Figure 6.4 below, causality remains inconclusive due to the effect of many other variables acting on the electricity price simultaneously. Factors which determine how carbon prices affect electricity prices include how closely the power generating sector is regulated, the power generating mix in an economy (Global Insight, 2004), the method of allowance allocation, and climate temperature (www.pointcarbon.com).

Figure 6.4. Correlation between electricity prices and the price of CO₂ allowances under the EU ETS



Source: European Energy Exchange as cited in Hyverinen, 2005

The CDP (2004) steers clear of the link between carbon prices and electricity prices, and focuses on showing how various increases in energy costs as a whole could impact the share price of companies. The impact on share price is consistently negative, depending on the percentage of energy costs to operating expenses, together with the percentage increase in energy price assumed. For example, a 10% increase in energy prices could result in a decrease in share price of between 5 and 27%.

The Sappi Group's energy costs were \$365 million in 2005. For every 1% change in the price of energy, Sappi estimates their earnings per share will increase or decrease by \$0.01 cent, based on their fiscal 2005 earnings (Sappi, 2005). Sappi does not disclose this percentage on a regional basis so the following analysis is undertaken on the group level. At a share price of \$12.47 (www.sappi.co.za, 27 August 2006) an energy price increase of 10% would result in a decrease in Sappi's share price to \$12.37 (0.8%). An increase of 40% would result in a share price decrease to \$12.07 (3.3.1%).

Sappi exposure to changes in chemical prices is double that of energy (\$0.02 cents per percentage rise in chemical costs (Sappi, 2005)). The manufacture of chemicals is highly energy intensive, resulting in a secondary effect of increased energy prices on chemical prices. Transport costs, affected by fossil fuel price increases, are also an important determinant of chemical prices. In the analysis above, assuming a one for one increase between energy and chemical prices, a 10% increase in energy prices will have a total decrease of \$0.3 on the share price. A 40% increase would lead to a \$1.2 decrease in the share price, to \$11.17, a 10% loss of value.

Sappi Southern Africa sources its chemicals from both local and overseas sources. Chemical manufacture in Annex B countries is likely to be subject to some form of emissions regulation sooner than that experienced locally given Annex B targets under the Kyoto Protocol. An increase in chemical costs from overseas suppliers will also be exposed to currency issues. Both these effects could result in a change to Sappi's supplier patterns and chemical costs in the short term.

Sappi is currently working on optimising their energy use in response to concerns over climate change. This is being addressed within the E4 (energy, environment, emissions and effluent) cluster, which is a technological committee internal to the company. Whilst many energy saving projects identified are cost efficient, a number are not. Not a lot of work has been done on this to date, and costing of these projects has only been identified within a 30% accuracy level. Combined heat and power plants which yield twice as much energy from the same fuel source as do conventional generating plants are used as standard across the company (ICFPA, 2005).

Energy efficiency projects or projects which switch to a less carbon intensive fuel could potentially be eligible to access carbon credits under the CDM process. Sappi has identified ten energy efficiency, or fuel switching projects in its South African operations with the potential to deliver around 400,000 carbon credits per annum. At a price of \$10, this represents a \$4 million annual revenue stream to the company, although costs and risks need to be taken into account. The projects include converting boilers to use natural gas as a fuel, installing energy management systems at mills, supplying natural

gas for combustions at Saiccor, motor size reduction and the use of solar panels for electrical supply.

Opportunities for biomass-based power production and bio fuels

The pulp and paper industry relies significantly on bio fuels derived from waste products of the paper making process to meet its energy needs. Bark and other residues are combusted in boilers, and black liquor (consisting of the lignin removed from the pulp in the chemical pulping process) is used to generate steam and electricity (Sappi Sustainability Report, 2004). In Europe, 63% of Sappi's energy is derived from bio fuels, and 38% in South Africa. Sappi is committed to increasing this percentage. The energy mix at each of Sappi's South African mills is described in Table 6.5. below.

Table 6.5. Energy mix at Sappi's South African mills

| | Ngodwana | Tugela | Saiccor | Enstra | Stanger |
|-----------------------------|-----------------------|------------------|-----------------------|-----------------|-----------------|
| Production process | Chemical & mechanical | Kraft (chemical) | Dissolving (chemical) | Soda (chemical) | Soda (chemical) |
| Energy source | | | | | |
| Coal and national grid | 55% | 50% | 60% | 96% | 97% |
| Gas | 0% | 25% | 0% | 2% | 0% |
| Oil | 2% | 0% | 1% | 0% | 0% |
| Biomass | 43% | 25% | 39% | 2% | 3% |
| Total energy use (GJ/annum) | 22,971,140 | 11,252,950 | 10,579,120 | 4,122,826 | 2,637,675 |

Source: (Chamberlain et al, 2005)

As can be seen from Table 6.5 above, the integrated pulp and paper mills use a far higher percentage of biomass than do the stand alone paper mills, as stand-alone mills do not have the availability of biomass waste from the pulping process (Chamberlain et al, 2005). The cost of disposing of this biomass waste is an additional incentive to use it on-site. Sappi quotes a cost of R193 per ton to dispose of biomass waste in a landfill: R178 for the landfill air space, and R15 handling fee.

Additional biomass to that arising from the pulping process is found in forest residues: both residues which naturally drop from trees during their growth cycle and 'slash' which refers to the cuttings arising during the harvesting process. Natural residues are important to the sustainability of the plantations as they provide essential nutrients to the

soil. Slash, however, can be collected for combustion and energy generation. The cost of getting slash to the mill in a chipped form has been estimated using two systems, and is shown as a cost per ton in Table 6.6 below.

Table 6.6. Cost Per Ton of Slash Arriving at Mill

| Operation | System 1 | System 2 |
|--------------------------------|-----------------|-----------------|
| Manual Collection of waste | R 66.67 | - |
| Grapple skid waste to roadside | R 15.36 | - |
| Tub Grind waste | R 18.36 | - |
| Bundle waste into bails | - | R 71.73 |
| Transport bails to roadside | - | R 18.00 |
| Transport bails to mill | - | R 36.78 |
| Load bails | - | R 6.00 |
| Transport chips to mill | R 53.45 | - |
| Chip at mill | - | R 18.36 |
| Total | R 153.83 | R 150.87 |

This compares with an indicative cost of coal of R330 per ton for a mill such as Tugela, a price which differs from mill to mill. A ton of biomass and a ton of coal do not yield comparative energy though. The calorific value of biomass is 35% of coal: 9.2 Mj per kg, as opposed to 26.6 Mj per kg (Tugela CER calculations final.xls). Comparatively, spending R154 on a biomass should yield the same energy as spending R115 (35% of R330) on coal, showing coal to still be more cost effective. However, should the cost of coal rise above R440, collecting and burning slash theoretically becomes viable.

A restricting factor to the increased uptake of biomass for energy generation is the cost of the technologies enabling generation. Gasification is a next-generation technology for generating energy from biomass, with significant emissions reduction potential (Weyenhauser, 2005). Whilst technology can offer further opportunities, it is still a long way off in terms of maturity. The use of biomass to generate energy for Sappi's own use acts as a hedge against a climate change induced rise in energy costs.

Awareness around climate change and the cost of using fossil fuel fired electricity is anticipated to increase the demand for electricity generated from renewable resources. Kolk and Pinkse (2005) discuss the entry of a Finnish paper, packaging and forests company into the green electricity market in a paper entitled "Business Responses to Climate Change: Identifying Emergent Strategies". They describe this strategic response to climate change as that of a 'horizontal explorer', "focusing on the exploration of opportunities in markets outside of their current business scope" (Kolk and Pinkse, 2005). Such a move on Sappi's behalf would comprise a shift in business strategy not currently envisaged by Sappi even under the most extreme scenarios. Sappi argues that 95% of the investment in their mills is focused on the paper-making process, as opposed to a power generating facility.

Another opportunity in the area of biomass generated energy is that presented by the CDM. In addition to the energy efficiency and fuel switching project described in the previous section, Sappi has identified nine further projects involving the use of biomass to replace fossil fuel fired electricity. These projects represent an additional 385,000 carbon credits annually. Again at a price of \$10 per tonne, Sappi could gain access to a \$3.8 million annual revenue stream

Sappi is currently developing a pilot CDM project which involves switching from coal to biomass at their Tugela mill. Should this first pilot prove successful, Sappi hopes to undertake more of the nineteen projects identified to date. The cost of developing CDM capacity to execute and monitor these projects is estimated to cost between R2.1 and R3.4 million per annum.

