Universitat Autònoma de Barcelona

Department d´Economia de l´Empresa

Doctoral Thesis

DEALING WITH SMEs' STRATEGIC ISSUES FROM THE APPROACH OF REAL OPTIONS

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To Zul, Zara & Azra

Former Student:

"Professor, this is the same question that you gave our class when I was a student twenty years ago. Don't you ever change the questions?"

Professor:

"The questions don't change – just the answer."*

*Weston & Shastri (2005), on Multi-period Capital Budgeting under Uncertainty: Real Option Analysis, p. 305.

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TABLE OF CONTENT

LIST OF FIGURES

LIST OF EQUATIONS

LIST OF APPENDICES

LIST OF ABBREVIATION

BOF	Blast Oxygen Furnace
CER	Generic Term for *Carbon Credit*
COMEX	Commodities Exchange New York
CSR	Corporate Social Responsibility
DCF	Discounted Cash Flow
EAF	Electric Arc Furnace
ENPV	Enlarged (or Strategic) Net Present Value
EU ETS	EU Emission Trading Scheme
GDP	Gross Domestic Product
GHG	Green House Gasses
LME	London Metal Exchange
MNEs	Multi-National Enterprises
NGO	Non-Governmental Organizations
NPV	Net Present Value
NPVq	Net Present Value quotient
OVS	Option-Value Space
PV	Present Value
RBV	Resource-Based View
ROV	Real Option Valuation
SMEs	Small- and Medium-sized firms
SWOT	Strengths, Weaknesses, Opportunities and Threats Analysis
UKELA	UK Environmental Law Association

Chapter One

INTRODUCTION

This thesis focuses on real options as a methodology that enables to bridge corporate finance and strategic management activities in small- and medium-sized firms (SMEs). Real Option Valuation (ROV) is used in every strategic evaluation stage, identified according to the chronological process of risk assessment, capital budgeting, strategic management and corporate social responsibility (CSR). ROV is seen as a powerful tool because of its ability to overcome weaknesses of most applied valuation methodologies based on discounted cash flows (DCF). Real options run away from rigid strategies formulated following DCF approaches by incorporating continuously changing business environments and flexibility into the analysis.

For SMEs, formulating strategic decisions based on changing business environments becomes very crucial. SMEs, being relatively small in size and revenue, have limited managerial capacity, expertise and resources. Contrary to SMEs' belief that being small restricts their capacity to be efficient and weakens them to face challenges, real options prove to be a set of valuable tools to be incorporated into management decision making. ROV is not as complicated and complex to be applied as it might seem, as this thesis tries to demonstrate, and therefore appropriate for SMEs although most large corporations are employing more elaborated and costly versions of this methodology. A remarkable characteristic of real options is its ability to be customized to fit SMEs' needs completely with flexible degrees of complexity in its approach and assumptions. This ability of real options to analyse and assess risk opens up more opportunities for SMEs. Instead of looking at business threats and weaknesses as the empty part of a glass, real options turn this into a half full glass that should be exploited when opportunity strikes.

In risk assessment, ROV is beneficial to formulate strategic options and provides SMEs with the right to exercise any favourable option without any obligation to fulfil it. The options are developed based on current business environment and uncertainties about the future. Once the options are developed, ROV evaluates the option(s) and assesses its (or their) economic value. First, the traditional Net Present Value (NPV) is calculated according to DCF principles. Then, ROV adds the value of the real option(s) embedded in the investment project and establishes the Enlarged Net Present Value (ENPV). Holding to the rule of thumb similar to the NPV when selecting investments, ROV is able to analyse the project´s return more comprehensively thus allows for better consideration of investment future prospects. This is true and realistic because many managers often admit that projects with negative NPV are also considered based on *subjective intuition* due to perceived future potential. This *subjective intuition* is now quantified through the adoption of real option principles to support strategic decision making. Together with quantified and justifiable subjective intuition, managers are able to incorporate advanced, comprehensive and accurate capital budgeting into their strategic decision making process.

Next, options are quantified, SMEs' managers move to strategic management based on inputs obtained from risk assessment and capital budgeting. With real options, SMEs are able to identify which option is valuable to be exercised in a near future, or which to be kept while waiting for further development and information. In the beginning, the kept options are least valuable but still worth considering. Eventually, SMEs are able to optimize limited capacity, expertise and resources to gain the higher expected return through resources reallocation and prioritization.

In addition to the above mentioned aspects, managing corporate social responsibility (CSR) is able to show the ability of real options to deal with issues that involve high uncertainty. The approach of real options manages to reach results with significant impact, as declared by most practitioners and academicians in this field, since the high levels of uncertainty cannot be tackled by DCF. Taking climate change as the most recent dilemma, real option analysis has proven that SMEs have the option to switch to greener technology by limiting operational profits (and/or losses) but gaining intangible value of long term benefits and reputation which, at the end, affect the final value of the business.

Holding to this skeleton, this thesis is written in four different content chapters. This first chapter acts as the *Introduction* while the sixth chapter presents the *Conclusion*. The content chapters are:

Chapter Two: *Real Options and Risk Management*
Chapter Three: *Real Options and Capital Budgeting*
Chapter Four: *Real Options and Strategic Management*
Chapter Five: *Real Options and Corporate Social Responsibility*

Chapters Two, Three and Four are based on the same stylized case study as exploratory research, following Cooper and Slagmulder (2004), and widely applied in real option analysis by many scholars, among others Brennan and Schwartz (1985), Dixit and Pindyck (1994) and Trigeorgis (1996). The chapters are constructed on the same case study of SMEs in the steel industry with the aim to prove the capability of real options to bridge corporate finance and strategic management activities, hence, binding it as one. Without this, it is afraid that the mechanism of continuity and connectivity could have not been clearly seen. The case study will be presented as *Research Setting A* with the aim to provide clear information and assist understanding. Chapter Five stands as an independent chapter which shows another possible application of ROV- linked to corporate social responsibility, a current relevant issue associated to high level of future uncertainties.

The research undertaken in this doctoral thesis has been contrasted to other scholars, presented in seminars and workshops, and sent to international conferences, where acceptance is based on a double blind peer review system. The paper versions of the four content chapters are also being sent for publication to academic journals, again with double bind peer review. The next paragraphs summarize the path followed by each of the four chapters until the submission of this doctoral thesis to the Department of Business of the Universitat Autònoma de Barcelona in November 2012.

Briefly, **Chapter Two: Real Options and Risk Management** has been presented as a complete individual paper entitled "Assessing Risk for Strategic Formulation in Steel Industry through Real Option Analysis" at 7th International Strategic Management Conference (Paris, France, July 2011). The proceeding of this conference is published on-line by Elsevier in its *Procedia Social and Behavioral Sciences* publication, which is indexed by the Conference Proceedings Citation Index (CPCI) of Thomson Reuters. This paper has subsequently been published in the *Journal of Global Strategic Management*, Volume 5, Number 2, pages 5-15, December 2011, under the same title.

Chapter Three: Real Options and Capital Budgeting has been primarily presented as the master thesis of the *Master of Research in Entrepreneurship and Business*

Management and also accepted at the 2nd International Conference on Economic and Management Perspective (2010). A more elaborated version has been presented at three international conferences, namely the XXI Jornadas Hispano-Lusas de Gestión Científica (Cordoba, Spain, February 2011), the Financial Management Association (FMA) European Conference 2011 (Porto, Portugal, June 2011) and the Real Option Group (ROG) 15th Annual International Real Option Conference (Turku, Finland, June 2011). The ROG Annual International Conference is a world leading conference that specifically addresses the topic of real options combining both experts from academic and practitioner origins. Acceptance to various international conferences has helped to substantiate the data obtained for building up the case, corroborate the parameters used by other researchers in the same field and ascertain on the mathematical approach applied in the research.

Chapter Four: **Real Options and Strategic Management** has been sent for publication to an academic journal of management and is currently under review.

Chapter Five: Real Options and Corporate Social Responsibility is based on a specific case of climate change but still taking SMEs in the steel industry as its research setting in order to illustrate how changes in business environment with high degree of uncertainty, which affects business value, can be incorporated into the analysis. The case is elaborated individually in Section 5. Different from the rest of the thesis, this chapter is self-contained and suitable for independent reading. The preliminary version has been accepted as a paper at the 7th International Conference of Business, Management, Economic and Finance (Izmir, Turkey, October 2011) under the title "*Green* Corporate Social Responsibility: To be or not to be?". The paper has later been published at the *International Journal of Social Sciences and Humanity Studies*, Volume 3, No. 1, 2011 (ISSN 1309-8063) under the same title. Besides that, on 14th December 2011 an advanced version of the paper was also presented at the research seminar of the Department of Business of the Universitat Autònoma de Barcelona, to which this thesis is being submitted, under the title *SME's Environmental CSR Investment: Evaluation, Decision and Implication,* and was subsequently published in the Working Paper Series of the Department (11/7).

As stated before, this thesis finishes with **Chapter Six** that summarizes the main conclusions for SMEs' strategic management drawn from the research undertaken.

This doctoral thesis diverges from other theses in real options which focus on building up a model with highly mathematical approach. The emphasis is being rather placed on real option managerial perspective. Through the exploration and study conducted, this thesis reveals the basic understanding needed by SMEs´ managers to apply ROV and benefit from this methodology to solve managerial insufficiency. It is hoped that with this, SMEs are able to deal with strategic issues with a broader and more comprehensive scope.

In addition to that, this thesis illustrates the ability of real options to "bridge" corporate finance and strategic management. The connectivity of one content chapter to the other shows the relationship between activities in the two fields. However, it is not easy as there are challenges in connecting real options to investment decision due to their complex nature of modelling, ownership of options and market characteristics of assets (Pinches, 1998). Nevertheless careful considerations of the different aspects involved the thesis, are able to overcome at least some of these obstacles and do it from the viewpoint of SMEs.

The case built for this study is a worldwide representative case. It is a general real case specifically built to assist comprehension of real problems to reflect real strategic questions. The case is presented in such a way that enables to present the tool´s capacity and interesting strategic effects resulting from the option valuation approach. This case demonstrates specifically how ROV in small businesses can be implemented.

In doing so, steel industry has been chosen as a focus. It is a complex industry which is dominated by large firms. Yet, due to recent innovation in steel making processes many small businesses have emerged to share the wealth bubble. Eventually, as the industry possesses complex and dynamic networks of supply chain, small businesses are able to move strategically in various directions. Therefore, the case chosen allows availability of multiple interesting strategic decisions being developed, i.e. managerial flexibility as well as serving the purpose of illustrating the capacity of ROV.

It is important to state that, regardless of the meticulous effort to produce a case closer to the real world, this case is unable to reflect any specific entity. Information obtained to build up this case is taken from various geographical areas and sources, thus factors such as geographical location, exchange rates, local regulations and customs are being ignored. The stylized case touches general issues that challenge most of small businesses in the industry. Furthermore, to obtain legal disclosure of information and protect privacy rights of small businesses have certain effects on the accuracy reflected in the case. Nevertheless, holding onto the objectives to illustrate strategic decisions and eventually simplifying the problem, the stylized case manages to fulfil its purpose.

The main questions highlighted by this case are presented according to the types of activity, either from activities of risk management, corporate finance (capital budgeting), strategic management or corporate social responsibility. The questions to be answered are presented in Figure 1A.

ACTIVITY	QUESTIONS TO BE SOLVED
Risk Management	• How SMEs are able to approach risk from an economic perspective? • How risks observed are integrated into capital budgeting and strategic management practices?
Capital Budgeting	• How can the high degree of uncertainty about input and output prices as well as reserves quantity be incorporated appropriately into the capital budgeting process? • Why does *NPV* fail to cope with strategic decision making valuation of small scale investment projects in the steel industry? • How do real option valuation (ROV) and the *enlarged NPV* (*ENPV*) contribute to access the optimal policy approach to continue, expand, defer or abandon investment project?
Strategic Management	• How firm can formulate flexible strategies in order to react to changes in environment while holding to the same financial evaluation process? • How to determine the best time to execute such strategies?
Corporate Social Responsibility	• How real option incorporates uncertainty arisen from climate change in capital budgeting process? • How managers are able to plan for strategic considerations arising from climate change?

Figure 1A. Questions to be Answered According to Research Activity.

RESEARCH SETTING A:
REPRESENTATIVE CASE STUDY ON SMEs IN STEEL INDUSTRY

Introduction to Small- and Medium-sized Enterprises

SMEs have a growing importance in generating economic activities in many countries. With limited capital and resources, SMEs' managers critically require a realistic and comprehensive valuation technique that assists them to make intelligent decisions about investment selection and strategic planning.

According to the European Commission (2003), there are 3 categories of SMEs – micro, small- and medium-sized enterprises. A micro enterprise consists of less than 10 employees and a turnover or balance sheet total of not more than €2 million. A small enterprise consists of employees less than 50, and a turnover or balance sheet total of not more than €10 million. A medium-sized enterprise consists of less than 250 employees and a turnover of not more than €50 million or a balance sheet total of not more than €43 million. (Source: *OECD Recommendation 2003/361/EC*).

In UK, a small company is one that has a turnover of not more than £6.5 million, a balance sheet total of not more than £3.26 million and not more than 50 employees. A medium-sized company has a turnover of not more than £25.9 million, a balance sheet total of not more than £12.9 million and not more than 250 employees. (Source: *Small and Medium Size Enterprise Statistics for the UK and Regions 2008*, published 14th October 2009).

In USA, the definition of SMEs is given by the Small Business Administration Size Standards Office. This definition determines the size of SMEs according to activities. The common categorizations are:

- 500 employees for most manufacturing and mining industries
- 100 employees for wholesale trade industries
- $7 million of annual receipts for most retail and service industries
- $33.5 million of annual receipts for most general and heavy construction industries

(Source: Small Business Administration (SBA) Size Standards Office).