Impact of water scarcity on operating costs

A continuous water supply is critical to the operation of paper mills. Southern Africa is already identified as a water-stressed region, and so Sappi currently operates at best practice levels of water efficiency internationally, and is at the cutting edge of research into water and effluent controls. As has been mentioned previously, this water efficiency costs the company in terms of energy use to recycle water.

Water costs in South Africa are tiered, with costs increasing the more one relies on government water infrastructure such as dams, pumping, storage and distribution

(Department of Water Affairs and Forestry, 1997). A viable alternative to paying for government infrastructure is to provide one's own in order to control water costs. Sappi is currently planning to build its own dam for these reasons. The extent of the water infrastructure required will depend on the projections of climatic change for the region. Currently, Sappi is planning to build a dam at a cost of R160 million. Should rainfall increase due to climate change (a possible scenario discussed in greater detail in a later section), Sappi could save R50 million on the costs of this dam. Should conditions become drier, an additional R250 million above the planned R160 million would be needed. A further R160 million would be used to reduce water and control effluent at mills through the piloting of new technologies

Installing water infrastructure will alleviate Sappi's risk of increased water scarcity to a certain extent, as would advanced water conservation technology in the mills. However, this risk remains substantial to the company, particularly given the cost implications on energy use under carbon emissions regulation.

6.2.2. Impacts on Forestry

Sappi Southern Africa's forestry assets are mostly situated on the Eastern Seaboard of South Africa, below the escarpment. South Africa is predicted to become warmer and drier in the west of the country as a result of climate change, but the impact of rainfall in the east, however, is less clear. Large climatic models, such as the Hadley model (UK Met Office, 2007), are not detailed enough to take into account the nuances that a landscape feature such as the escarpment provides. Therefore it is not certain whether the eastern seaboard will become warmer and drier, or warmer and wetter. The scientific consensus seems to be emerging on the side of increased precipitation, but remains open to debate (Scholes, 2006).

In discussion with Scholes, two general scenarios were identified as being likely to be relevant to Sappi. Both involve a 5% increase in temperature. The Medium Scenario sees a 15% increase in precipitation, whilst the High Scenario sees a 15% decrease in precipitation. In both scenarios the variability of precipitation increases. In terms of tree growth, the Medium Scenario is very positive, whilst the High Scenario is very negative for Sappi. With regard to fire and pests in Sappi's plantations, the Medium Scenario is likely to result in a 15% increase in the incidence of new pest varieties, but no increase

in wildfires. The High Scenario sees a 20% increase in wildfires, but no impact on pest varieties.

The fair value of Sappi's land assets is determined quarterly, with any impairments or positive adjustment being reflected as expenses or revenues in the income statement. This can have a major impact on earnings, as was demonstrated in the third quarter of 2006, when Sappi Forest Products incurred a downward fair value adjustment of \$22 million, contributing 35% of their headline loss of \$0.2 per share in that year. This impairment was a result of changes in the mark-to-market energy costs of bringing wood to market over their entire plantation investment (Sappi, 2006). The impact of climate change on Sappi's forestry assets through yield, fire or pest damage will show immediately as an impact on earnings through the same mechanism.

Sappi's plantations and additional land holdings also present a unique opportunity as a result of climate change, that of sequestering carbon (see page 76 of this study). There are however significant restrictions on what the company can claim in terms of sequestered carbon and under what circumstances. The land use change and forestry sector is singled out as having significant uncertainty surrounding its CO₂ data (Baumert et al, 2005).

Increased risk from fires and pests

Sappi is constantly undertaking research and development into different tree varieties, both for their ability to yield a higher 'mean annual increment' of fibre per tree, and for their resistance to pests and fire. Sappi treats fires as an operational risk, and self-insures their plantations as a global portfolio. Fire watching and response mechanisms are built into Sappi's day-to-day operations and a coding system of alert has been devised. Whilst a trended increase in fires has been noted over the past few years, it is still unclear whether this trend is long term. The scientific community's findings of a likelihood of increased precipitation (the Medium Scenario) would tend to suggest that fires are less likely to be a significant risk going forward. The Medium Scenario does, however, show an increase in the threat of pests. Monitoring pests and developing mitigation strategies through breeding and organic controls is a key part of Sappi's forestry operations currently.

Sappi therefore remains at risk by the threat of a serious fire or pest outbreak, and both are potential occurrences as a result of climate change. Either would result in an immediate negative impact on earnings.

Decreased value of land assets

Apart from the threat of fire and pests, Sappi's land assets are also vulnerable to a change in climatic conditions reducing fibre growth, or from once off extreme events which would severely disrupt and damage plantations.

Sappi's plantations, whilst predominantly located in warm equatorial climatic conditions, are also situated in other areas with distinctly different climates. Sappi is therefore routinely investigating and breeding for a matrix of climatic types, which means it will be able to adapt fairly easily should climatic conditions change. The timeframe of climate change gives Sappi a degree of lead time in which to respond by changing their planting pattern, and they are closely monitoring and responding to these changes on an ongoing basis. However, only 16% of South Africa's surface is climatically suitable for plantation forestry (Van der Zel, (1989) as cited in Chamberlain et al, 2005), so intense climate change does still pose a threat.

Sappi's land could theoretically appreciate in value should climatic changes render it suitable for a more lucrative land use than plantation forestry. For this to happen in reality would require a change in demand for the alternative use. For example, the farming of exotic fruits such as papayas is determined more by economic signals such as the increase in demand for fruits, rather than by availability of land. Small areas of land may be converted, but it is doubted that this could happen to a large extent. Changes in land use are also a ten year irreversible decision, which has implications for the decision making process.

Climate science points to an additional source of value for forestry assets. Increased volumes of CO₂ in the air could result in increased growth of plantations. The scientific community has not reached consensus about this, although changing species and varieties may indeed be able to realize some of this benefit.

Should climate change progress to a stage at which plantation land in close proximity to Sappi's mills becomes unviable, this could significantly impact Sappi's earnings potential. Transport costs are critical in the cost of fibre arriving at the mill, and increasing the distance between the mill and plantation could strand many of Sappi's mill assets. Currently however there is no evidence of this being likely. Forestry remains viable in all the mid-range Intergovernmental Panel on Climate Change (IPCC) scenarios (Scholes, 2006).

Water scarcity will impact the growth rate and fibre yields of Sappi's plantation, but again this is something that Sappi envisages being able to respond to through its breeding programmes. However in a scenario as extreme as the High Scenario, water scarcity would result in a more than linear scaling back of both planted area and tree production, i.e. greater than 15%. The Medium Scenario would result in an increase in tree growth and yield, resulting in a stylized 15 – 20% increase in production.

Sappi is charged a water licence for forestry resource management, but at a total of R6 million for the entire South African forestry sector, this charge is not material; forestry only uses up 6% of South Africa's water resource (Vawda, 2006). In addition, the industry has negotiated a cap on the charge of R10 per cubic litre. Given the tree type and conditions upon which this cap is based, Sappi would not exceed the cap even under extreme water scarcity such as depicted in the High Scenario.

Sappi acknowledges that the biggest risk to its plantations is once-off extreme events such as prolonged frosts, or three consecutive El Nino years whose frequency is predicted to increase as a result of climate change (CDP, 2005). Plants respond to very subtle changes in their environment, so even the smallest climatic change could put Sappi's plantations at risk. The scenarios described in the section above will both result in large and dramatic changes in plantation growth, given the subtlety of plant's response mechanisms. Currently Sappi is unable to prepare for these, given the uncertainty surrounding what could occur, and when.

Opportunities to enhance cash flow from carbon sequestration

One way of reducing atmospheric carbon is to sequester it in vegetation, or 'carbon sinks'. Opportunities for forestry companies to sequester carbon are less obvious than

it immediately appears. Well managed plantations will tend to have a stable carbon balance, meaning that no additional carbon is sequestered over time.

Where forestry companies may be able to claim sequestration credits in their normal activities is in land set aside for conservation reasons (Weyenhauser, Stora Enso and International Paper responses to CDP, 2005). This tends to be small compared to the total hectares covered in plantations. Sappi has 25,000 hectares of land which is classified as areas of High Conservation Value, out of approximately 130,000 which are not dedicated to plantations. The company aims to keep the High Conservation Value land as natural as possible, so doubts there is potential for carbon sequestration on this land. They haven't considered the potential for carbon sequestration of the remaining 105,000 hectares.

However, if plantations are not felled as normal, but allowed to remain standing for the long term they could capture atmospheric carbon and claim carbon credits for this for a period of between five and ten years as the plantation grows to maturity. Given Sappi South Africa's 250,000 hectares of plantations, and an upper limit of 37 tonnes of CO₂ sequestered per hectare, the total carbon sequestered per year by Sappi's plantations (assuming no felling occurred) would therefore be in the region of 9.25 million tonnes. At a carbon price of \$10, this represents a revenue stream of \$92.5 million per annum, with R2 million initial methodology costs and R1 million per year in monitoring and verification (Everard and Morris, 2006). Using a discount rate of 9%, the WACC Sappi uses in asset valuation (Hawkes, 2006), the NPV of plantations for sequestration is \$585.22 million as opposed to the fair value of Sappi's plantations reported in 2005 (Sappi, 2005) of \$604 million as inputs to the manufacture of pulp and paper. The analysis shows that on paper the value of the plantations is relatively similar under current forecasts regarding the paper and carbon prices. However there are a number of important caveats to this analysis.

Setting plantations aside for sequestration would obviously encompass a change in business strategy, and would not be eligible under the CDM for reasons of additionality. When negotiating the Kyoto Protocol, Annex B countries had to decide up front whether to include their forest reserves under their national targets (Schoene and Netto, 2005).

A strategy of carbon sequestration would therefore only be eligible if South Africa elected to include their forests under a future national cap.

Claiming carbon has been sequestered is extremely complex methodologically, and subject to the policy conditions described in the previous paragraph. There is also a lot still to be done on the eligibility of various types of vegetation, including biomass in soil. In the CDM, sequestration projects have therefore taken a lot longer than emission reduction projects to develop. At this point only three sequestration methodologies have been approved by the Methodology Panel (www.unfccc.int), with eleven in the pipeline. Given these issues, credits from carbon sequestration, or 'sinks', are not currently eligible in the EU ETS, and certain Annex B countries have a policy of not using sink credits to meet their Kyoto targets.

The length of time the carbon remains sequestered for, termed the 'permanence issue' is also controversial. After the ten year period of growth and sequestration, the plantations would require ongoing management to ensure that the carbon remains sequestered. How this would be done remains a significant outstanding issue, and would mean then that the plantation asset has a finite life of ten years, as opposed to the life of a plantation for paper production which is far longer.

The assumptions of being able to claim the full tonnage of carbon sequestered for ten years at a price of \$10 per tonne under a future (non-CDM) international climate change policy environment as envisaged under the previous analysis are therefore highly speculative.

Yet this step change in conventional understanding of the business value of a plantation is not unprecedented. Schoene and Netto (2005) refer to the change brought about in forestry in Western Europe as a result of the discovery and use of coal. Whereas initially forests were focused on producing charcoal, this focus changed to that of timber once the use of charcoal was superseded. This change called for different tree varieties, rotations and planting practises. Schoene et al (1999 as cited in 2005) suggests "Interest in carbon sequestration could generate a new shift; some native, high-density hardwoods may sequester as much carbon as some introduced, fast-growing but low-density softwoods, and for a longer time". Therefore whilst setting aside a plantation for

carbon sequestration in its entirety may be extreme, incorporation of plantation planting, varieties and management practices aimed at maximising carbon sequestration may yet be able to earn Sappi carbon credits.

Sappi does not currently calculate the volume of carbon sequestered in its plantations. It is keeping a watching brief on international policy to see to what extent carbon sequestration is eligible as the international policy rules develop.

6.3. Real Options Analysis of Climate Change Impacts on Sappi's Value

Using a real options framework, the seven climate change impacts can be described as providing Sappi with a portfolio of options, existing and potential, which the company can monitor and exercise when further information relating to climate change regulation and science becomes available. Some of these options can avoid costly and incorrect investment decisions, other involve opportunities to move into new product and process areas, taking advantage of the changing economic environment. Each option is related to a certain asset, market niche or process owned by Sappi.

6.3.1. Sappi's Portfolio of Climate Change Related Real Options

Sappi owns a number of options to switch from a high emissions activity, process or product to a less emissions intensive one. For example, the company can switch from using coal and grid electricity to using additional biomass fired energy, or from truck to rail transport, or from petrol to bio fuels. It can use more waste paper instead of virgin pulp as a source of fibre, or it could switch its primary product, coated paper, to one which is less refined or less reliant on chemical usage. Further switching options can be created by the company by ensuring that all new capital expenditure has the capability to run off renewable fuels as well as fossil fuels, and accept both virgin pulp and recycled paper. The additional cost of installing the flexible technology can be viewed as the cost of the option to switch in the future, thereby preventing Sappi being stuck with stranded assets in the face of a sharp rise in input costs as a result of climate change.

By virtue of its vertical integration with the forestry and pulp sector, Sappi owns the option to expand its operations to export renewable energy to the grid should the demand for renewable energy warrant this in the future. In a world of high fossil fuel

energy costs, and strong consumer awareness of climate change issues, Sappi's ability to generate renewable energy presents an additional potential revenue stream to the company, together with a means to reduce the company's own exposure to carbon regulation. Similarly, the CDM creates options within Sappi's operations to develop CDM projects and gain access to revenues from CERs.

Sappi can also consider its water supply from an options perspective. The option to delay building additional water infrastructure until such a time when the extent of future water scarcity is better known, may prevent a costly over- or under- investment. An opportunity cost is associated with this option in the form of higher short term water prices as Sappi utilises the government water infrastructure in the interim. Real options technique can incorporate this complexity into an options valuation. Similarly, Sappi has the option to delay the installation of energy efficient and renewable energy equipment until such a time when the extent of the electricity and fossil fuel price increase is better known. This option also buys Sappi time whilst energy efficiency and renewable energy technology matures.

On the forestry side, Sappi can create an option to mitigate the risk of a once-off extreme weather event impairing the asset value of its plantations by taking out insurance, potentially in the form of weather derivatives. The cost of the insurance is the cost of the option to mitigate the risk. Under current climate change forecasts the value of this option is likely to increase as the unpredictability and frequency of these events increase.

Sappi has already created the option to switch tree varieties in response to climate change impacts by virtue of their breeding programmes. This option will also prevent stranded assets as climatic changes render the growth of certain varieties unfeasible.

In the face of extreme climatic change Sappi has the option to abandon and sell impaired land assets, the cost of exercising the option (abandoning the land) representing the mitigated loss. A corresponding opportunity is the option that Sappi has to acquire land assets in more favourable climatic zones, or to switch their land use to one offering higher value than plantation forestry, or to sequestration. The value of the option reflects the ability Sappi has to wait and see which side the scientific debate

comes out on (either the Medium or the High Scenario), and whether increased CO₂ levels in the atmosphere stimulates fibre growth or not.

Awareness of the options described above should influence Sappi's capital budgeting and strategic decision making processes. Creating and maintaining valuable options relating to climate change will become increasingly important for the company as climate change awareness and impacts increase, enabling it to respond optimally as uncertainties are resolved.

However, in order to fully realise the value of the options perspective, each option should be quantitatively valued. These values will provide information on the relative importance of the options, and their magnitude relative to the value of Sappi's business units and group as a whole. Options valuation can also provide direction as to the optimal timing for exercising each option.

6.3.2. Choice of the Real Option Problem

Given time and data constraints, only one of the real options in Sappi's portfolio was valued. In order to value a real option, the underlying asset needs to be sufficiently well defined, and a certain level of data must be available. The pilot CDM project being developed at the Tugela mill has been well defined by Sappi and their CDM consultants both in terms of the technology, logistics and cost, and as such presented an accessible example for the application of the real options valuation technique. The CDM has strategic implications for Sappi, as it implies investment in less emissions-intensive processes across the company's operations, and can be used to position the company with regard to its reputation and expertise in climate change mitigation.