Despite of different SME definitions available worldwide, the importance of SMEs in world economics is widely acknowledged (Birch, 1989; Storey, 1994). More and more SMEs generate economic activities in various sectors and contribute to country's development (Culkin and Smith, 2000). Participation covers a wide range of sectors, from manufacturing and processing, electrical and electronic, mining, services, automotive, construction, energy and heavy industry. Due to that, many governments have promoted and encouraged SMEs activities in their agendas to boost up economic development (Abdullah and Bakar, 2000).

With growing participation of SMEs in complex sectors, a simple NPV is insufficient for the purpose of analysing investment with high degree of uncertainty or planning strategically. Furthermore, with the association to limited capital, resources and expertise, it is difficult for SMEs to plot their strategic moves (Wang, Walker and Redmond, 2007). The unique characteristics of SMEs involving in complex activities, plus their big roles in economic development have provided an interesting research field for studying ROV and the linkage between corporate finance and corporate strategy.

Business Environment of Steel Industry

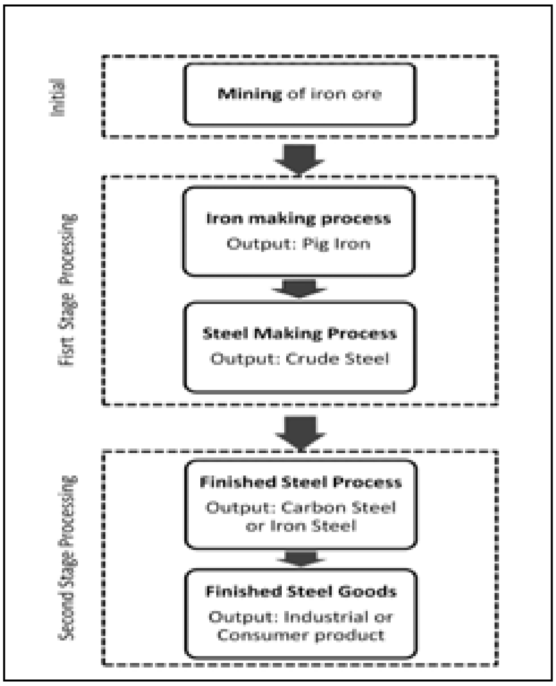

Figure 1B. Segmentation of Steel Industry According to Process Activity.

(Source: Own design)

Generally, steel industry is divided into two main activities, mining and processing. Mining involves basically in the extracting activities. Processing covers first stage processing (which process ores into crude steel) and second stage processing (which turns crude steel into either intermediate products for usage by other industries like automotive, construction, heavy machinery, shipbuilding or marine, or final finished products, such as manufacturing of electronics compartment and appliances, tools, hardware, furniture and fittings). The above Figure 1B summarizes the industry in general.

The case analyzed in this thesis shall look specifically into the first stage processing - a complex process and highly capital intensive. Innovation milestones have changed the whole process into various stages based on mini-mills because firms have to maintain quality requirements as the output is traded in international or terminal exchange markets (for example, London Metal Exchange, LME, and/or Commodities Exchange New York, COMEX) and comply with the Kyoto Protocol for preventing direct and indirect pollution.

Application of mini-mill approach gives the opportunity for steel processors to operate based on demand and supply (Sato, 2009). When demand is high, all mills operate to the optimum, but when demand is low, they may reduce cost by temporary shutting down certain mills. Another advantage of this approach is that steel processors may sub-contract the process to other firms. Major steel processors are multi-national enterprises (MNEs). With mini-mill approach, MNEs are able to search for low technology inputs and cost, with specific design and process relevant to the output requirement (Crone and Watts, 2000).

The industry is having a steady demand despite the up and down of the economic condition. Steel manufacturers are still important to support other sectors such as automotive, construction, infrastructure, oil and gas, and container (*Sustainability Report of the World Steel Industry 2005*). *Economic Watch* has reported that currently the industry is moving positively due to many milestones in innovations which focus on minimising cost and increasing production rate simultaneously.

Seeking to balance between technology input and low cost, specific design and requirement, the industry has attracted many small businesses to share the wealth (Crone and Watts, 2000; US Bureau of Labor Statistics, 2010-2011). The participation of SMEs has created a gateway for MNEs to strive for cost minimising and product differentiation. By operating in small scale, the sector is able to save cost and improve quality.

Oracle White Paper 2009 has reported that despite of the promising return, any investment in the industry is a highly capital concentrated thus presenting significant risks. Environmental factors, market shifts, unforeseen engineering challenges, improper planning, overly optimistic goals, skilled talent issues and a host of innumerable pitfalls have the possibility to contribute to failure. When huge investment has been undertaken, the expectation is absolute and failure is not an option. Therefore, issues of viability and priority must be added in the investment evaluation as to obtain proof beyond reasonable doubt that the investment will drive corporate strategy, minimize risk and meet return on the investment-related metrics.

In another specific context of Indian steel industry, Popli and Rao (2009) discover that Indian SMEs have to face great challenges to survive. These SMEs would not be able to compete due to weaknesses related to obsolete technology, high cost of production, poor quality of goods, lack of capital, weak infrastructural facilities, plethora of labour legislation, lack of cohesion among SME units, ineffective associations, lack of up-to-date information, lack of international exposure to their products and lack of standards conforming to international standards. Therefore, specific measures are required so that SMEs are able to grab the opportunity created by MNEs – especially in seeking cost minimisation and fulfilling specific design-requirement in their production system.

Economic

Regardless of size, the fluctuation of iron ores prices is critical in this sector. Even though the prices are not traded in exchange market, prices set by several leading miners act as benchmark and adapted by others (Robertson, 2008; Bilous and Hon, 2004). Big informal cartels like Vale, Rio Tinto and BHP Billiton are among the influential price setters and control nearly 80% of the iron ores market. With the quantity of iron ores depleting every year, the scarcity leads miners to keep commodities and sell them later to enjoy the surging market and earn higher profit. Latest practice of short term quarterly contracts also affects steel processors as the amount of cost to be absorbed is higher and leads to further price speculation (Glader, 2006).

On the opposite end, the outputs produced are priced according to commodity markets such as London Metal Exchange (LME) and New York Commodities Exchange (COMEX). Prices are highly adhered to specification and quality. However, in certain conditions where contracts exist between producers and buyers, variation provides flexibility to both parties resulting in better prices and profit margin.

Environmental

Environmentally, steel industry has been identified as the main contributor to Green House Gasses (GHG) emission. With the increase in public awareness towards global warming and climate change, steel industry is demanded to reduce their carbon emission to a pre-determined level set according to Kyoto Protocol. As a result, there are increased observations noted in the development of related technological innovations to address these issues. The increased awareness in the state of environment has chain effect on the technology, politics and legal aspects.

Technological

Technological evolution in steel processing is moving positively along time. Initially the aim is concentration in being cost effective. However through time, efficiency, resources sustainability and pollution reduction have emerged as equally important. Two techniques - Blast Oxygen Furnace (BOF) and Electric Arc Furnace (EAF) in the crude steel production are continuously improved. The improvements are mostly requiring additional investment and usually expensive yet the outcome is noticeable.

Political and Legal

With the existence of international agreement linked to United Nation Framework Convention on Climate Change, Kyoto Protocol has been set up to bind targets for industrialized countries and European Community to reduce GHG emission. The reactions to the encouragement and commitments have encouraged voluntary involvement from many countries all over the world to achieve the objective of average 5% reduction within five years.

Besides international cases handled by International Court of Justice (for example the Trail Smelter Arbitration, 33 AJIL 1939), government bodies begin to formulate and regulate rules and law that support the prevention, remediation and conservation of environment. The supports include introduction of penalty and punishment for producing overly or excessively pollutants into the environment. United States for example has promulgated regulations in the Code of Federal Regulation. Title 40 has been set as the primary code containing regulations of the Environmental Protection Agency, together with other titles like Title 10 (Energy), Title 18 (Conservation of Power and Water Resources), Title 21 (Food and Drugs), Title 33 (Navigable Waters), Title 36 (Parks, Forests and Public Property), Title 43 (Public Lands: Interior) and Title 50 (Wildlife and Fisheries).

In Australia, the Environment Protection and Biodiversity Conservation Act 1999 is the main legislation related to environmental issue. Meanwhile in United Kingdom, a non-governmental body (NGO) based on charity registered as the UK Environmental Law Association (UKELA) works hand in hand with the British government to improve the environmental law, its implementation, understanding and awareness of any environmental issues including networking among lawyers and non-lawyers of the same interest. Currently, UKELA publishes bi-monthly electronic journal for members, reports and consultation document besides organising activities for their nearly 800 members.

In Japan, the Ministry of Environment has established the Basic Environmental Law. Far from being basic, the law is quite comprehensive, consisting 46 articles covering issues such as policy formulation, environmental plan, environmental quality standards, pollution control in specific areas, implementation of policies, international cooperation, bearing the costs, and financial measures, among others.

Investment Details – If project starts now

The project chosen for the evaluation is an investment in the first stage steel processing, a mini-mill smelting project. A mini-mill project can be standing on its own or combined with another purpose of mini-mill, easily run in small scale and able to replicate a small business. The investment requires €10 million, €6 million in t_0 and €4 million in t_1. By investing this amount, the firm will have a plant with capacity of producing 182000 tons per year.

It is noted that the plant would not be able to produce up to maximum capacity in order to maintain emission and effluent at minimum level. The management intends to reduce its carbon print hence prevents from paying for excessive emission of carbon, i.e. carbon credit spending. Therefore, the optimal production level at the moment, holding up to current technology employed, is 75%.

Meanwhile, fixed cost incurred for production below 50% capacity is €2 million and anything more than that will double up the cost to €4 million. Hence, the net cash flows generated based on yearly production scales are shown in Figure 1C.

Uncertainty

The current trend of steel industry shows that the business is potentially exposed to an increase in demand and also in input and output prices in the future. In this case, the uncertainty of demand, supply and prices are represented by market prices of steel as a proxy. Other factors such as uncertainty in governmental rules, environmental policies and tax regime are ignored. The uncertainty of steel prices affects firms' decision towards creation and exercise of option in the later stage.

		(in € million)			
Year	**Production Rate (%)**	**Gross Revenue**	**Fixed Cost**	**Variable Cost**	**Net Revenue**
2	14,8	8,190	2	6,825	-0,635
3	45	24,570	2	20,475	2,095
4	75	40,950	4	34,125	2,825
5	75	40,950	4	34,125	2,825
6	75	40,950	4	34,125	2,825
7	75	40,950	4	34,125	2,825
8	75	40,950	4	34,125	2,825
9	75	40,950	4	34,125	2,825
Total					**18,410**

Notes

Production rate of a typical mini mill is obtained from energyefficiencyasia.org, with potential capacity of 182,000 tonnes per year. Usually due to adjustment period, it takes 2 years until the plant is able to reach its optimal level. This information is taken from a proposed project meant to be carried out in Southern Thailand.

Gross revenue is calculated by multiplying production rate to average steel price in various forms (i.e. rod, billets and sheets). Information regarding daily prices of these commodities is available at London Metal Exchange. However, for the purpose of financial evaluation applied in this case, a standard price of 300€ per tonne has been applied following the practice of Australian Mining Association. The amount in Euro is being approximated from Australian Dollar.

Fixed and variable costs are obtained from a case of proposed project in India. This case is a case study for training and obtained through energyefficiencyasia.org and by personal contact with GERIAP National Focal Point (India), National Productivity Council, 5-6, Institutional Area, Lodi Road, New Delhi – 110003. These figures are given as estimation of total round-up figures in Euros.

Net revenue is equal to Gross Revenue – Fixed Cost – Variable Cost.

Figure 1C. Net Revenue during Operation Years[1].

[1] There are some variations of data available. This table has been brought to the 15th Annual International Real Option Conference for discussion with many experienced researchers of the same field. At the end of the attendance, this table is concluded as a table that encompasses basic financial information which is suitable for and applicable to generalize a typical investment of mini-mill.

Volatility of Steel Prices

The volatility of steel prices is supplied by market bursas and steel organisations. The data varies with slight variations which are insignificant. Therefore, the volatility of steel prices used in this case is $\sigma = 30\%$.[2]

Discount Rates

Risk-free rate is 5% (continuously compounded 4.879016%) while adjusted-risk rate is 12%. Following the usual convention, any cash out flows are discounted using risk-free rate, while cash in flows are discounted using adjusted-risk rate. As the figures are real figures taken from various geographical locations in their respective currencies, it is assumed that the rates of 5% and 12% are to be applied following other analyses made by scholars in this area.

Project Time Frame

The project is assumed to last for 10 years including 2 years of construction for the purpose of assets depreciation. However, in reality the life span of this plant is uncertain due to evolution of innovation and legislation. In this study, the evaluation is done based on 2 years of constructions (t_0 and t_1) and 8 years of operations (t_2 till t_9).

Time Steps

A time step of 1 year for each node, thus $\delta t = 1$.

NPV

Following most common practice of DCF to evaluate project investment, discounted investment value, *I*, is €9.81 million while discounted net cash flows, *V* is €9.25 million.

Present value of investment, I = 6 + 3.81

= €9.81 million

[2] Volatility of steel prices in various forms has been calculated based on historical data available at London Metal Exchange and www.steelonthenet.com. First, individual prices are calculated, and compared. The difference between the two sources is not significant. Later, this figure has been cross-checked while attending 15th Annual International Real Option Conference with other researchers. Volatility of 30% is applied when studying volatility of steel industry, following the production volatility of iron and supply of other mineral ores in steel-related mining activities. This figure has also been concluded as the best way to represent the relationship of supply and demand of the world steel market.

Present value of net cash flows, V = - 0.635 + 2.095 + 2.825 + 2.825 + 2.825 + 2.825 + 2.825 + 2.825

= €9.25 million

With this information, the NPV of the project is *V- I* = €-0.56 million (*negative NPV*).