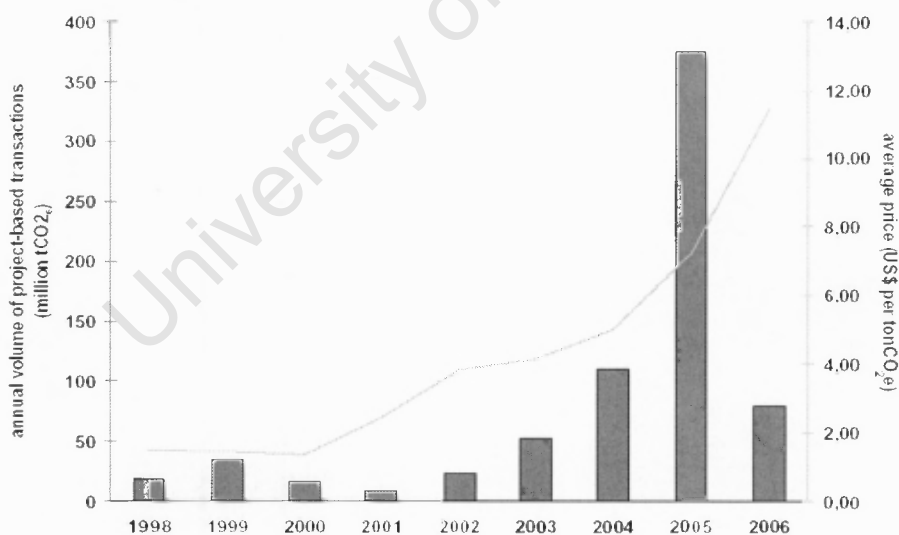
6.3.3. Describing and Framing the Real Option Problem

The Tugela CDM project involves the conversion of a pure coal boiler to a co-fired thermal boiler burning a mix of coal and bark. The boiler generates 227,000 tonnes of steam energy per annum, using a combination of 70,000 tonnes of biomass and 3,800 tonnes of coal. Through the CDM it also generates 55,912 tonnes of emissions allowances, termed Certified Emission Reductions (CERs), per year by replacing fossil fuel energy with biomass energy, over a ten year project crediting lifetime.

Firstly, a DCF analysis was undertaken as input into the real options analysis. Key inputs and assumptions used in the analysis are described below. Additional inputs are included with the actual DCF analysis spreadsheet as Appendix A to this thesis.

- The retrofit will cost the company R27m in capital costs, and R336,000 per year in additional operating costs.
- The cost of developing and registering the CDM project is conservatively estimated to be R1 million (United Nations Development Programme (UNDP), 2006). Ongoing costs of validating and issuing the carbon credits are anticipated to be in the region of R328,000 per year (UNDP, 2006).
- It is assumed that the project is implemented in 2007. A current CER price of \$10 is assumed up until the end of the Kyoto First Commitment Period in 2012, based on the World Bank analysis (Ambrosi and Kapoor, 2006) demonstrated graphically in Figure 6.7 below. In the DCF analysis CERs generated post 2012 are assumed to be subject to a discounted price of \$2 given policy uncertainty after this point.

Figure 6.7 Average Project Based Carbon Credit Prices (up to 2012 vintages)



Source: World Bank, 2006.

The DCF value of the Tugela CDM project is R31.9 million, and it has a payback period of 2.7 years. Sappi's investment decision hurdle rate is generally that of a payback

period of three years or less. However, in April 2006 the company's management imposed a capital freeze owing to a run of poor performance (Sappi, 2006), and maximum one year payback for all projects not prescribed by regulation. Under this investment decision hurdle rate, the Tugela CDM project would not be allocated capital by Sappi.

There are a number of circumstances however which would render this project more valuable to the company. Examples of these are i) if fossil fuel energy prices rose significantly in the future on the back of carbon constraints, ii) if carbon prices rise significantly in the future, iii) if the CDM was ensured of a life past 2012, or iv) if the cost of developing a CDM project was reduced. Carbon credits are denominated in dollars or euros, rendering them particularly attractive revenue streams should the rand exchange rate depreciate.

By owning the exclusive right to undertake this project at the Tugela mill anytime before 2012, Sappi owns an *option to delay* implementing the project until such a time that circumstances are more favourable. By not being forced to implement the project now, Sappi does not expose itself to the downside risk inherent in the uncertainty surrounding the carbon and energy prices determining the project's value. The total value of the project to Sappi today therefore consists not only of the R31.9 million NPV calculated from the DCF, but also the NPV of the option.

6.3.4. Valuation of the Option to Delay

A number of parameters describe the binomial lattice used to value the option:

Time Steps

A time step of one year for each node was chosen, consistent with annual crediting of emission reductions from the project: $\delta t = 1$.

Option Timeframe

The time period for which the option is valid is assumed to be five years from the beginning of 2007 until the end of 2011, whereafter it expires and has no further value. This period has been chosen given the Kyoto policy uncertainty post 2012, and it has been assumed that no new CDM projects will be able to register after this point. A CDM

project of the nature of the Tugela will take at least a year to register after the decision has been made to develop the project under the CDM. Other factors which support the choice of five years option lifetime are issues of technological maturation and best practice additionality under the CDM. Therefore, after 2011 it is assumed that Sappi will no longer be able to register the CDM project before the end of 2012 and the option expires worthless. The option to delay is defined as an American call option, as it can be exercised at any point between 2007 and the option expiry date of end 2011.

Uncertainty

Only the uncertainty and volatility inherent in CER prices was considered. Other sources of uncertainty in the project such as the cost of fossil fuels or the CER transaction costs were ignored for reasons of lack of data availability. Therefore the NPV of the CER revenue stream is modelled as the underlying asset, as opposed to the NPV of the CDM project. This simplification is not held to compromise the case study results. Including additional uncertainties would only serve to increase the option value and strengthen the conclusions.

Post 2012 uncertainty around CER prices is assumed to be incorporated into the CER price volatility factor. An alternative treatment of this once-off uncertainty is the use of step changes in real options analysis. This technique has been used in a study undertaken by the IEA (2006). The uncertainty of international climate policy post 2012 is interpreted as being a price shock, a discrete jump in price at some known time in the future, and incorporated as such into real options models for valuing the impact of climate change policy uncertainty on the power generating sector. This approach is perhaps more appropriate than the random walk approach taken by the present study for some of the uncertainties relating to climate change impacts. Including this modelling technique would have increased the sophistication of the real option analysis, and improved the robustness of the results. The random walk approach was used in order to keep the valuation simple and transparent.

Volatility Estimate

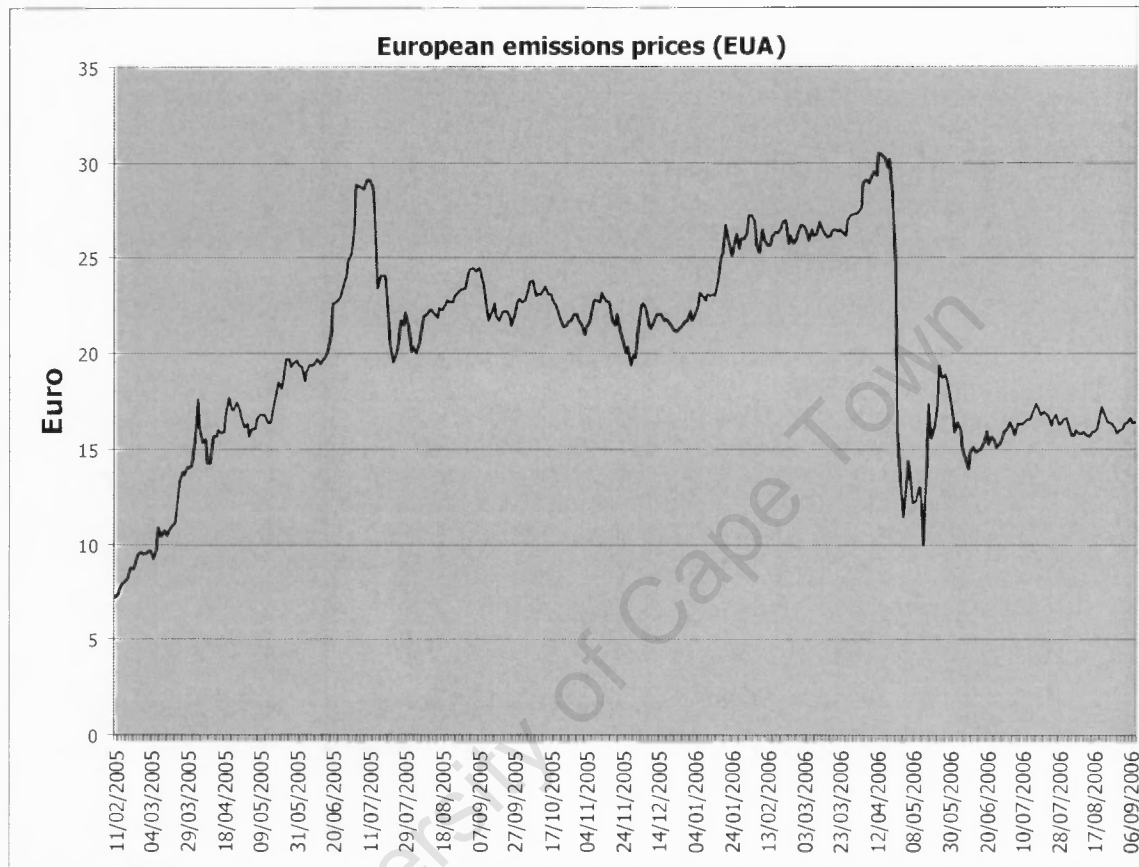
The volatility or uncertainty of the price of CERs is represented by sigma; $\sigma = 56.5\%$. Historical data has been used to estimate this volatility. Whilst using forward looking prices may have been more appropriate, futures prices for the carbon market are not yet

available, and forecasts give wide-ranging and incomparable prices due to the difference in the assumptions upon which they are based. The data set used is that of EU ETS prices from 11/02/05 to 06/09/06, sourced from Reuters (Reuters, 2006). EU ETS prices are used in lieu of CER prices for a number of reasons. Firstly, the price of CERs is subject to very low transparency in that it is contract and project specific, and seldom disclosed. Secondly, whilst there is currently a spread between CER and EU ETS prices, Emission Reduction Purchase Agreements increasingly link CER prices to that of the EU Emission Trading Scheme price, suggesting that the volatility of the two units is comparable. Thirdly, once a CER has been issued, subject to an outstanding technicality presented by the requirements of the International Transaction Log (United Nations Framework Convention on Climate Change, 1997), a CER is theoretically fully fungible with an EU ETS unit.

The rule of thumb for the number of historical data observations required for estimating volatility is that of the number of days to which volatility should be applied. In this case, five years worth of trading days (252 days per annum) gives 1260 observations. Unfortunately, data is only available for 395 observations given that the EU ETS only began in 2005. This is recognised as being sub-optimal, and a limitation of this analysis. Time is measured in trading days as opposed to calendar days, as this has been found to be the appropriate measurement for volatility calculations (Hull, 2003).

A graph of the data is shown in Figure 6.8 below, demonstrating the data's volatility graphically.

Figure 6.8. Historical EU ETS Prices



Source: Reuters, 2006

What is clearly evident from the diagram above is the break in the data in April 2006. This was a result of a market correction, and a data smoothing technique has been used to account for this. The average volatility is taken from the set of one month annualised volatility estimates, to arrive at $\sigma=56.6\%$. The volatility of the un-smoothed data set is significantly higher at 75.7%.

Up and Down Factors

Recalling equations [1] and [2],

$$u = e^{\sigma \sqrt{\delta t}} \quad [1]$$

$$d = \frac{1}{e^{\sigma \sqrt{\delta t}}} \quad [2]$$

the up and down factors are calculated as 1.76 and 0.57 respectively.

The Risk Free Rate

$rf = 8.5\%$. Sappi uses a 10 year yield curve on debt, the R201's current yield (www.fin24.co.za; 20/09/2006) is used as their risk free rate (Hawkes, 2006).

Probability Factor

Recalling equation [4],

$$p = \frac{[(e^{\sigma \sqrt{\delta t}})^{rf} - e^{-\sigma \sqrt{\delta t}}]}{(e^{\sigma \sqrt{\delta t}} - e^{-\sigma \sqrt{\delta t}})}$$

The probability factor is calculated as 0.404.

Decision Rule

Sappi will exercise the option, or implement the CDM project, when the project is paid back within a year. Assuming all other variables are constant, this will occur when the NPV of the CER revenue stream is R158.8 million, using the DCF analysis in Appendix A. Therefore when the value of the CER revenue stream is greater than, or equal to this amount, it is assumed that Sappi would decide to implement the CDM project.

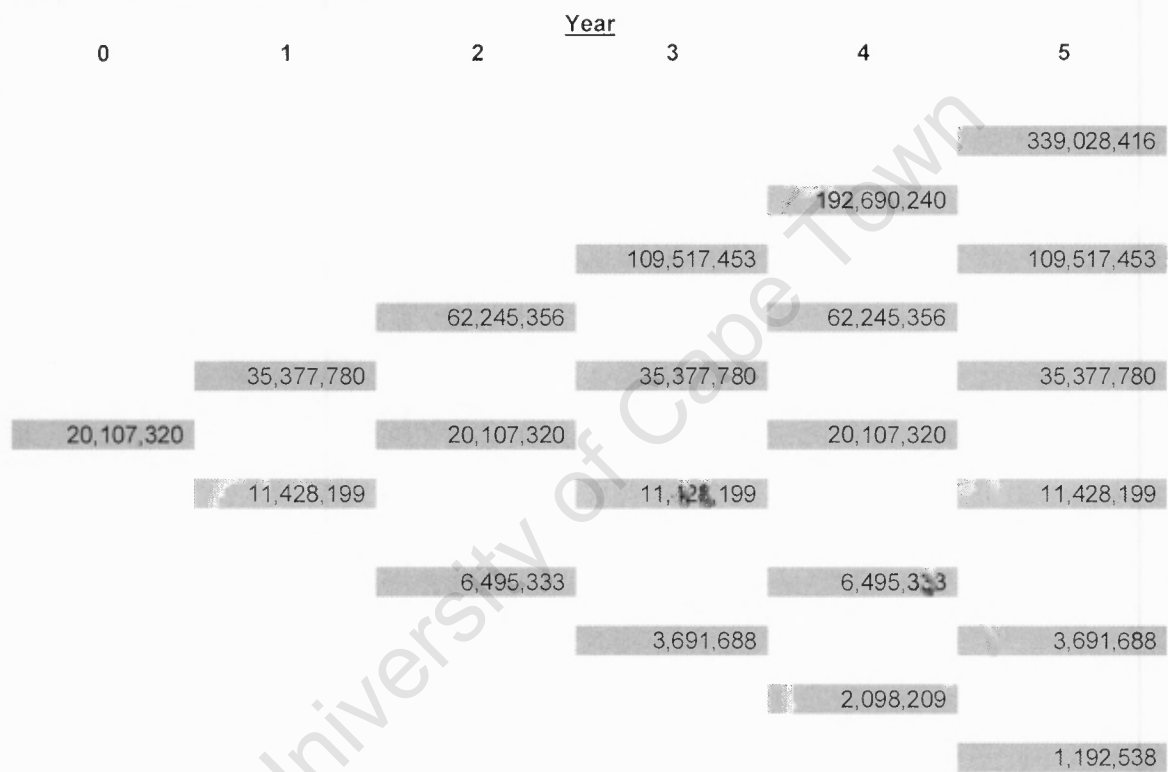
Cost of Exercising the Option

The cost of exercising the option is the cost of developing the Tugela CDM project. This cost is R28.04 million, comprising the capital expenditure plus the upfront CDM costs.

Using these inputs, the binomial lattice of the underlying asset, the CER revenue stream, is derived.

The R20.1 million value in year 0 is the NPV of the CER revenue stream calculated as part of the DCF analysis. Multiplying this by the up and down factors results in the two nodes at year one, and so on until the lattice is fully described by year five.

Figure 6.9. Binomial Lattice of the CER Revenue to the Project over Five Years in Rands



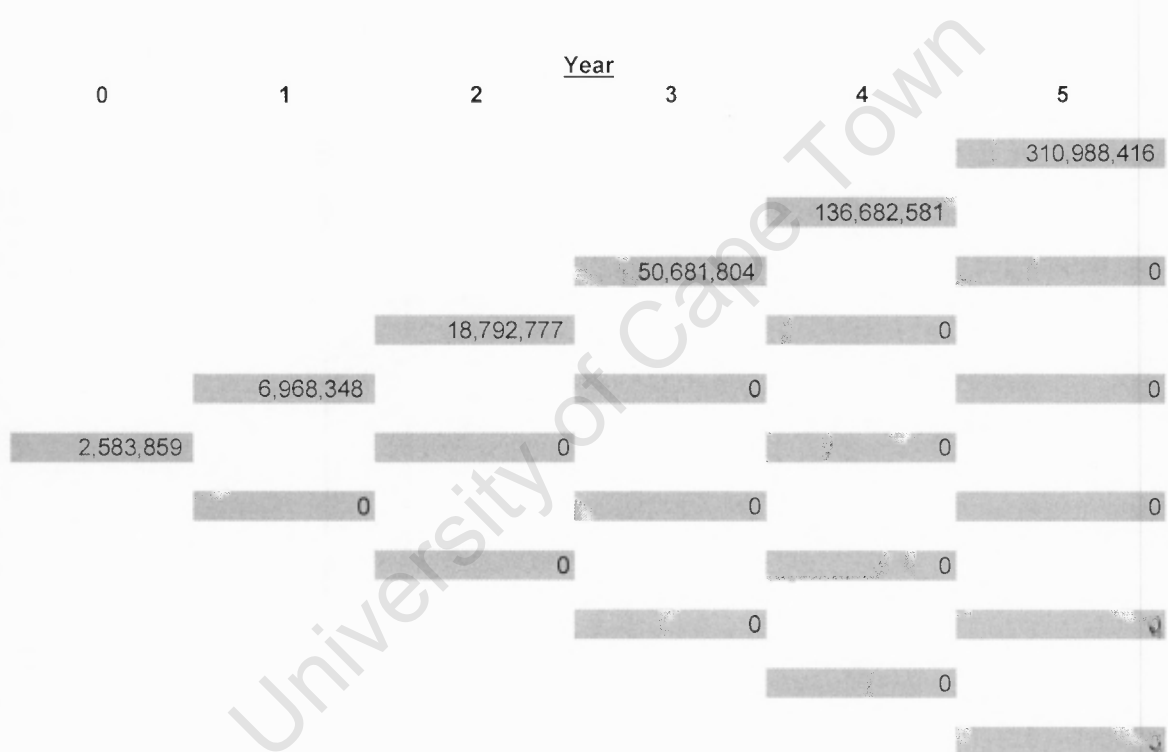
Using the backward induction technique, the end nodes of the lattice in Figure 6.9 above less the cost of exercising the option (R28.04 million) are compared to the R158.8 million decision parameter. Only the top right hand node compares favourably. Sappi would therefore decide to exercise the option at this point, and realise the value of R339 – R28.04 = R310.9 as depicted in Figure 6.10 below. The decision at the other four end nodes would be to let the option expire unexercised, and therefore worthless.