Strategic Options

Looking at the business environments circulating the proposal, there are uncertainties related to steel market that should be considered wisely. While the impact of 2009 economic crisis is still lingering, development in ores' prices, shorter relative contract terms to deal with scarcity issue and slower demand in steel related industry (such as automotive and constructions) suggest that any new investment in the field should be evaluated properly. Projections of future conditions can either turn to pure profits or disaster.

In order to prepare and "cushion" the proposed investment, several precautionary steps to overcome risks have been identified. Four real options have been formulated, which are the option to defer investment, the option to cancel investment, the option to expand investment and the option to abandon investment for salvage value.[3]

Option to defer (Tourinho, 1979; McDonald and Siegal, 1986; Paddock, Siegel and Smith, 1988) is valued as an American call, where the strike price is the required outlay if the investment is made in the future. In this case, the project initiation may be delayed to next year, t_1. The projected net cash flows will remain static but the cost of investment will increase by 5%.

Option to cancel during construction is valued as a compound option of a call on a put (Cortazar and Schwartz, 1993). With this option, construction can be cancelled at any time without any penalty. The firm might earn any invested amount, being discounted at the adjusted-risk rate of 12%. Once cancelled, the project cannot be deferred, expanded

[3] The purposes of these options are detailed in Chapter 2 on "Real Options and Risk Management".

or abandoned (i.e., the other three options considered). Disinvested amount is considered as the strike price since it represents the saving due to discontinuation of the project.

Option to expand (Brennan and Schwartz, 1985; McDonald and Siegal, 1985; Pindyck, 1988; Myers and Majd, 1990) is valued as a European call. This is the option to make further investment and increase production output if future conditions are favourable. The strike price of the call option is the cost of creating the additional capacity discounted over to the time of exercising it. By embedding this formula, the firm has the opportunity to increase capacity by 25% without spending extra amounts on carbon credits for polluting the environment according to the Kyoto protocol at year t_4. The expansion activity includes improvement in process innovation, up-to-date hazard prevention equipment and upkeep with technical advancement.

Option to abandon is valued as an American dividend paying put (Myer and Majd, 1990). This is an option to sell down or close a project where the put value is on the project´s value. Meanwhile, the strike value is the liquidation (or resale) value of the project after deducting all closing down costs. At any time the project can be abandoned for alternative use and enjoy a salvage value of, in principle, 50% of accumulated capital outlays net of 10% average annual depreciation, being discounted at adjusted-risk rate of 12%. The purpose of this option is to mitigate poor investment outcome and to increase initial valuation of the project.

These options can be embedded in the project investment individually or together with the maximum combination of three of them. The following chart, Figure 1D, compares every possibility of the project investments - with and without options.

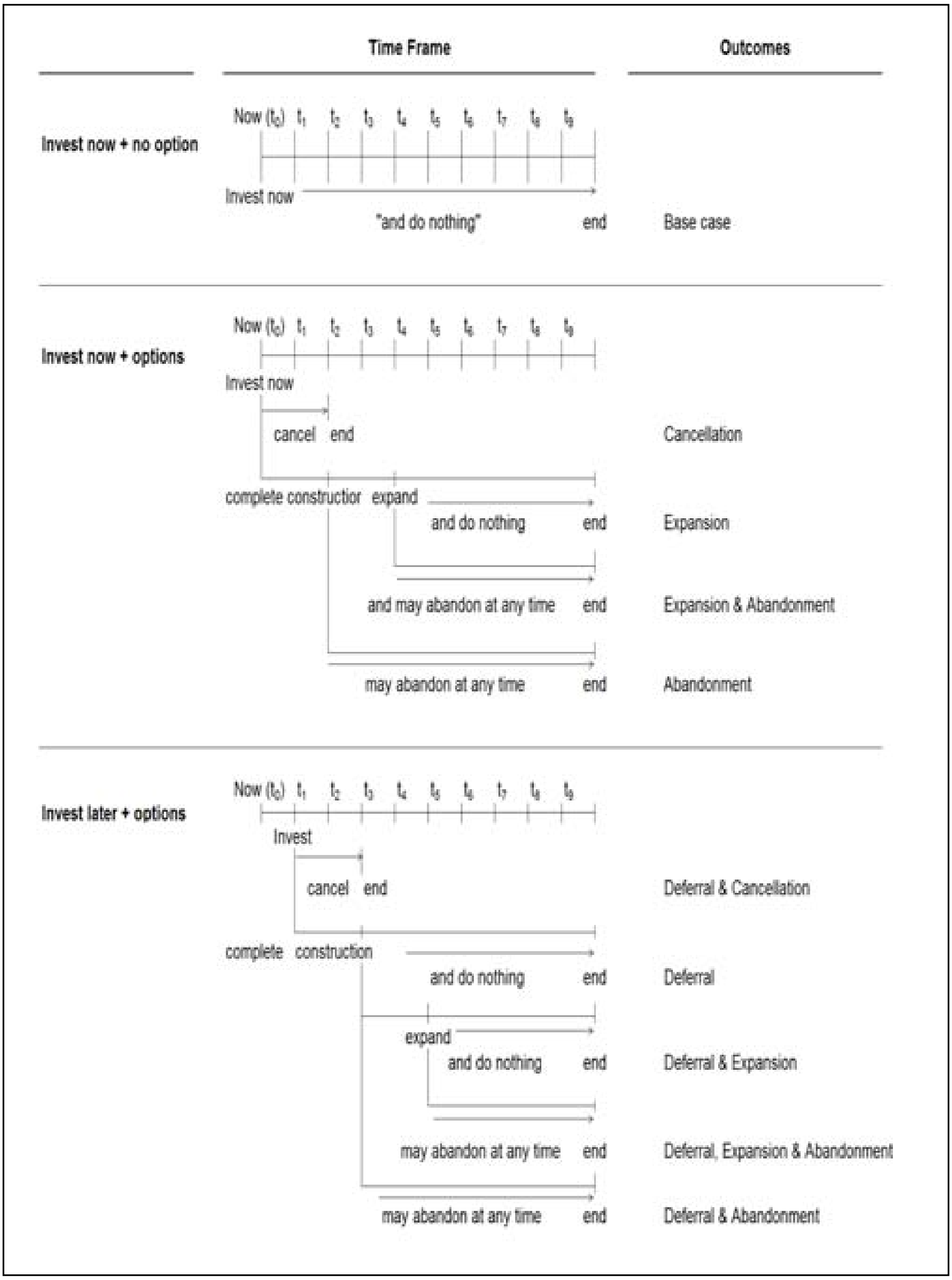

Figure 1D. Overview of the Proposed Mini-mill Iron Smelting Project and Firm's Strategic Choices. (Source: Own Design)

Chapter Two

REAL OPTION AND RISK MANAGEMENT[1]

[1] A preliminary version of this chapter has been presented as paper at the 7th International Strategic Management Conference (July, 2011) in Paris, France. The Proceedings of the Conference has been issued online by Elsevier in *Procedia Social and Behavioral Sciences*, 24 (2011), 991-1002 (a publication indexed by the Conference Proceedings Citation Index (CPCI) of Thomson Reuters).

Besides, that version of the paper was accepted for publication and has appeared in the *Journal of Global Strategic Management*, December 2011, 5(2), pp.5-15, under the title "Assessing risk for strategy formulation in steel industry through real option analysis".

While the efficiency of financial systems rests primarily on proper risk assessment and management, real option valuation (ROV) grounds strategic thinking and decision making analysis. Followed by the adoption of ROV in capital budgeting process, risk is assessed in a way so that it can be prevented or exploited or both, creating future options that incorporate uncertainty and provide flexibility. Taking both statements into concrete consideration, this chapter analyses the risk faced by small- and medium-sized firms (SMEs) in the steel industry, aiming to exploit it in a different perspective. Despite the fact that the participation of SMEs in this industry is growing, many of them are still facing problems in allocating limited resources, assessing risk and strategic planning - financially or non-financially. ROV is capable to provide solutions to deal with the lack of SMEs strategic management practices by providing general application guidelines on risk assessment for the purpose of strategic planning.

2.1 INTRODUCTION

Risk is defined by Collins Concise Dictionary and Thesaurus (2006) as *"the possibility of bringing about misfortune or loss"* which also bears the same meaning as *"danger, hazard, pitfall, peril and UNCERTAINTY"*. Taking this definition into economic perspective, risk is future uncertainty which needs to be managed in order to avoid a variety of consequences ranging from negative surprises to permanent loss (Triantis, 2000).

It is important to emphasize risk assessment in managerial activities. Firms manage risks for various reasons. For example, in current conditions where input suppliers hold their reserves to enjoy profits on surging market and higher prices, there is a need to enter into a contract with better terms thus agreed upon a specific price (Triantis, 2000); or face the risk of incurring higher input cost for production in the future. Firms should plan to maintain a steady cash flow so that the risk of falling short of earnings is avoidable (Triantis, 2000). Maintaining a "proper" flow of revenue is also part of tax strategy to avoid the risk of paying higher tax (Chapman, 2006). The rationale: under a typical tax regime, the amount of corporate tax paid is a convex function of its profits. Reducing variability and volatility of cash flow lead to higher after tax profits.

In undertaking new investments, proper risk management will reduce the incidents of decreasing value of investment decisions and reduce the probability of costly external financing on firms' value (Triantis, 2000; Chapman 2006). Early recognition of possible risk facilitates the achievement of optimal investment. Besides that, Chapman (2006) adds that risk management gives the opportunity to "copy" industry peers to avoid underperforming benchmark and increase firms' value. The effect – with the increment of firms' value – will lower the probability of bankruptcy, lead to better access to capital markets and increase debt capacity.

With the various advantages profited from managing risk, apart from being illustrated above, limited number of businesses especially SMEs are putting serious effort into this activity (Wang, Walker and Redmond, 2007). Risk management is seen as a sophisticated activity that belongs only to big corporations.

Rationally, this should not be the case. SMEs are new economic drivers for many countries. Nowadays, the natures of business of these SMEs are not limited to simple and traditional activities. With an increased participation of SMEs in many complex activities, such as steel industry in Belgium, Indonesia, China and India (Culkin and Smith, 2000; Sato, 2000; 2009), it flags that SMEs are in great need to practice a proper way of managing risk. Furthermore, with the support of governments' policies in many economic agendas (Abdullah and Bakar, 2000), SMEs should exploit the opportunity to grow and prosper. Yet, there are questions arising when it comes to combining managerial and financial approaches of assessing risk. The missing link between financial and managerial approaches for evaluating investment has been highlighted since long ago (Myers, 1987).

Therefore, this chapter aims to answer two questions, pertaining to risk management from the real option approach, which are:

a. How are SMEs able to approach risk from an economic perspective?
b. How are observed risks integrated into capital budgeting and strategic management practices?

Aiming to include the additional tool of real option valuation (ROV) into the risk assessment process, this chapter aims to answer to the above questions. By performing a case study based on stylized facts in the first stage steel processing, it is hoped that it contributes to enrich the literature towards the usage and application of ROV, which has been highlighted by Trigeorgis (1993b). The results also propose solutions to SMEs on how risks should be exploited and turned into opportunities, thus able to be incorporated into their strategic practices. The approach of this chapter is different compared to other dominant studies in real options and risk management, since most studies deal with quantitative aspects of real options to mitigate risk. In contrast, this chapter tackles the qualitative aspect of real option in risk management activities.

This chapter is structured as follows. The next section, Section 2.2, summarizes the development of risk management without the attachment onto any financial derivatives. With the introduction of ROV into the assessment process, risks – especially those related to operational uncertainties – are assessed before being incorporated into the evaluation. Section 2.3 illustrates the framework of study before analyses on the risk management process is conducted in Section 2.4. Also, in section 2.4, results are tabled and discussed. Finally, Section 2.5 concludes the study.

2.2 LITERATURE REVIEW: REAL OPTION AND RISK MANAGEMENT

Risk management started to gain attention when Bowman in 1980 identifies the “risk-return paradox”. According to this paradox which is based on the investors´ viewpoint, stocks with greater risk need to offer higher return in order to attract risk-adverse investors’ interest. Yet, the finding from Bowman’s study (1980) shows totally an opposite result. Firms with greater return have actually lower level of risk. This is due to strategic practices which adapt skilful, rigorous and continuous activities of risk management (Bettis, 1983). Since then, many developments of risk management approaches, processes and tools emerged.

One of the developments includes real option theory which emanates from the seminal articles by Black-Sholes and Merton on European and American options in 1973. The key element argued by this theory is the failure of Net Present Value (NPV) to include uncertainty and provide flexibility in pricing investments. This weakness leads to undervaluation (Trigeorgis, 1993a), difficulties in incorporating investment decision into strategic planning (Bierman, 1988) and becomes a very rigid framework for firms to react to continuously changing business environments (Luerhman, 1998; Pogue, 2004). Ross (1995:101) insists on that *"for most investments, the usefulness of the NPV rule is severely limited".*

Real options adapt financial options parameters which are based on operational activities (Kogut, 1991). Real options are relevant to strategists as all decisions are made based on the ability of firms to allocate resources that fit into the strategic mission (Bowman and Hurry, 1993). Real options also grant the "preferential access to future opportunity" (Bowman and Hurry, 1993: 762). Furthermore, the beauty of real options is that it includes both the options of undertaking activities or acquiring resources (Sanchez, 1993). These advantages are quantified, providing quantitative intuition for the decision making process (Luerhman, 1998) to support qualitative analyses.

With uncertainty and flexibility being incorporated into investment evaluation and strategic planning, managers hold the ability to select an outcome only if it is favourable (McGrath, 1997). It is seen as a risk management tool because of the ability to limit negative outcomes (Bookstaber, 1981; Bowman and Hurry, 1993; Sanchez, 1993), which is consistent with the aim of risk management (Triantis, 2000; Chapman, 2006).