The intermediate nodes are then considered using the backward induction technique, and risk-free probability analysis. The intermediate node value is defined by equation [3] below:

$$\text{Intermediate Value} = [p(e^{\sigma \sqrt{\delta t}}) + (1-p) e^{-\sigma \sqrt{\delta t}}] e^{-rf(\delta t)} \quad [3]$$

Applying equation [1] to the intermediate nodes completes the option value lattice.

Figure 6.10. Option Valuation Lattice



The value of the option in year 0 is therefore R2.6 million in NPV terms.

6.3.5. Interpreting the Results of the Valuation

The option to delay the Tugela CDM project is worth R2.6 million to Sappi. This option value is best interpreted as additional value embedded in the Tugela boiler and Sappi's managerial ability to design and implement a CDM project.

In this case, the option value is relatively low compared to the current value of the DCF analysis, and to the upfront cost of exercising the option of R28 million. This value provides a realistic understanding of the financial opportunity this CDM project offers over a longer investment valuation timeframe.

One of the main reasons for the low value is that the carbon revenue generated by this project represents a small portion of the overall returns to the project, and therefore is not a primary driver of the project's value. This will not necessarily be the case for other CDM projects. Given the CDM's additionality requirement, theoretically the CER value should drive the project's value. This has interesting implications for a company's prioritizing of CDM projects, and too for the methods used to argue and prove additionality. Understanding the options relating to all nineteen of Sappi's potential CDM projects will provide management with insight regarding their relative value under different future scenarios. This insight will be useful in prioritising the implementation of the different projects, and ensuring that those with particularly high options value yet low DCF values are not discarded.

A second reason for the low value of the option is that the valuation holds all sources of uncertainty apart from the CER price constant. By incorporating the additional volatilities and uncertainty of future fossil fuel prices, demand for renewable energy, the costs of the CDM, and other climate change impacts, the option value would theoretically be anticipated to increase. This is fairly straightforward to value by using Monte Carlo simulation to assess the NPV of a DCF analysis, and incorporating the sum of the additional volatilities. The underlying asset would then be the CDM project value as an entity.

Should Sappi upgrade the boiler using coal specific technology, it will lose the option relating to the CDM project. The option value should be considered in addition to the DCF value of the retrofit when comparing this project against alternatives in a capital budgeting exercise. This option value, and others like it, are therefore an important component of all strategic decisions relating to the Tugela mill.

An option to delay is only valuable if it more than offsets any harm that may come from delaying the project's implementation. For reasons of simplicity, this analysis has not

incorporated any negative financial implications of delaying the boiler retrofit. These should however be considered for a more accurate option valuation.

The CDM presents an opportunity and incentive for developing countries to benefit financially from reducing emissions under the Kyoto Protocol; it does not include any obligations on emitting entities in these countries. Therefore delaying the project does not hold any regulatory penalties. However, it could be argued that the environmental costs of delaying the boiler retrofit far outweigh the financial value of delaying to Sappi. It could also be argued that Sappi should not apply its usual investment hurdle rates to projects which have an environmental benefit. Both these arguments require the incorporation of an 'environmental good' value into investment analysis, beyond that currently occurring through the existence of a carbon price.

6.4 Discussion of the Case Study Findings

As stated previously, the objective of this research is: *"To assess the potential of the real options approach in enhancing the understanding of the impact of climate change on company value"*

Real options analysis of the climate change impacts on Sappi has revealed sources of value in the form of options which are overlooked by DCF and other traditional financial valuation measures. The existence and value of these options has important implications for the strategic and capital budgeting processes within the company. For example, should Sappi need to dispose of one of two similar mills, knowing that the first has a valuable climate change related option embedded in it may inform the decision in favour of disposing of the second. Faced with installing two different types of technology, Sappi may choose to invest in the one which is more expensive in that it creates a valuable option related to potential climate change regulation in the future.

A real options approach has also been shown to help Sappi identify areas where they can create valuable options to hedge against climate change uncertainty. The greater the number and value of Sappi's options, the better the company is positioned to grasp opportunities and mitigate the losses climate change presents.

Understanding the climate-change-related options embedded in Sappi's assets provides additional information to analysts wishing to assess the future fortunes of the company, particularly with regard to climate change. A company with a greater number of more valuable options will survive the transition to a low carbon economy better than one with fewer, less valuable options.

However, real options analysis has its considerable limitations. The methodology and mathematical rigor supporting real options analysis is still maturing and remains complex and involved. This reduces its appeal to practitioners, particularly if climate change is not given high priority by management.

The data required for real options analysis is equal to, if not greater than that required for DCF. Limitations on data availability are noted as being particularly relevant for the impacts of climate change on the pulp and paper industry internationally (Baumert et al, 2005; Austin and Repetto, 2000). Sappi's situation in a developing country exacerbates this, as an awareness of environmental issues and their regulation has historically been behind that of the developed world.

Real options valuation requires accurate volatility estimates. Whilst sufficient historical data is not currently available for a satisfactorily robust analysis, the trend towards market mechanisms to regulate greenhouse gas emissions increases the likelihood of these being available in the future, as well as scientific estimation of the likely physical impacts from climate change.

Whilst the application of real options analysis to climate change opportunities is intuitively fairly easy to grasp, the accurate framing and valuation of negative real options is more complex, and requires further work to confirm the application.

Despite these limitations, this research has shown that real options analysis enhances the understanding of the impact of climate change on company value in the case of Sappi's South African operations. Using a process of analytical generalisation, it is suggested that the real options approach could similarly enhance the understanding of climate change impacts on company value in general, and further research is encouraged to test this. This study's findings suggest further that a real options

approach may be especially appropriate for companies with operations in South Africa and other non-Kyoto Annex B countries, given the additional climate change regulatory uncertainty of these countries. The approach may also be particularly applicable to sectors such as pulp and paper, which have highly volatile value drivers and therefore greater uncertainty around future cash flows even in the absence of climate change, rendering techniques such as DCF less valuable. Further research is required to confirm this.

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Chapter Seven: Conclusions and Areas for Future Research

Climate change is one of the greatest challenges facing humankind today, threatening our continued existence on this planet. The impacts of climate change are wide-ranging, and subject to complex feedback loops. There is, therefore, a great deal of uncertainty surrounding the evolution of the threat, and correspondingly the international and local policy response. This uncertainty is demonstrated through the large ranges given by scientific and economic reports forecasting a temperature rise of between 1.4 and 5.8 degrees Celsius (IPCC, 2001), and global value at risk between \$192 and \$915 billion (Gars and Volk, 2003).

The impact of climate change on company value is material, strategically important and again, highly uncertain. The mechanisms through which climate change impacts are translated into value impacts are also wide-ranging and complex. Different sectors will be impacted to greater and lesser degrees, and individual companies within these sectors have been shown to fare very differently according to their location, traditional sources of competitive advantage, existing asset portfolio and management capabilities.

As such, climate change presents companies with a 'strategic dilemma' (Kolk and Pinkse, 2005), and the impact of climate change needs to be incorporated into strategic analysis and planning. The financial community is therefore challenged to provide financial valuation analysis which will support the consideration of climate change from a strategic perspective. Both investors and company managers need to be able to assess the value implications of climate change.

A literature review of techniques used to assess the impact of climate change on company value finds that these techniques, predominantly based on the Discounted Cash Flow (DCF) analysis, demonstrate shortcomings relating to their treatment of uncertainty and management flexibility. Most often, uncertainty is incorporated through the use of probability weighted scenario analysis, with the outputs being expressed as a range of possible net present values. Scenario analysis is limited in its treatment of

uncertainty in that it is a static analysis, unable to incorporate management flexibility in response to changing circumstances.

The strategic implications of climate change are also not well catered for by DCF analysis. Whilst some of the studies do consider and put a value to a company's strategic ability to optimize their response to climate change, this is again from a static perspective. The results are argued to be of little assistance to companies wishing to gain insight into the ongoing strategic management of the climate change issue. These shortcomings therefore result in the studies potentially missing out on key sources of value.

In contrast to the DCF based techniques used to date, the emerging technique of real options analysis takes a proactive, dynamic approach to uncertainty, and assumes a flexible management able to consider the arrival of new information and learn accordingly. Real options analysis therefore also has particular application to strategic investment decisions. As such, the technique demonstrates an ability to address the shortcomings associated with the more traditional valuation approaches when used to value climate change impacts.

The appropriateness of the use of the real options approach is further strengthened through the availability of a carbon price, given the use of market mechanisms in climate policy. Market pricing is advantageous in the estimation of a volatility measure required for the solution of real option problems. Climate change is associated with a long timeframe, with uncertainties taking many decades to resolve. This characteristic is again congruent with options thinking, where the greater the time until the option expires, the more valuable the option is likely to be. Finally, the high level of climate change risk and uncertainty again increases the value of associated options. Converse to most financial thinking, from a real options perspective risk increases value.

The application of real options valuation to climate change impacts is tested in a case study on Sappi Ltd, a South African pulp and paper company. Sappi is found to be exposed to seven material climate change impacts: increases in operating costs due to higher energy prices, exposure to national carbon emissions regulations, opportunities in biomass-based power production and bio fuels, possible opportunities to enhance cash

flow from carbon sequestration, increased risk from fire and pest problems, decreased value of land assets due to climatic extremes, and the scarcity of water for milling operations. Due to the uncertainty of the extent, and in some cases direction of these impacts, determining the implications for Sappi's value using DCF based techniques becomes relatively meaningless.

Using a real options approach, Sappi can be described as having a portfolio of options arising from these seven climate change impacts. For example, Sappi can delay the installation of energy efficient equipment in response to an expected rise in the energy price (an *option to delay*), or it owns an *option to switch* to biomass generated energy to avoid carbon taxes on the use of fossil fuels. Sappi has an *option to expand* its recycling of waste paper in order to reduce its reliance on plantations hit by extreme weather events, or an *option to scope up*, selling biomass generated electricity onto the grid as demand for green electricity escalates. The flexibility these options represent is a source of value to the company, as the company can avoid costly investment mistakes, and optimise investment timing as uncertainties are resolved. The greater the number of options, and the more valuable these options are, the better the company is positioned to take advantage of climate change opportunities, and mitigate its climate change risks. Sappi can create additional options through installing technologies which enable a switch to lower emission processes, or by purchasing additional assets which give it access to potential future low emission product markets.

Real options can be quantitatively valued, giving an indication of the size of their value to a company, useful for capital budgeting and strategic decision making processes. The valuation of an option to delay Sappi's Tugela Clean Development Mechanism (CDM) project revealed that this option is worth R2.8 million to Sappi. The Tugela project involves converting a coal fired boiler to use biomass as an additional fuel.

The value of the option indicates to management whether it is strategically important to maintain the option, and gives an indication of the ability of the project to return value to the company in the future. R2.8 million is not a particularly high value relative to either the cost of exercising the option (R28 million) or the net present value of the project as calculated by a DCF analysis (R31.9 million), and suggests therefore that it may not be important to maintain this option. This has implications should Sappi have to choose

between upgrading the boiler conventionally and converting it. In the former, the company loses its delay option on the CDM project. Undertaking a valuation of the options embedded in the rest of Sappi's climate change option portfolio is likely to reveal similar insights about various assets.

Real options valuation technique enhances the understanding of climate change impacts on Sappi's value by identifying sources of value overlooked by traditional DCF analysis and other mainstream valuation techniques. A company with a greater number of more valuable options is likely to survive the transition to a low carbon economy better than one with fewer, less valuable options. This finding suggests that real options may then also provide insights into the impact of climate change on companies in general, and particularly those operating in Kyoto's non-Annex B countries, where climate change policy is subject to additional uncertainties. Further exploration and empirical testing is however required.

Similar exploratory case studies would usefully extend the findings of this research to other companies, sectors and countries, adding to the theory building process. In addition, issues around the application of real options to climate change impacts touched upon in these study present specific opportunities for continued investigation.

This study has undertaken a very limited valuation of the option to delay a CDM project, incorporating only one source of uncertainty that arises from the CDM, the CER price. Extending this analysis to incorporate additional sources of climate change uncertainty would increase the robustness of this research, and may provide further insights into the application of real options.

The work undertaken recently by the IEA (2006) on real options analysis in the energy sector included a step-change approach to modelling post -2012 policy uncertainty. This approach should be explored for inclusion in further real options analysis of climate change impacts, as it potentially presents a more realistic and accurate representation of this source of uncertainty.

Considering the application of real options valuation to the CDM specifically may assist in understanding the relative value of various CDM projects in a portfolio, and provide

insight to project developers regarding the timing of the sale of their CERs. It may also help project developers to gauge whether to proceed with the development of a new CDM methodology, or to wait until an applicable methodology has been registered by another party.

Whilst less clear from this research, real options valuation may provide insights into the concept of additionality under the CDM from a company financial perspective. The relationship between a value of an option dependent on the CER revenue of a project, and its additionality argument may warrant further exploration.

This study has suggested that real options analysis can be used to value the entire range of impacts of climate change on a company, through the valuation of its portfolio of real options arising from climate change. Further work is required to confirm this application of real options analysis, and to explore its implications for company valuations.

Real options analysis may not be equally useful to different companies and sectors. The high levels of uncertainty in the value drivers of the pulp and paper sector, together with the uncertainty inherent in the climate change impacts on Sappi confirmed the use of real options in this context. However, there are other sectors where more traditional valuation techniques may be more appropriate. Further work could usefully be undertaken to understand the conditions that determine where real options analysis might be appropriately applied.

Climate change impacts may create multiple options for one asset, or options whose value is inter-related. Financial options theory accommodates numerous types of 'exotic' options, some of which have been applied to options on real assets. An assessment of whether an analysis of exotic options relating to climate change is feasible or useful given the complexity of the methodology provides scope for further investigation.

The description of environmental issues as characteristically having an "unpredictable speed of issue evolution; [and] historical trends which do not provide clear guidance for the future" (Earle and Rhodes, 1995) is especially apt for climate change. Given its ability to transform our global economy from one driven by the economics and politics of

fossil fuel consumption into one which is carbon constrained, the development and application of new financial valuation techniques may well be appropriate. This study finds that real options analysis enhances the understanding of climate change impacts on Sappi Ltd, South Africa by valuing its ability to respond to climate change impacts as the issue evolves and uncertainties are resolved. These findings suggests that further exploration of the potential of real options analysis in understanding climate change impacts on companies in general may prove a rewarding area of research.

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Glossary

| | |
|------------------------|--|
| Annex B | <i>Terms used to refer to the countries who have taken on targets under the Kyoto Protocol.</i> |
| CAP | <i>Competitive Advantage Period</i> |
| CDM | <i>Clean Development Mechanism</i> |
| CDP | <i>Carbon Disclosure Project</i> |
| CERES | <i>Coalition for Environmentally Responsible Economies</i> |
| CERs | <i>Certified Emission Reductions</i> |
| CFO | <i>Chief Financial Officer</i> |
| CO₂ | <i>Carbon Dioxide</i> |
| CO₂e | <i>Carbon Dioxide Equivalent</i> |
| CSIR | <i>Council for Scientific and Industrial Research</i> |
| DCF | <i>Discounted Cash Flow</i> |
| EB | <i>United Nations CDM Executive Board</i> |
| EBIT | <i>Earnings before interest and tax</i> |
| ERPA | <i>Emissions Reduction Purchase Agreement</i> |
| EU ETS | <i>European Union Emissions Trading Scheme</i> |

| | |
|--------------------------------|---|
| EV | Enterprise Value |
| EV/EBITDA | Enterprise Value financial ratio |
| EVA | Economic Value Added |
| First Commitment Period | A Kyoto Protocol term used to describe the period between 2008 and 2012 during which Annex 1 countries have to demonstrate compliance with emission reduction targets. |
| GWP | Global Warming Potential |
| IPCC | Intergovernmental Panel on Climate Change |
| IRRC | Investor Responsibility Research Centre |
| Methodology Panel | Methodology Panel of the CDM Executive Board |
| MOP | Meeting of the Parties (to the Kyoto Protocol) |
| NPV | Net present value |
| OEM | Original Equipment Manufacturer |
| PDD | Project Design Document |
| PE | Price to earnings ratio |
| PE ratio | Price Earnings Ratio |
| ROIC | Return on invested capital |

| | |
|----------------|---|
| SAM | <i>Sustainable Asset Management</i> |
| SRI | <i>Socially Responsible Investing</i> |
| UNEP FI | <i>United Nations Environment Programme Finance Initiative</i> |
| UNFCCC | <i>United Nations Framework Convention on Climate Change</i> |
| WACC | <i>Weighted Average Cost of Capital</i> |
| WRI | <i>World Resources Institute</i> |
| WWF | <i>World Wildlife Fund</i> |