Real options allow a subtle different understanding between corporate investments and risk (Bowman and Hurry, 1993; Sanchez, 1993; Trigeorgis, 1993a, b; McGrath, 1999). The method of application varies, to highlight some of it: from quantitative approaches applied in capital budgeting (Brennan and Schwartz, 1985; Trigeorgis, 1993a, b; Kellogg and Charnes, 2000) to more qualitative approaches such as in measuring value creation and strategic planning (Luerhman, 1998; Amram and Kulatilaka, 2000; Smit and Trigeorgis, 2006). Real option application includes evaluating corporate social responsibility (Kanter, 1999), risk management (Bowman and Hurry, 1993; Miller and Reuer, 1996) and preparation of contingency plans (Rogers, Gupta and Maranas, 2003).

Rogers, Gupta and Maranas (2003) have adopted a real option approach to the portfolio planning of a pharmaceutical product development. Such adoption is chosen as it accounts for the value of managerial flexibility to react to arising contingencies during R&D stage. The technique permits hedging opportunities present in the financial markets to track uncertainties in the project value. The results of such adoption are consistent with the firm´s desire to avoid late-stage investment costs on risky, marginally profitable products and are quantified through a sensitivity analysis which enhances the firm's strategic decision making process.

In another case, Benaroch, Lichtenstein and Robinson (2006) have proposed an option-based risk management analysis of an IT-investment project in order to control risk and maximise value. This framework is used as a set of normative risk-option mappings for choosing a specific real option to be embedded into an investment. From 50 cases studied, it shows that IT managers' decisions are mostly pure intuitions. However, these "pure intuitions" are consistent with the logic of option based risk management. From the study it is concluded that real options are capable of quantifying qualitative intuition, which provides better insights in risk mitigation.

Both findings above undoubtedly involve "what if" and "how to" reasoning that lead to scenario planning. Together with real option analysis, risk management receives complementary strengths through a beneficial tool that assists strategic investment decision making under uncertainty. Miller and Waller (2003), for example, have combined these two approaches in the framework of building an integrated risk management process. Steps that involve scenario development, exposure identification, formulating risk management responses, and implementation are employed. By applying it into a corporate-level perspective, this application takes risks into consideration at the full range of exposures across the firm's portfolio. In contrast with the predominant emphasis on quantitative analysis in the real option literature, Miller and Waller (2003) illustrate qualitative assessment of real options.

Looking into gold mining activity, Tufano (1996) has found that firms whose managers hold more options manage less gold price risks while firms whose managers hold more stocks manage more gold price risk - suggesting that managerial risk aversion affects the corporate risk management policy. This flags that real option is a proper way to deal with high uncertainty. The conclusion is further strengthened by a statement found in Burgundy Report (2003), which indicates that, *"...at a more macroeconomic level, the efficiency of financial systems rests primarily on proper risk assessment and management in project evaluation.... (thus) real options approach is the crucial analytical tool to fulfil such a need and act as a link between the financial and the real sectors."*

2.3 METHODOLOGY

The research conducted in this study follows a stylized fact case study approach as exploratory research following Cooper and Slagmulder (2004). The approach is similar to other studies in the field of real options, such as Brennan and Schwartz (1985), Dixit and Pindyck (1994) and Trigeorgis (1996), in the case of natural resource activities. This approach requires of the construction of a base case with various sources of information representative in a worldwide scenario.

The analysis adapts the general risk management process by Chapman (2006), steps which are not much different from Miller and Waller (2003), as discussed in the previous section. Chapman's approach is adopted in order not to confuse between terms like "scenario development" and "scenario planning". The original steps of Chapman's process begin with analysing business and its environment.

Next, risks are identified and assessed before formulating strategies. According to the Total Model Value by Boer (2002:76), risks affect economic and strategic capital[2]. Boer (2002) explains that the strategic capital of an organization, similar to its economic value, is affected by risks, diminishing returns and innovation, thus should be included together with every aspects of the outside world, i.e. business environment. However, different from economic value, the strategic capital involves knowledge and talent, which can only be valued through real options in the planning activities.

[2] An illustration and brief explanation of Boer's Total Value Model to value businesses is available as supplement under Appendix 2A.

Therefore, in order to deal with valuation of strategic capital, it is suggested that Boer's interpretation of a strategic plan is applied to Chapman's framework. Apart from the original Chapman's process, another step, called valuation, should be added to quantify managers' intuition in risk management. As a result, a comprehensive risk management process is derived. Figure 2A provides a clear framework on how risk management activities are enhanced with the adoption of real option valuation.

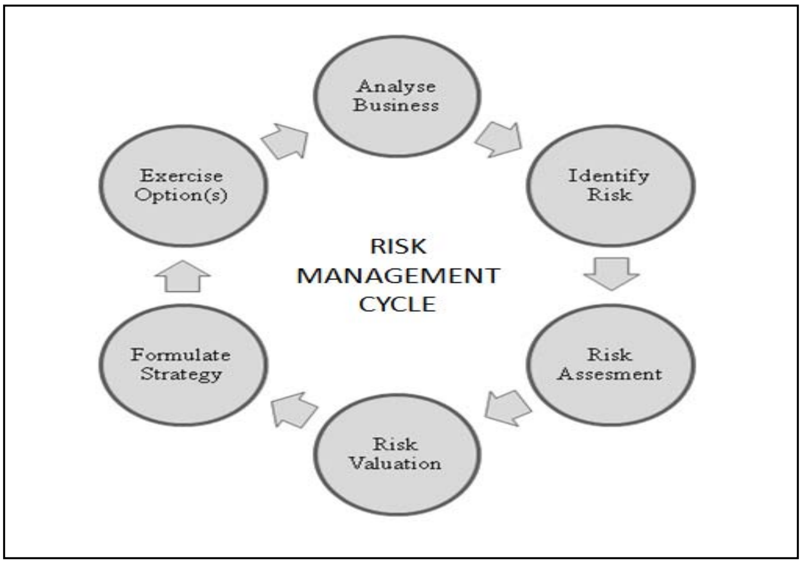

Figure 2A. Risk Management Cycle. (Source: Own design)

The process is a cyclical process as to suit constantly changing environment. It starts with analysing the business characteristics: strengths, weaknesses, opportunities and threats (SWOT) – the mostly applied strategic assessment tool. Next, relevant risk exposures are identified. Each risk is assessed individually and collectively before being measured and valued according to the ROV methodology. The valuation process applied in this study follows the methodology of the log-transformed binomial lattice approach developed by Trigeorgis (1991). Calculations are performed using *DerivaGem* (Hull, 2010).

The values are later added to the traditional NPV for a more meaningful value. The result, termed as Enlarged Net Present Value, incorporates uncertainties i.e. in this case – risks; and provides flexibility (Trigeorgis, 1993a) as per equation 2A.

$$\text{Enlarged (or Strategic) NPV or ENPV} = [\text{NPV} + \text{Real Option(s)}] \qquad [2A]$$

At a further stage, strategy is formulated to suit the firms' interest and mission. When uncertainty becomes plain into view and options are approaching their expiry date, firms will choose the best options to be exercised. The cycle will restart after this and proceeds to react constantly to continuously changing environment.

2.4 ANALYSES, RESULTS AND DISCUSSION

Based on the framework drawn in Section 2.3, this section analyses the process of risk management from *Step 1: Analysing Business Characteristics,* until *Step 4: Risk Valuation*, taking example of a new investment in a mini-mill iron smelting project of the first stage steel processing carried by SMEs. This section aims to demonstrate how ROV is feasible and practicable to manage risk by illustrating a clear example that highlights how risks are treated as opportunity and treated by creating potential real options.

In order to do so, firstly, it is important to understand why a mini-mill iron smelting project is feasible as SMEs' investment. According to Bonmo (1998), mini-mill approach requires low specific investment that attracts new comers, which supports the recent increase participation of SMEs in the steel industry (Culkin and Smith, 2000). Furthermore, a mini-mill production system is able to reduce the labour cost by minimum 60% man hour per tonne, giving greater flexibility to the process and, most importantly, having a lower impact on the environment. As the plant is small in scale, it has the possibility to be located near the steel users' plant.

Mini-mill approach is preferable among investors because it has many technical advantages such as replacing the use of coke ovens with COREX process from Siemens VAI[3], thin slab technology for hot strip production, including continuous linking of downstream pickling and cold rolling. This production method starts to gain its popularity due to its lower operating cost and efficiency.

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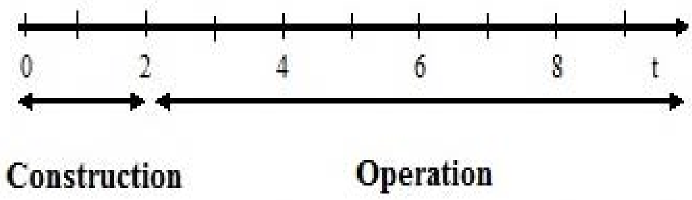
[3] Corex® is an industrially and commercially proven smelting-reduction process developed by Siemens VAI. In the Corex process, all metallurgical work is carried out in two separate process reactors – the reduction shaft and the melter gasifier.

Step 1: Business Analysis and Case Background

Referring to **Research Setting A** presented in the first chapter, it is summarised that there is a new proposal of building up an iron smelting plant based on a new process innovation, the mini-mill iron smelting[4]. The investment requires €10 million, €6 million in t_0 and €4 in t_1. By investing this amount, the firm will have a mini-mill plant with capacity to produce 182000 tons per year. However, due to Kyoto Protocol, the plant is allowed to produce only up to 75% of its capacity in order to maintain emission and effluent at optimum level.

The investment has an expected useful life of 10 years. 2 years are dedicated for construction and the remaining 8 years are operational. Volatility is forecasted to be σ=30%. Two discount rates are employed: 5% as the risk-free interest rate and 12 % of adjusted-risk rate. Holding to this information, discounted investment cost (*I*) is €9.81 million, while discounted net cash flows (*V*) is €9.25 million resulting in a NPV of €-0.56 million (*negative NPV*). The project is summarized in Figure 2B.



Volatility, σ = 30 %.	PV of I = €9.81 million
Risk-free rate = 5%	PV of V = €9.25 million
Adjusted-risk rate = 12%	NPV = - € 0.56 million

Figure 2B. Summary of Proposed Investment: Mini-mill Iron Smelting Project.
(Source: Own design)

[4] Upon submission of this chapter as working paper to conferences and publisher, the case is incorporated in full but focusing on facts that are relevant to the analyses.

Step 2: Risk Identification

In the second step, risks are identified according to its relevancy to the above investment and most of those risks are related to operational activities. Uncertainty is hedged with options rather than using derivatives in financial markets. In short, the possibility of hedging with derivatives is totally disregarded in this study.

Schütz (2003) reported in his article entitled "Steel Industry Risks" published in *Regards* that the industry is highly concerned about the risk of operational hazard especially when it comes to producing as a mini-mill plant. Hazards include explosion, fire and radioactive contamination. Explosion and fire are caused by incidents in furnaces that involve oxygen and highly flammable materials used in heat production. Mishandling of ferrous scraps such as Caesium -137 (CS 137) and Cobalt 60 (^{60}Co) may result in radioactive contamination thus incur into expensive cleaning cost if it happens.

The other type of steel industrial risks is less serious but more complicated to deal with – the business interruptions risk. The first interruption is fluctuation in price of inputs and outputs. Input prices are controlled by major producers and adapted by other small miners as benchmark (Bilous and Hon, 2004; Robertson, 2008), while outputs are traded in terminal exchange markets like London Metal Exchange (LME) and Commodities Exchange New York (COMEX). Therefore steel producers have little influence in controlling the raw material cost and revenue.

The next business interruption risks are legal, taxation and environmental regulations. As the business involves hazardous activities, there is usually a higher requirement to be followed and certified. The steel industry has to compile with many and complex environmental laws imposed which nowadays become more and more critical, such as awareness to the Kyoto Protocol. The tax regime is also continuously changing depending on government interest and the current economic situation.

The third type of steel industry risk is technical risk, which is due to obsolesce of technology affecting process and production, hazard prevention or business management. With competition getting stiff, evolution of technical aspects has been developed to overcome pollution, reduce production cost and improve product quality. Therefore, for a business to survive in this industry, awareness in such development becomes essential.

Similar to any other investment project, the investment in mini mill iron smelting is also exposed to financial risks in terms of debt and borrowing cost, interest rates and currency exchange risks. These rates add to uncertainties as volatility parameters that can be assessed only with ROV.

In this study, fluctuation of iron prices in the terminal market is taken as a proxy which presents the actual risk in form of volatility rates. Iron prices react closely to supply and demand of quantity and prices in the market. This signals the reaction of the industry towards the risks above. Differently, anticipation of future risks is mitigated by formulating options. For example, a major mishap may result into the firm being out of business. So, in order to avoid industrial hazard the firm has to employ anti-hazard precaution gadgets. Improvements of technology increase the price of steel by improving quality. However, in the long run when the technology becomes common, it is able to reduce the price and provide higher quantity supplied. Adoption of new gadgets and technology may trigger options of expansion while adjustment to higher tax rates and harsh legal penalty allow firms to contract production scale, abandon project or switch activities. All these risks are able to be anticipated quantitatively when firms are adopting a ROV approach.

Step 3: Risk Assessment

Based on the recognized risks above, several precautionary steps to overcome risks have been identified and established by formulating four types of real options. The options are the option to defer investment, the option to cancel investment, the option to expand investment and the option to abandon investment for salvage value.

Option to defer (Tourinho, 1979; McDonald and Siegal, 1986; Paddock, Siegel and Smith, 1988) is valued as an American call, where the strike price is the required outlay if the investment is made in the future. In this case, the project initiation may be delayed to next year, t_1. The projected net cash flows will remain static but the cost of investment will increase by 5%.