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Appendix A: Tugela CDM DCF Analysis

Additional Assumptions

- For purposes of the financial analysis, the project is described as a stand alone energy generator which 'sells' steam to the Tugela mill. Therefore internal transfer pricing has been used for the steam price.
- The costs saved from the reduction in coal use are included in the calculation of the value of steam produced, which is based on a cost to company of producing the steam from coal, and the fuel saving income line item.
- There are no savings on biomass landfill costs, as the bark used in the boiler would otherwise have been composted. The revenue which could have been gained from the composting has been included as an opportunity cost to the project. This is a conservative assumption.
- The WACC used by Sappi to evaluate assets (Hawkes, 2006) of 9% has been used.
- Avoided transport and landfill emissions have been excluded from the analysis for reasons of conservativeness.

Tugela CDM DCF Analysis : Inputs

| INPUTS | | SOURCE |
|--|---------------------|--|
| Annual carbon volume tCO2 | 55,912 | Sappi CDM calculations spreadsheets |
| Rand : Dollar exchange rate | | Absa first quarter 2007 forecast CPIX rate. |
| | 6.5 | http://www.finforum.co.za/absa_publications/financialmarkets/Currency%20and%20inflation%20forecasts.pdf |
| CDM Development up to and incl. CDM registration | \$160,000 | UNDP's assessment of progress with the CDM, May 2006, unpublished |
| Premium for first year verification | \$13,000 | as above |
| Annual Monitoring and report costs, annual | \$10,000 | as above |
| Annual verification | \$12,000 | as above |
| EB admin charges for first 15,000 credits per year | \$1,500 | UNFCCC CDM website, http://cdm.unfccc.int/ |
| EB admin charges for remaining credits per year | \$53,186 | UNFCCC CDM website |
| Adaptation Fund | R 72,686 | UNFCCC CDM website |
| CER price | \$10 | Uncertain Range |
| Tonnes steam produced | 227,000 | Tyrone Hawkes |
| Value of steam per tonne | R 54 | Sappi CDM calculations |
| Discount rate | 9% | Discount rate (Hawkes, in '2005 Kraft bp2005a.xls'), as it is assumed that Sappi will finance the project on-balance sheet. |
| Fuel savings | as per NPV analysis | Sappi analysis (Hawkes, 2006). |
| Cost of coal | R 330 | Henry Coppens, telephone communication |
| Tonnes of coal used per year | 3,846 | Sappi CDM calculations spreadsheets |
| Cost of biomass | | Opportunity cost of composting (Hawkes, 2006), no additional costs (Jeanette Sullivan, Pr. Eng. Process Engineer, |
| | R 50 | Utilities: Sappi Kraft) |
| Tonnes of biomass used per year | 90,800 | Sappi CDM calculations |
| Additional operating costs | R 336,000 | Jeanette Sullivan: these comprise additional power, millwater, effluent and labour costs required. |
| Discount on post 2012 allowance price | 80% | Author's assumption |
| Tax Rate | 0.29 | Hawkes, 2006 |
| Year on year inflation | 4.7% | Absa June 2006 one year forecast CPIX rate http://www.finforum.co.za/absa_publications/financialmarkets/Currency%20and%20inflation%20forecasts.pdf |

Tugela CDM DCF (in ZAR)

| Years | 0 | 2007 1 | 2008 2 | 2009 3 | 2010 4 | 2011 5 | 2012 6 | 2013 7 | 2014 8 | 2015 9 | 2016 10 |
|-------------------------------------|--------------------|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Capital costs | | | | | | | | | | | |
| Technology | 27 000 000 | | | | | | | | | | |
| Upfront CDM costs | 1 040 000 | | | | | | | | | | |
| Sub-total | 28 040 000 | | | | | | | | | | |
| Operating costs | | | | | | | | | | | |
| Additional operating costs required | | 336 000 | 351 792 | 368 326 | 385 638 | 403 763 | 422 739 | 442 608 | 463 411 | 485 191 | 507 995 |
| Opportunity costs of composting | | 4 540 000 | 4 753 380 | 4 976 789 | 5 210 698 | 5 455 601 | 5 712 014 | 5 980 475 | 6 261 561 | 6 555 854 | 6 863 980 |
| CDM transaction costs | | | | | | | | | | | |
| Monitoring | | 65 000 | 68 055 | 71 254 | 74 603 | 78 109 | 81 780 | 85 624 | 89 648 | 93 861 | 98 273 |
| Verification | | 162 500 | 31 666 | 85 504 | 89 523 | 93 731 | 98 136 | 102 748 | 107 577 | 112 634 | 117 927 |
| CDM issuance | | 54 686 | 57 256 | 59 947 | 62 764 | 65 714 | 68 803 | 72 037 | 75 422 | 78 967 | 82 679 |
| Adaptation levy | | 72 686 | 76 102 | 79 679 | 83 424 | 87 344 | 91 450 | 95 748 | 100 248 | 104 960 | 109 893 |
| Sub-total | - | 5 230 871 | 5 338 251 | 5 641 498 | 5 906 649 | 6 184 261 | 6 474 922 | 6 779 243 | 7 097 867 | 7 431 467 | 7 780 746 |
| Income | | | | | | | | | | | |
| Steam energy produced | | 12 258 000 | 12 834 126 | 13 437 330 | 14 068 884 | 14 730 122 | 15 422 438 | 16 147 292 | 16 906 215 | 17 700 807 | 18 532 745 |
| Fuel savings | | 8 703 | 9 402 | 9 844 | 10 307 | 10 791 | 11 298 | 11 829 | 12 385 | 12 967 | 13 577 |
| CER Revenues | | 3 634 280 | 3 835 091 | 3 983 930 | 4 171 175 | 4 367 220 | 4 572 480 | 4 787 477 | 5 002 479 | 5 227 595 | 5 462 926 |
| Sub-total | - | 15 900 983 | 16 648 619 | 17 431 104 | 18 250 366 | 19 108 133 | 20 006 216 | 20 947 246 | 21 936 079 | 22 970 370 | 24 058 248 |
| Pre Tax Cash Flow | -28 040 000 | 10 670 112 | 11 250 369 | 11 789 606 | 12 343 717 | 12 923 872 | 13 531 294 | 14 167 056 | 14 823 211 | 15 500 902 | 16 200 248 |
| Taxation | | | | | | | | | | | |
| Tax allowance | | 11 216 000 | 5 608 000 | 5 608 000 | 5 608 000 | - | - | - | - | - | - |
| Taxable amount | | -545 888 | 5 652 369 | 6 181 606 | 6 735 717 | 12 923 872 | 13 531 294 | 14 167 056 | 14 823 211 | 15 500 902 | 16 200 248 |
| Tax Payable | | -158 307 | 1 639 187 | 1 792 666 | 1 953 358 | 3 747 923 | 3 924 075 | 4 117 833 | 4 327 731 | 4 562 252 | 4 821 706 |
| Post-tax cash flow | -28 040 000 | 10 828 420 | 9 621 182 | 9 996 940 | 10 390 359 | 9 175 949 | 9 607 219 | 7 339 523 | 7 684 480 | 6 045 651 | 6 423 796 |
| Cumulative cash flow | -28 040 000 | -17 211 580 | -7 590 399 | 2 406 541 | 12 796 901 | 21 972 850 | 31 580 069 | 38 919 591 | 46 604 071 | 54 649 722 | 63 073 518 |

| | |
|--------------------------|---------------------|
| Net Present Value | R 31 899 054 |
| iRR | 33% |
| Payback Period | 1 |
| | 1 |
| | 1 |
| | 0.788925833 |
| | 2.788925833 |