Option to cancel during construction is valued as a compound option of a call on a put (Cortazar and Schwartz, 1993). With this option, construction can be cancelled at any time without any penalty. The firm might earn any invested amount, being discounted at the adjusted-risk rate of 12%. Once cancelled, the project cannot be deferred, expanded or abandoned (i.e., the other three options considered). The amount disinvested is considered as the strike price since it represents the saving due to discontinuation of the project.

Option to expand (Brennan and Schwartz, 1985; McDonald and Siegal, 1985; Pindyck, 1988; Myers and Majd, 1990) is valued as a European call. This is the option to make further investment and increase production output if future conditions are favourable. The strike price of the call option is the cost of creating the additional capacity discounted over to the time of exercising it. By embedding this formula, two years after operation begins, i.e. at year $t_{4,}$ the firm has the opportunity to increase capacity by 25% without spending extra amounts on carbon credits for polluting the environment according to the Kyoto protocol. The expansion activity includes improvement in process innovation, up-to-date hazard prevention equipment and upkeep with technical advancement.

Option to abandon is valued as an American dividend paying put (Myer and Majd, 1990). This is an option to sell down or close a project where the put value is on the project´s value. Meanwhile, the strike value is the liquidation (or resale) value of the project after deducting all closing down costs. At any time the project can be abandoned for alternative use and enjoy a salvage value of, in principle, 50% of accumulated capital outlays net of 10% average annual depreciation, being discounted at adjusted-risk rate of 12%. The purpose of this option is to mitigate poor investment outcome and to increase initial valuation of the project. Figure 2C summarizes the purpose of these options.

Besides these four individual options, it is possible that two or more options are combined together. Therefore, it is important to analyse the sequence of options in order to identify any possibility of combining several real options and embed them in the investment project, as done by Smit (1997) in the case of petroleum concession.

Types of Option	Purpose
Deferral	• To deal with extreme fluctuation of prices in input and output. By holding this option, investment will be postponed until prices are stable and fluctuation is minimal. • To hold investment so that information on latest environmental concern/issues are evident. • To plan for better tax planning to benefit from tax incentives or to reduce tax imposed on heavy/hazardous activities. • To provide an opportunity of performing stage-investment strategy. • To hold investment for better resources allocation.
Cancellation	• To obtain financial flexibility in the case that increment cost of investment is significantly higher than perceived. • To avoid any incurrence of additional extreme legal and taxation cost that arises from hazardous incidents during construction. • To avoid further losses if demand is not competitive.
Expansion	• To equipped plant with better technology in order to prevent hazardous and technical risk of obsolesces, and to improve production process and product quality. • To keep up with increase in demand without violating environmental law and avoid penalty.
Abandonment	• To stop production and enjoy salvage value if output prices fall beyond profitable rate or fail to reach breakeven point. • To cease operation if legal suits leads to further losses or bankruptcy.

Figure 2C. Types and Purpose of Options

Given the conditions of each option created earlier, a diagram tree is produced to easily illustrating the possibility of how individual options may be exercised one after another. To start with, it is feasible that the investment can be taken now at t_0 or postponed to next year of t_1. This is the option to *invest now* or to *defer*. Then from there, the path unfolds to other three conditions, *option to cancel*, *option to expand* and do-nothing option (option to *continue* as it is). These are the second branch of the path. From the second branch, the path unfolds to the final option, whether to *abandon* or not. The diagram is presented in Figure 2D.

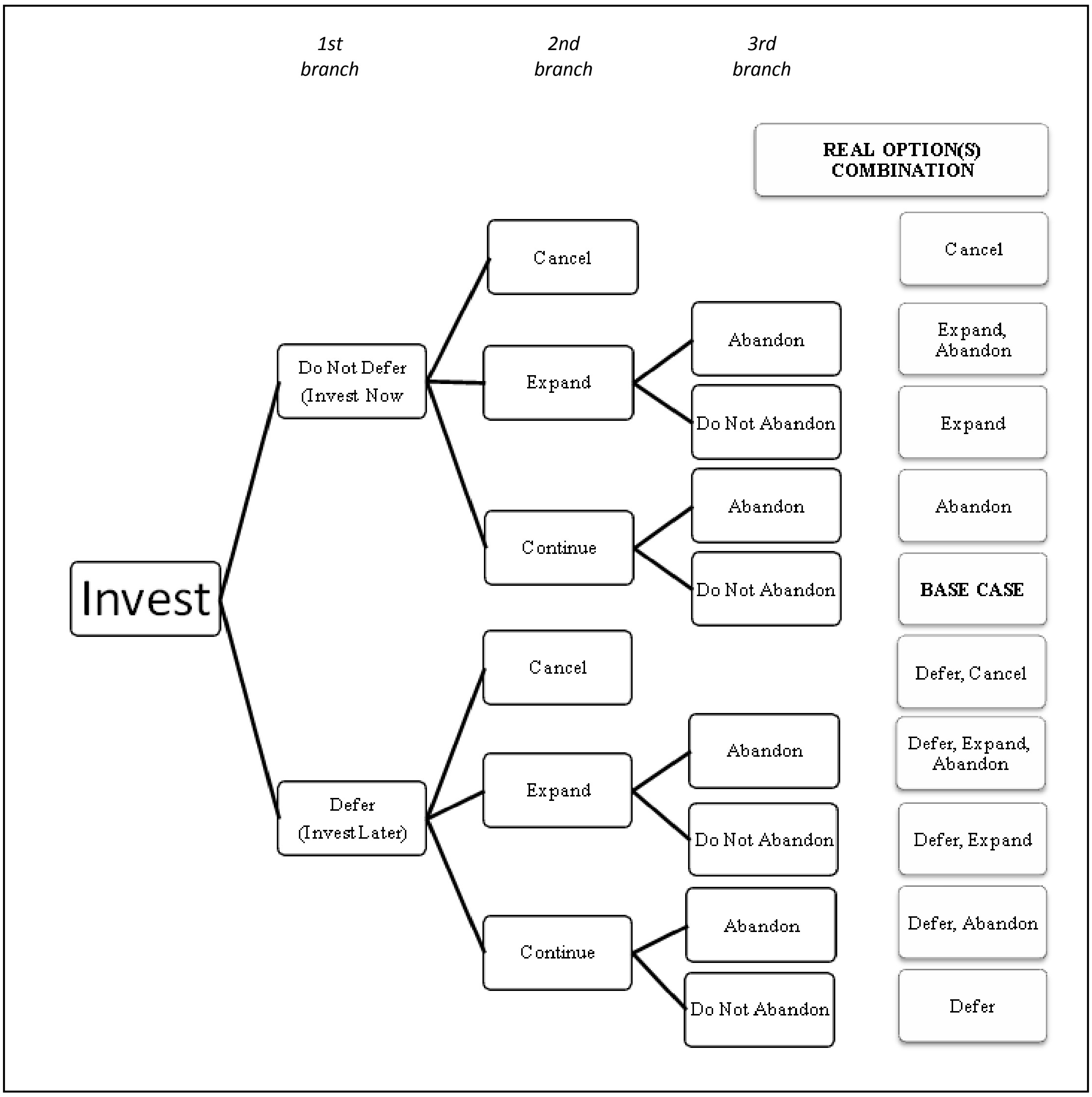


Figure 2D. Combination of Options for the Investment According to the Proposed Sequence. (Source: Own design)

The base case of Research Setting A without any option is represented by the box with BASE CASE. The path that represents this investment consists of taking the route of option not to defer (i.e. to invest now) at the first branch, then continue at the second branch and do not abandon at the third branch.

In our case study, there are four individual options. To embed an option individually into the initial investment, managers have to refer to the tree diagram. For example, the investment has to be postponed to the year t_1 and operation follows with neither expansion nor abandonment being incorporated, which represents the individual option to defer. Thus, the path is to opt for *defer* in the first branch, *continue* in the second branch and *do not abandon* in the third branch.

Referring to the tree diagram in Figure 2D also, it is obvious that there are possibilities that an option is combinable with another. For instance, despite from the original base case, first, the firm has an option whether to invest now or defer investment. By choosing an option to invest, it opens up to more options. After investment is taken, the firm may choose to cancel it during construction. However, by exercising the option to cancel construction, it closes the opportunity of incorporating other options in the future. Contrariwise, if construction proceeds, managers may exercise the options to expand and/or abandon the investment.

Taking another situation for reference, after carrying out the proposed investment as plan now (at $t_{0)}$, management decides that it is worth to consider expanding the project after two years of operation, i.e. in t_4. However, the feasibility of such expansion is still uncertain. Therefore, incorporating a future plan of expansion in t_4 today allows management to put aside financial allocation so that when the option is available to be exercised in later days the resources are all available. However, since information and development of the steel market fluctuate, it is too soon to be concrete. Possible risk of such expansion is also being cushioned up with the possibility to abandon the whole project after expansion has been taken. By this, the plant is diverted to another usage and the initial investment can be partially recovered. This path follows the expand-abandon route of Figure 2D which combines two individual options together.

Having a tree diagram to illustrate the path of investment and its possible options has the advantage of identifying the maximum number of options combinable. Therefore, it eliminates assessment of condition which is totally impossible – a situation that allows all four individual options being combined together.

From the pre-determined conditions of individual options created to be embedded in the investments, Figure 2D also shows that the maximum number of options that can be combined is three (3). This combination is obtained by following the path of the options to defer, expand and abandon.

Step 4: Risk Valuation

The next step performed in this analysis is to value risks which have been incorporated into options using ROV and integrate them into the evaluation of the project investment. The options are valued individually and collectively as combinations of several options using *DerivaGem*. The valuation process is a capital budgeting activity which involves meticulous calculation processes based on scenarios that result from risk assessment processes tackled with in this section. In short, valuation process should be conducted only after risks have been assessed properly, while valuation shall be done during capital budgeting activities take place.

As the calculation of each embedded options into the project is carried out in the next chapter, Figure 2E summarizes the result[5]. From this figure, it is noticeable that the project embedded with the single option of expansion carries the highest value of all. The real option value is €3.22 million, resulting in an ENPV of €2.66 million. Overall, embedding real options into the proposed project results into a positive ENPV except for the project with the single cancellation option and the project with the options to defer and cancel.

[5] Further discussion on the results is provided in depth in the chapter Real Option and Capital Budgeting where calculation of the final figures supplied in Figure 2E is explained in detail. Reference may be made to Appendix 3A, page 63-70, for detailed calculation.

Item	Value of Option	*ENPV*	Interaction [a]
Individual option			
Defer	1.48	0.92	Not Applicable
Cancel	0.17	-0.39	
Expand	3.22	2.66	
Abandon	1.17	0.61	
Value with two real options			
Defer and cancel	0.23	-0.33	-1.42
Defer and expand	2.12	1.56	-2.58
Defer and abandon	1.63	1.07	-1.58
Expand and abandon	1.81	1.25	-2.58
Value with three real options			
Defer, expand and abandon	2.37	1.81	-4.14

[a] The value of the combined options minus the sum of separate values i.e. (defer and expand) – (defer + expand).

Figure 2E. Values of Options, ENPV and Interactions. (€ in millions)

2.5 CONCLUSION

With the capability of real options valuing investment and evaluating it with all captured uncertainty completed with flexibility, it is possible to integrate risk management into strategic planning. Risk and flexibility are translated by providing opportunity for managers to defer, cancel, expand and abandon investment (Triantis, 2000). It is also important for managers to understand that having optional commitments to mitigate risks from various uncertainties can help firms to avoid losses and enhance firms' value.

Risk management process using ROV as a tool starts with analysing business characteristics. Risks in the business environment are then identified and assessed before being valued. The results obtained from these steps are taken as a benchmark in strategy formulation. Once uncertainties become clearer and plain, managers will choose the best strategy to be executed that suits to their firm's interest by following the tree diagram plotted as per Figure 2D. When an option is exercised, the whole process of risk management needs to be performed again in order to identify additional/new risk, assessed and valued before a new set of strategic planning is formulated. This process will continue along during the project's life and span over time.

Assessing risk qualitatively and assigning quantitative value requires of a meticulous analysis of the business environment. Previous practices assess risk qualitatively. Among these various qualitative approaches, SWOT analysis for example, helps in identifying strength and opportunity that can be exploited.

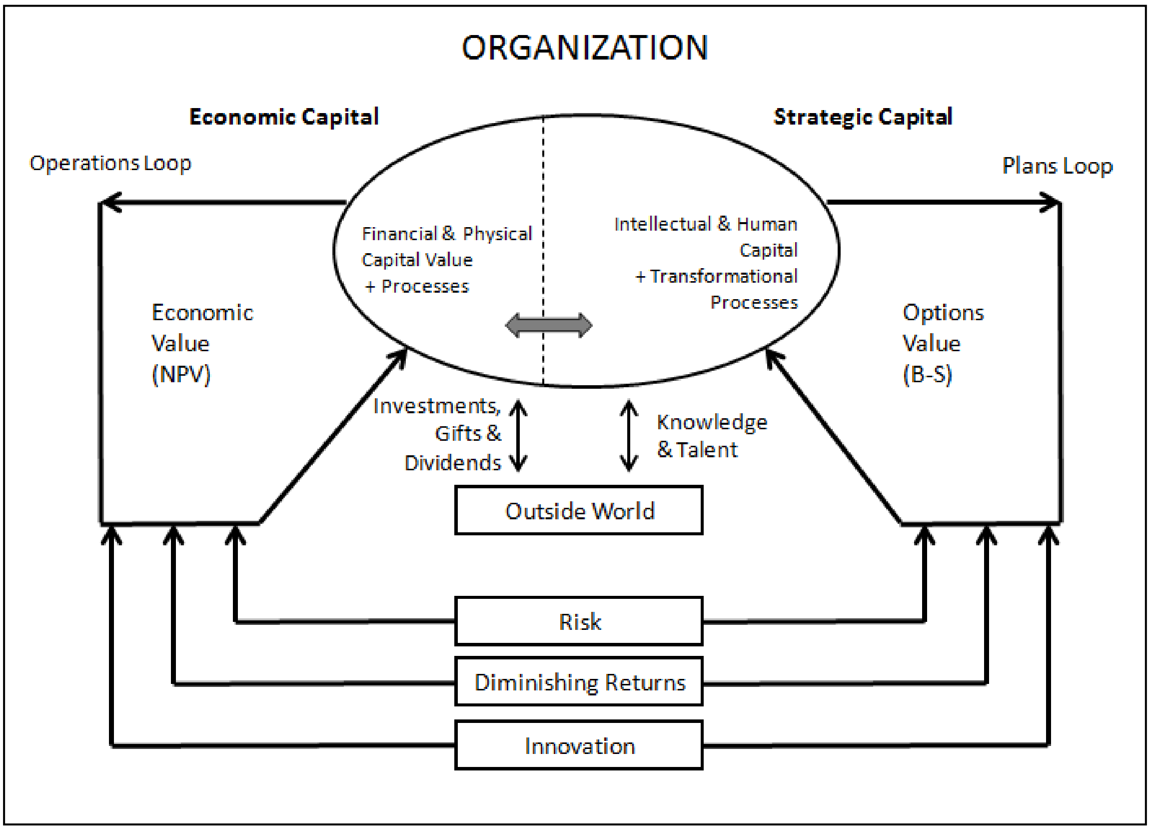
Adding quantitative elements into qualitative assessment on risk, supports risk management practices. While weaknesses are overcome, threat is flipped to become an opportunity and is being tackled positively. Approaching risk assessment activity through real options adds extra value to the normal practice of SWOT analysis. Before, SWOT analysis provides qualitative intuition for strategy formulation. Then, with real option this qualitative intuition is quantified and becomes more meaningful.

From the whole process of managing risk analysed using ROV, it is concluded that real options are a useful risk management tool. With high potential, free of cost in most of the cases or with low cost, ROV proves to be a cheap tool that suits SMEs limited budget perfectly.

The advantages of ROV are higher compared to financial hedging as real options open more opportunities. In some cases, risk hedging is only possible with real options for uncertainties in technical aspects, competitiveness issues, legal/taxation regulations and fluctuation in demand. However, it does not mean that financial hedging should be eliminated in total. Projects with financial hedging back up contracts in currency exchange or interest rates would be more secure with the complementary of real options.

Including real options as part of risk management is beneficial. Real options help to minimise risk by conquering it and maximise firm's value, proven against the risk paradox (Bowman, 1980; Bettis, 1983). Strategic practices adapt skilful, rigorous and continuous activities of risk management allowing firms to enjoy higher profits (Bettis, 1983) and ROV is seen as a highly potential tool for this purpose.

APPENDIX 2A: Total Model Value (Boer, 2002)



Total Value Model (as presented in diagram above) values businesses from two different dimensions. Business environment is divided into two segments, which are economic capital and strategic capital. DCF analysis is use to evaluate the economic value of the company while real options method is used to value the strategic value. Adding both economic and strategic values result in the total value of the company.

The model is applicable to all types of business, from riskier to less risky. Based on this model, a firm is able to transform its strategic capital into economic capital by exercising or selling real options. It also has the inverse capacity to transform economic capital into strategic by purchasing real options.

One of the elements that exist in both dimensions is risk, which affects both operational and strategic loop of organizations. Strategically as time, volatility and risks affect business value, it is important to reduce risk faces by businesses. However, risks associated with strategic capital are more important but complex to manage compared to risks associated to economic capital.

Chapter Three

REAL OPTION AND CAPITAL BUDGETING[1]

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[1] The first version of this chapter has been presented as *Master Thesis* of the Research Master in September 2010. The same version also has been accepted at the 2nd International Conference on Economic and Management Perspective (ICEMP, October 2010) in Famagusta, Cyprus.

Further versions of this chapter have been presented at other three international conferences:

- XXI Jornadas de Hispano-Lusas, February 2011, in Córdoba, Spain;
- Financial Management Association (FMA) European Conference, June 2011, in Porto, Portugal; and
- Real Option Group 15th Annual International Real Option Conference, June 2011, in Turku, Finland.

The most advanced version of this chapter is currently under review to be published at an international Asian journal.

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Complex components of investment projects can only be analysed accurately if flexibility and comprehensive consideration of uncertainty are incorporated into valuation. Discounted cash flow (DCF) analysis has failed to cope with strategic future alternatives that affect the right value of investment projects. Real option valuation (ROV) proves to be the right tool for this purpose since it enables to calculate the enlarged or strategic Net Present Value (*ENPV*). This study attempts to provide an insight of the usage of ROV in capital budgeting and investment decision making processes of SMEs. Exploring into the first stage processing of steel industry, analysis of alternatives to cancel, to expand, to defer or to abandon is performed. Completed with multiple options interaction and a sensitivity analysis, our findings prove that the application of ROV is beneficial for complex investment projects independently from the size of the company and particularly suitable in scenarios with scarce resources. The application of Real Option Valuation (ROV) is plausible and beneficial for SMEs to be incorporated in the strategic decision making process.

3.1 INTRODUCTION

Since the first applications of option theory to real investment analysis, real option valuation (ROV) has been showing its power and benefit in valuing managerial flexibility accurately (Brennan and Trigeorgis, 2000; Copeland and Antikarov, 2001; Dixit and Pindyck, 1994; Trigeorgis, 1996). This approach, which has proved to deserve attention in sectors such as natural resources related projects, land and real estate development, electric sector, construction of large-scale infrastructures and energy-generating plants, pharmaceutical and biotechnological industries, research and development strategies, start-up ventures, Internet companies, capital intensive industries (such as airlines and railroads) and other industries subject to volatile demand (consumer electronics, toys, machine parts) or supply (oil and electric power facilities, chemicals, crop switching), among others, allows managers to price different alternatives throughout the project's life before formulating their path of strategy in investment activities.

Real option valuation (ROV) extends the valuation of the Net Present Value (*NPV*) based on discounted cash flows (DCF) to the Enlarged (or Strategic) Net Present Value

(*ENPV*)[2]. Although many decisions in capital budgeting are dominated by the *NPV*, it is obvious that this method is insufficient to capture the whole complex nature of investment projects (Ross, 1995), let alone to provide tools to value managerial flexibility. Real option valuation takes care of these flaws by adding into the traditional *NPV* the value of flexibility calculated as the value of one or several real options.

$$\textit{Enlarged (or Strategic) NPV or ENPV} = [\textit{NPV} + \textit{Real Option(s)}] \qquad [2A^3]$$

As managerial flexibility is important and complex, several issues are being highlighted in the valuation methodology. Brennan and Schwartz (1985a, b), Trigeorgis and Mason (1987), and Trigeorgis (1990), for example, apply real option valuation to investments related to natural resources and underlay the importance of managerial flexibility. Pindyck (1991) emphasizes the issues of irreversibility and uncertainty into investment valuation. Learning from microeconomic theory, McDonald and Siegel (1985) incorporate the importance of having an option to shut down a project and apply the idea to real option valuation. They also identify (1986) the value of waiting to invest, resulting in a comprehensive illustration of deferring investment. Similar issue and importance are also being highlighted by Majd and Pindyck (1987). Since then, other real options have been defined to value managerial flexibility and the pricing formulae or methodologies to calculate them have been established. Real option approach has proved to be important – and sometimes even critically crucial – in many strategic investment decisions.

When real option valuation has been applied to price strategic components of complex projects, these were specifically large-scale investments undertaken by multi-national enterprises (MNEs). This chapter contributes to the literature in this field proving that this methodology can also be very useful for SMEs' managers. A new practicability of real option valuation of flexibility is presented based on the first stage processing of steel industry, an activity undertaken by SMEs worldwide. It is a heavy industry sector which has connection with natural resources. The unique characteristic of this sector is

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[2] *Enlarged NPV* (*ENPV*) and *Strategic NPV* (*SNPV*) convey the same idea of extended *NPV*. Both names have been used alternately by many authors (see, for example, Smit and Trigeorgis, 2004).

[3] This equation has been introduced for the first time in Chapter 2, p 29.

that both input and output prices follow random walks, which implies that firms do not have (total) control over them. Furthermore, more firms are managing their operations in small scale according to mini-mill systems. More and more small firms are participating in the supply chain networks, hence creating a significant percentage growth of the whole SMEs involvement in the industry.

Therefore, besides an attempt to apply real option valuation into a specific sector of industry that has not attracted the interest of researchers (and practitioners) up to now, this chapter is also tackling ROV for small scale sector, might it be a business unit, subsidiary or SME. The case study approach of the research applies a valuation methodology that does not differ from ROV applied in the analysis of large-scale investments when discrete-time treatment is used. The objective is to show that real option analysis is also feasible for SMEs managers. Thus the convenience to apply ROV does not depend on the size of the company undertaking the investment project but on the degree of complexity of the project itself. Disregarding ROV when the nature of the project requires sophisticated methodology can only lead to undervaluation, independently from the size of the company.

More precisely, in this chapter we aim to answer three basic questions. Firstly, in the evaluation of projects undertaken by SMEs, how can the high degree of uncertainty about input and output prices as well as reserves quantity be incorporated appropriately? Secondly, why does *NPV* fail to cope with strategic decision making valuation of small scale investment projects in the steel industry? Finally, how do real option valuation (ROV) and the *enlarged NPV* (*ENPV*) contribute to access the optimal policy approach to continue, expand, defer or abandon natural resource investments, also in the case of investments undertaken by SMEs such as the one addressed in this chapter? For these reasons, a mini-mill iron smelting project, potentially being carried out by small businesses in the steel industry, has been chosen as a subject of study.

This chapter is organized as follows. Section 3.2 summarizes some literature review relevant to the topic. Methodology is explained in Section 3.3 and a ROV analysis is undertaken to obtain individual and multiple interacting option values. A sensitivity analysis is applied in Section 3.4 to show the broad scope of alternatives available to managers in this subsector of the steel industry when the project has to be flexible against changes in the risk-free rate and volatility. Finally, Section 3.5 discusses this chapter's findings and Section 3.6 concludes with some remarks about strategic management of flexibility, focusing especially on SMEs in whatever an economic context – expansion, stagnation or recession – they have to perform.

3.2 LITERATURE REVIEW: REAL OPTION AND CAPITAL BUDGETING

The discounted cash flow (DCF) method that leads to the calculation of the traditional *NPV* is the approach that dominates capital budgeting analysis (Ross, 1995). However, due to the inability of DCF to capture the whole nature of complex projects, often these calculations lead to undervaluation of investments in different economic sectors. New proposals to deal with these problems started to appear in the 1980s, once option pricing of financial assets had been consolidated during the previous decade. This meant the birth of real option valuation techniques, which since then have proved to be a powerful and prospective tool to solve strategic decision making successfully.

The key year for the inception of option theory is 1973, with the publication of the Black-Scholes model to value *European options* and the Merton model to price *American options*. Afterwards, more researchers enriched option theory. The introduction of fundamental economic principles of option pricing by arbitrage methods and simple numerical procedures for valuing options have been made by Cox and Ross (1976) and Cox, Ross and Rubenstein (1979). The design of more complex option contracts, known as non-standard options or *exotic options*, enlarged the scope. Some exotic options such as i) *compound options* – which are options on options (Geske, 1979); ii) *Asian options* – where the payoff depends on the average price of the underlying asset during at least some part of the life of the option (Kemna and Vorst, 1990); or iii) options to exchange one asset for another, also referred to as *exchange options* (Margrabe, 1978), do not only play an important role in financial option strategies but have also proved to be extremely useful in real option valuation (ROV).

ROV incorporates the financial assets valuation approach into the evaluation of investments in capital budgeting analysis. It is a powerful tool as it captures the project's nature and uncertainty comprehensively, enabling for a good valuation of managerial flexibility. As stated in equation [1], the enlarged *NPV* (*ENPV*) – calculated as the sum of the traditional *NPV* discounted at the risk-adjusted rate of return plus the value of the real option(s) involved in the project's nature – becomes the right measure to be taken into account by managers.

Besides being applied in investments related to natural resources, many other economic fields also profit from ROV methodology. Just to quote some contributions, among many others: Kellogg and Charnes (2000) in valuing a biotechnology company, Schwartz and Moon (2000) pricing an Internet company, Grenadier and Weiss (1997) valuing investments in technological innovations, Alonso, Azofra and de la Fuente (2009) studying an electric company, and Willigers and Hansen (2008) analysing a pharmaceutical industry.

The application of real options into investment analysis is expanding. It proves to be useful, in particular because it is capable of capturing uncertainty and real project's nature, which also includes providing managerial flexibility. By flexibility we may understand a wide array of alternatives, individually or combined: options to defer, alter, switch, abandon or shut down activity in variety of industries.

In mining of iron and similar minerals like gold and copper, the options available are the *operating option* and the *closing option* (Brennan and Schwartz, 1985a, b). The operating option deals with the decision to either operate or to shut down temporarily and later re-open the mines. The closing option allows firms to premature abandonment of the mine, if variable cost becomes higher than revenue; or permanent abandonment due to mine exhaustion. The options explored are different compared to oil and gas industry, where firms have staging option in mining (Smit, 1997; and Paddock, Siegel and Smith, 1988) due to business characteristics.

General options in production or investment decision are discussed by scholars such as Amram and Kulatilaka (1991), Trigeorgis and Mason (1987), and McDonald and Siegel (1986). Firms firstly have the *timing option*, which deals with timing flexibility to defer investment. Hence, firms get some timing allowance to delay investment. Similarly, the *staging option* also gives this allowance, but in order not to miss the opportunity to enjoy market growth, firms are investing stage-by-stage, waiting for signals and reaction towards investment made. By this, managers count with more options to continue or expand, to grow, to delay, to abandon for salvage value or to switch (inputs or outputs) along the whole investment plan.

The *growth option* allows firms to consider the opportunity to penetrate into another market. On the contrary, the *option to expand* requires additional investment to increase capacity so that firms are able to meet demand increments. The *option to contract* allows firms the opportunity to produce at smaller scale. Along the way, if the project produces unsatisfying results, firms have the *option to abandon or exit* in order to minimize accumulated loss.

Switching options (Kulatilaka and Trigeorgis, 1994) open a wider flexibility in a project, either in input or output switching. Input switching would allow firms to alternate between two or more inputs. For example, in steel industry, heat is generated by two sources – fossil fuel and bio-fuel. When one fuel price increases more than efficient band, firms have the opportunity to curb the increased costs by switching to another type of fuel. Output switching on the other hand allows firms to redirect production according to demand.

Another option is the *flexibility option*. Flexibility option is usually exercised when firms have two different plants in different continents. This option allows firms to enjoy different production costs, different demand curves and exchange rates. The *operating option* does not have this flexibility. Instead of producing, it gives flexibility to firms to outsource rather than to produce. The *learning option* is mostly practiced by firms wanting to test market penetration of new products before launching a large-scale marketing and advertising campaign.

All the above suggest the possibility of applying real option analysis in the first stage processing sector of the steel industry. However, few studies have been conducted in this economic field. Cortazar, Schwartz and Salinas (1998) have conducted a very close case study of options available for steel industry. Their study in a smelter plant identified options to expand, to close and open a plant based on maximum capacity, to temporary closing as well as to contract. In order to identify the possible suitable options available for this particular sector, it is important to first analyse the nature and characteristics of a business before incorporating real option valuation, which has been the base of the study as illustrated in detail under the introduction chapter as Research Setting A.

3.3 METHODOLOGY

The research conducted in this study follows a stylized fact case study approach as exploratory research following Cooper and Slagmulder (2004). The approach is similar to other studies in the field of real options, such as Brennan and Schwartz (1985a, b), Dixit and Pindyck (1994) and Trigeorgis (1996), in the case of natural resource activities. This approach requires of the construction of a base case with various sources of information representative in a worldwide scenario.

The project chosen for the evaluation is an investment in first stage steel processing, a mini-mill smelting project as per **Research Setting A** in Chapter 1. To sum up, there is a new proposal of building up an iron smelting plan based on new process innovation, mini-mill iron smelting. The investment requires €10 million, €6 million in t_0 and €4 in t_1. By investing this amount, the firm will have a mini-mill plant with capacity of producing 182000 tons per year. However, due to Kyoto Protocol, the plant is allowed to produce only up to 75% of its capacity in order to maintain emission and effluent at minimum level.

The investment has an expected useful life of 10 years. 2 years are dedicated for construction and the rest 8 years are operational. Volatility is forecasted to be $\sigma = 30$ %. Two discount rates are employed which are 5% of risk-free rates and 12 % of adjusted-risk rate. Holding to this information, discounted investment cost is *I*, is €9.81 million while discounted net cash flows, *V* is €9.25 million resulting in NPV of €-0.56 million (*negative NPV*).

Analyses conducted in Chapter 2 have added 4 individual options to the case. Instead of investing €9.81 million and getting return of NPV €-0.56 million (*negative NPV*), the investment is now embedded with option to defer, option to cancel during construction, option to expand and option to abandon. The scenario is illustrated as per Figure 3A.

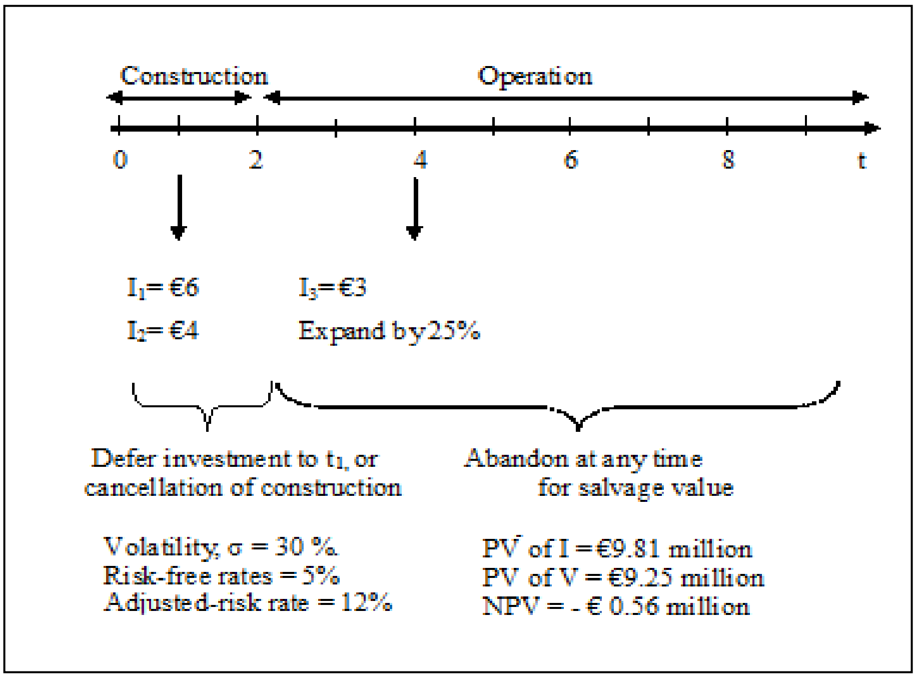

Figure 3A. Investment Project with Expected Option of Deferring Investment, Cancellation during Construction, Expansion and Abandonment. (Source: Own design)

Analysis and Calculation

The analysis and calculation follows the log-transformed binomial lattice approach developed by Trigeorgis (1991). The framework of the valuation is illustrated in Figure 3B. Calculation is performed by software *DerivaGem*[4]. The usage of this software has been precisely chosen to contribute to the aim of this chapter, i.e. showing that, if such

[4] *DerivaGem* is valuation software available as a complement with the textbook by John Hull (2009). However, there are many real option pricing softwares available in the market. Simple real option pricing method softwares are usually available for free and can be obtained as complement of textbook or online. Meanwhile, expensive real option pricing softwares are usually more detailed, complex and apply complicated custom-made mathematical models completed with simulation, like Real Option Analysis Toolkit by Jonathan Mun (2006).

In this study, simple software is used to render simplicity and enhance understanding of a complex valuation methodology. If complex software were used, it is afraid that it would expunge the objective of the study.

competitive valuation software is available in the market and firms' managers have a sound knowledge of the industry they are performing in, it is feasible to apply ROV as a valuation tool independently from the size of the company.

Step 1	Initial parameter specification *V, r, σ, T, EX′s (I′s)* and *N* Additional parameter specification cash flows (amount and timing), and real option data
Step 2	Preliminary (sequential) calculation of *K, μ, H* and *P*
Step 3	Determination of terminal values (at *j=N*) For each state *i* Asset (project) value : $V(i) = e^{iH}$ Opportunity value (with embedded options): *R(i) = max [V(i), 0]*
Step 4	Backward interactive process For each time step *j* (*j=N*,.....1) and every second state *i*, Calculate opportunity values (using information from step *j+1*) $R'(i) = e^{-rk/\sigma^2}\,[PR(i+1) + (1-P)R(i-1)]$ --- Adjustment for any cash flows (dividends) At each cash flow (ex dividend) time, determine downward extension of triangular path and shift (*ε*) for each state of index *i* $R'(i) = R(i - \varepsilon) + CF$ At each cash flow (exercise) time: $R'(i) = R(i) - I$ --- Adjustment for any multiple real options At each time a real option is encountered, opportunity value is revised as indicated

Figure 3B. Flow Chart for Applying the Log-transformed Binomial Algorithm.

(Source: Trigeorgis, 1996, p. 323)

3.4 ANALYSIS AND RESULTS[5]

3.4.1 Individual Options

The real options involved in our case study are built up based on the characteristics and nature of a standard mini-mill iron smelting plant. The four options are developed as per chapter 2 and explored as follows:

Option to defer (Tourinho, 1979; McDonal and Siegal, 1986; and Paddock *et al*., 1988), is valued as an American call, where the strike price is the required outlay if the investment is made in the future. This option allows project initiation to be delayed to the next year, t_1. The projected net cash flows will remain static but the cost of investment will increase by 5%. Real option value of this option is €1.485 million, representing about 16% of the gross project value. The *ENPV* of the project is €0.925 million.

Option to cancel during construction, which is valued as a compound option of a call on a put (Cortazar and Schwartz, 1993). In the case where the commodity price is unfavourable, construction can be cancelled at any time without any penalty. The firm might earn any invested amount, being discounted at the adjusted-risk rate of 12%. Once cancelled, the project cannot be deferred, expanded or abandoned (i.e., the other three options considered). The amount disinvested is taken as the strike price since it represents the saving due to discontinuation of the project. Real option value of this option is €0.17 million, representing nearly 2% of the gross project value. The *ENPV* of the project is €-0.39 million (negative *ENPV*).

Option to expand (Brennan and Schwartz, 1985a, b; McDonald and Siegal, 1985; Pindyck, 1988; Myers and Majd, 1990) is valued as a European call. This is the option to make further investment and increase production output if future conditions are favourable. The strike price of the call option is the cost of creating the additional capacity discounted over to the time of exercising it. Two years after operation, i.e. at t_4, the firm has the opportunity to increase capacity by 25% without being penalized for polluting the environment according to the Kyoto protocol. Real option value of this

[5] Detailed calculation relating to this section is presented as appendix at the end of the chapter.

option is €3.22 million, representing about 35% of the gross project value. The *ENPV* of the project is €2.66 million.

Option to abandon is valued as an American dividend paying put (Myer and Majd, 1990). This is an option to sell down or close a project where the put value is on the project´s value. Meanwhile, the strike value is the liquidation (or resale) value of the project after deducting all closing down costs. At any time during operational years, the project can be abandoned for alternative use and enjoy a salvage value of, in principle, 50% of accumulated capital outlays net of 10% average annual depreciation, being discounted at adjusted-risk rate of 12%. Real option value of this option is €1.17 million, representing about 13% of the gross project value. The *ENPV* of the project is €0.61 million.

3.4.2 Multiple Interacting Options

As already stated in chapter 2, besides these four individual options, there is possibility of two or more options being combined together. Therefore, it is important to analyse the sequence of options in order to identify any possibility of combining several real options embedded in the nature of an investment project. Smit (1997), for example, has identified the stages in a petroleum offshore concession project before valuing it.

In our case study, four possible options have been identified for the purpose of strategic investment valuation. Based on this base case, first, the firm has an option whether to invest now or defer investment. By choosing an option to invest, it opens up to more options. After investment is undertaken, the firm may choose to cancel it during construction. However, by exercising this option, it closes the opportunity of incorporating other options later. If construction proceeds, investment has the options to expand and/or abandon in later time. Figure 3C shows possible option combinations for the investment according to the sequence proposed.

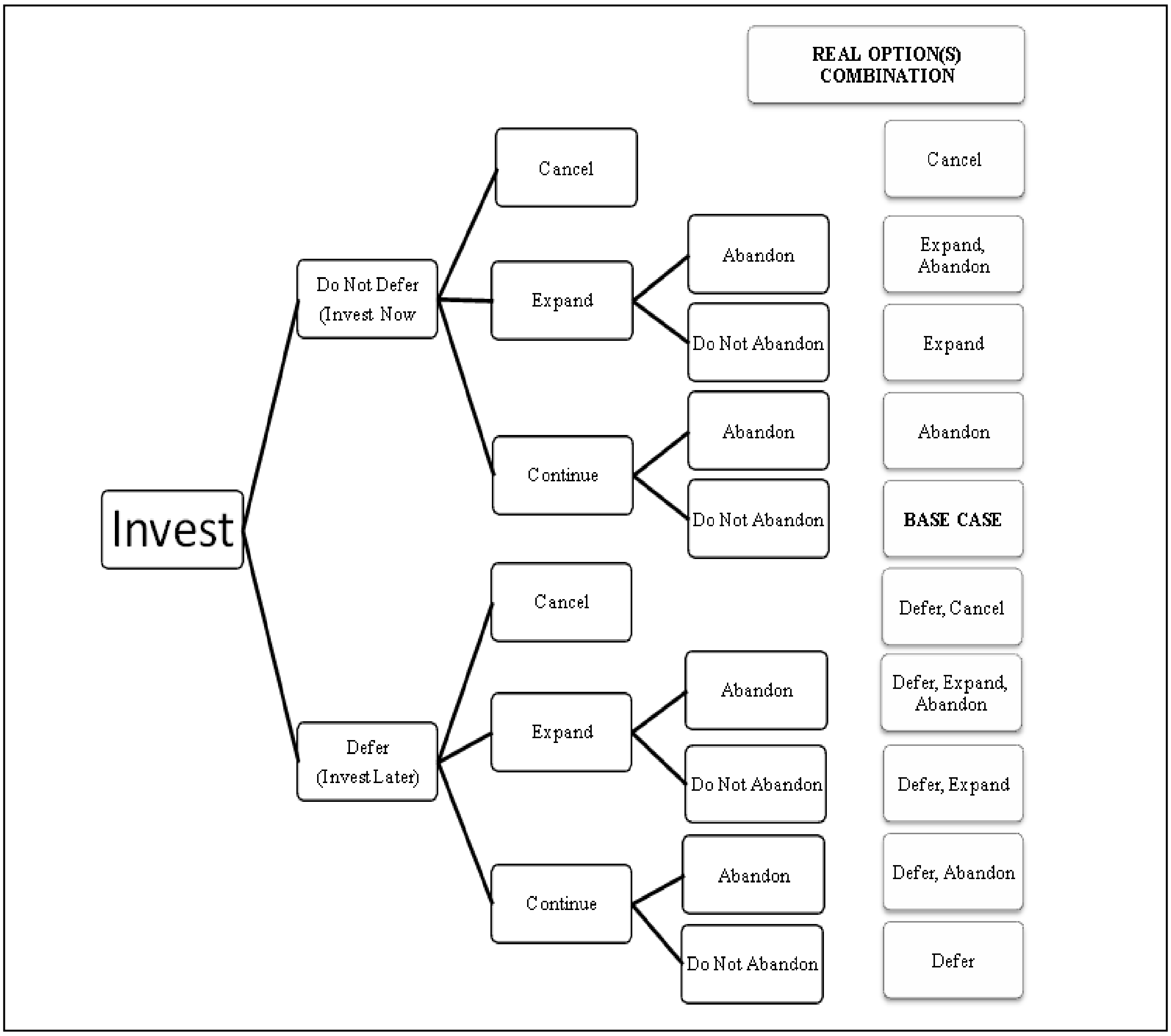

Figure 3C. Combination of Options Embedded in the Investment According to the Proposed Sequence - Viewed in a Tree Diagram. (Source: Own design)

To comment briefly, the option to expand and abandon is valued at €1.81 million, resulting in *ENPV* of €1.25 million. The options combined together are negatively interacting with individual options to expand and to abandon by €4.14 million.

The next combined option is to defer and cancel, valued at €0.23 million, resulting in an *ENPV* of €-0.33 million (negative *ENPV*). The options combined together are negatively interacting with individual options to defer and to cancel by €-1.42 million.

The third combination joins together the most possible options available for the project, which are the options to defer, to expand and to abandon. This option is valued at €2.37

million, resulting in an *ENPV* of €1.81 million. The interaction among individual options is negative €-4.14 million.

The fourth option combination is to defer and to expand, valued at €2.12 million, resulting in *ENPV* of €1.56 million. The options combined together are negatively interacting with individual options to defer and to expand by €-2.58 million.

Finally, is the option combination to defer and to abandon, valued at €1.63 million, resulting in an *ENPV* of €1.07 million. The options combined together are negatively interacting with individual options to defer and to expand by €-1.58 million. Figure 3D summarizes the results of valuation for both individual options and multiple interacting options.

Item	**Value of Option**	***ENPV***	**Interaction** [a]
Individual option [b]			
Defer	1.48	0.92	Not Applicable
Cancel	0.17	-0.39	
Expand	3.22	2.66	
Abandon	1.17	0.61	
Value with two real options [c]			
Defer and cancel	0.23	-0.33	-1.42
Defer and expand	2.12	1.56	-2.58
Defer and abandon	1.63	1.07	-1.58
Expand and abandon	1.81	1.25	-2.58
Value with three real options [d]			
Defer, expand and abandon	2.37	1.81	-4.14

[a] The value of the combined options minus the sum of separate values i.e. (defer and expand) – (defer + expand).
[b] Refer to Appendix 3A(I) – 3A(IV) for details.
[c] Refer to Appendix 3A(V) – 3A(VIII) for details.
[d] Refer to Appendix 3A(IX) for details.

Figure 3D. Values of Options, ENPV and Interactions. (€ in millions)

3.5 DISCUSSIONS

3.5.1 Impact of ROV into Project Valuation

Referring to Figure 3D on individual options, cancellation during construction option illustrates an example where adding up the value of real option does not necessarily make an investment attractive. In this case, if the investment is cancelled during construction once is has been undertaken, the *ENPV* of the project ends up being negative -€0.39 million. Yet, having an option to cancel reduces the loss.

For the rest of options, individually embedded in the project, the value of *ENPV* is positive. The most significant difference between *NPV* and *ENPV* appears when an expansion plan is considered. The expansion option gives the highest option value available for this project, which is €3.22 million and results in an *ENPV* of €2.66 million.

Combinations of multiple options may result in additive or non-additive value (Trigeorgis, 1993). Based on the case study, it is found out that the interaction among multiple options is all non-additive. The biggest interaction as stated in Figure 3D is noted when deferral, expansion and abandonment options are considered simultaneously causing a negative effect of €-4.14 million. It is identified that the cause of these negative interaction among all groups of multiple options is due to the different types of option, the period of exercising the options and the types of option being exercised earlier.

3.5.2 Sensitivity Analysis

Sensitivity analysis is a powerful complementary management tool in strategic decision-making. In this subsection we study the effect of changes in volatility and risk-free interest rate towards each option. Volatility is based on the average annual standard deviation of price fluctuation of outputs[6] that are being traded in terminal commodity

[6] Steel outputs of pig iron are in form of steel billets, rolled coil, steel plate and wire rod.

exchanges. Volatility being 30% in the base case is assumed in the sensitivity analysis to fluctuate by +/- 5% to 25% and 35%.

The second parameter, the risk-free interest rate, is based on the future prevailing yield on two- to four-year Treasury bonds. In the base case, the risk-free interest rate is 5%. Changes analysed consider the risk-free interest rate sinking to 3% (2.95588% continuously compounded) or rising to 7% (6.765865% continuously compounded). This analysis is summarized in Figure 3E, which shows the option values when volatility and the risk-free interest rate change and compares them with the base case.

For individual options, higher volatility results in higher option values while effects of changes in the risk-free interest rate depend on the type of option. Increases in the risk-free interest rate result in higher values of deferral and expansion options, denoting that both are call options. On the contrary, option values fall in cancellation during construction and abandonment reflecting the put option nature of these two real options.

For multiple options, the sensitivity analysis considered must reflect all the factors interacting during valuation. These factors depend on the types of options and the degree of overlapping of exercise regions. It has been identified that the cause of these negative interactions among all groups of multiple options is due to the different types of option, the period of exercising the options and the types of option being exercise earlier which are consistent with finding of Trigeorgis (1993).

The whole sensitivity analysis is performed with other variables held constant, and only considering only changes in volatility and the risk-free interest rate. The result is presented in Figure 3E.

From Figure 3E, it is found that the movement of option values depends on the final nature of options being exercised. For example, in deferral and cancellation, it can be seen that the values are increasing with increment of volatility rate but decrease when risk-free interest rate falls.

Risk-Free Interest Rate	Volatility 25%	Volatility 30%	Volatility 35%
Cancellation			
3%	0.13	0.21	0.29
5%	0.10	0.17	0.25
7%	0.08	0.14	0.21
Deferral			
3%	1.11	1.35	1.59
5%	1.24	1.48	1.72
7%	1.38	1.62	1.86
Expansion			
3%	3.05	3.08	3.11
5%	3.20	3.22	3.25
7%	3.34	3.36	3.38
Abandonment			
3%	1.18	1.41	1.64
5%	0.98	1.17	1.39
7%	0.86	1.04	1.21
Deferral and Cancellation			
3%	0.19	0.30	0.40
5%	0.14	0.23	0.33
7%	1.10	0.18	0.27
Deferral and Expansion			
3%	1.91	1.98	2.05
5%	2.07	2.12	2.18
7%	2.31	2.26	2.31
Deferral and Abandonment			
3%	1.64	1.81	2.00
5%	1.46	1.63	1.80
7%	1.43	1.47	1.64
Expansion and Abandonment			
3%	1.79	2.05	2.33
5%	1.58	1.81	2.03
7%	1.39	1.63	1.85
Deferral, Expansion and Abandonment			
3%	2.41	2.62	2.81
5%	2.29	2.37	2.58
7%	2.29	2.29	2.35

Figure 3E. Sensitivity Analysis on Individual Strategic Options to Reflect Changes of Volatility and the Risk-free Interest Rate. (€ in millions)

It should be noted that the changes of option value towards volatility and the risk-free rate indicate its minimum value regardless of any changes in volatility or the risk-free interest rate. In the combination of deferral, expansion and abandonment options, when the risk-free interest rate is at 7%, any volatility below 32% will not affect the option value. The option value is affected when volatility grows above 32%. When risk-free rate is 5%, option value starts to be constant at €2.29 million as volatility falls below 28%. Meanwhile, the option value started to be constant at €2.29 million as risk-free rate is 3% once the volatility falls below 23%. Figure 3F illustrates this condition, where the asymptotic behaviour of the real option value functions becomes evident.

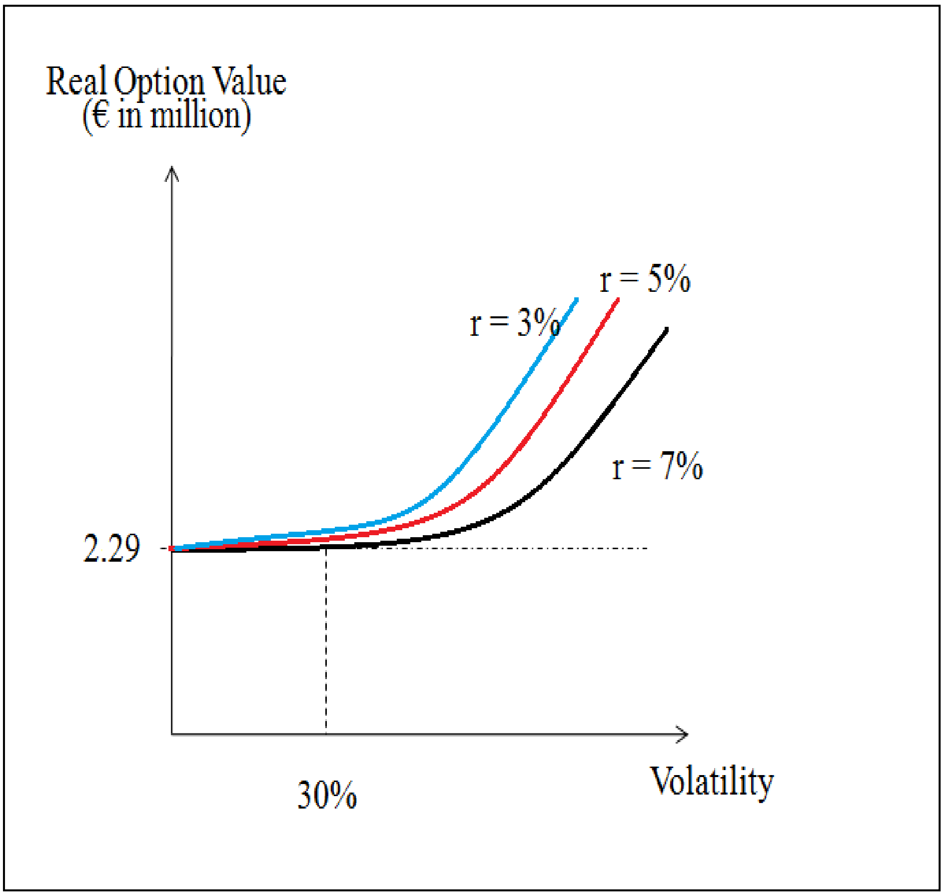

Figure 3F. Effect on Option Value to Defer-Expand-Abandon When Changes in the Risk-free Interest Rate and Volatility Occur.

3.6 CONCLUSION

The complexity of real option valuation may intimidate managers, in particular those of SMEs, and deter them from applying it. This complexity may give the impression that this method is suitable only for large firms with complex activity. Steel industry also bears the same complexity compared to other economic fields, such as mining (Brennan and Schwartz, 1985a,b; Cortazar, Schwartz and Salinas, 1998), oil and gas concession (Smit, 1997), Internet companies (Schwartz and Moon, 2000) or pharmaceutical research and development activities (Nichols, 1994), just to quote some examples.

Bearing the advantage for SMEs that activities can be staged out and carried by different smaller entities, strategic investment decision making becomes crucial in the steel industry under various circumstances. However, it is more crucial during recession because resources are scarce for all companies, particularly for SMEs especially in their attempts to have access to new financing funds. The attractiveness of steel industry arouses the interest of additional SMEs (Crone and Watts, 2000) to invest, but such investment requires careful and meticulous analysis before decision is made as SMEs do not have the same capacity to absorb losses as large firms. Furthermore, a collapse of one member in the supply chain will most probably trigger the fall of other as this industry is capital intensive and industry specific (Sato, 2000). Therefore, measures have to be taken to prevent as much as possible wrong investment decisions. In other words, the complex characteristics of the production activity in the first stage processing of the steel industry, mainly undertaken by SMEs worldwide, offers the opportunity to prove how convenient (if not necessary) ROV happens to be for the investment analysis in this industry.

Embedding options into the enlarged *NPV (ENPV)* through real option valuation (ROV) contributes interestingly to strategic management of any company and, as shown in this chapter through a case study analysis in the steel industry, of SMEs too. Uncertainty and flexibility of steel industry have to be incorporated into investment decision making, a goal that this methodology achieves. By being capable of reflecting the complex nature of steel industry, ROV becomes a highly valuable tool to support managers in their strategic investment decisions. Contribution of ROV does not only reflect the market value of the project comprehensively. It also helps managers of small businesses in steel industry to decide upon the convenience of undertaking an investment, deferring it, altering the production conditions or abandon the business activity, i.e. a wide array of situations, since this methodology is capable of pricing flexibility and strategic resource allocation accurately.

It is important for managers, especially in SMEs, to understand that flexibility has its value when it comes to investment analysis. ROV values this flexibility as options embedded in the investment project before combining them to result in *ENPV*. Yet, the traditional valuation method through discounted cash flows is not totally discarded, in fact it is being enhanced. The stylized approach applied in this chapter should be a stepping stone for SMEs' managers to realize the scope of the benefits of ROV. Furthermore, the existence of different software programmes easily available in the market – like *DerivaGem* used in this chapter – turn applying ROV into a feasible decision making tool for SMEs' managers.

ROV provides solutions to managers' dilemmas about capital budgeting decision making and helps them efficiently in the evaluation of alternative future scenarios in any conditions – growth or contraction, market boom or recession, even at any point of the firm's learning curve. The advantages are not linked to the size of companies but to the complexity of the investment projects that are being analysed, making it more attractive, competitive and meaningful compared to the traditional *NPV*.

APPENDIX 3A: Detailed Calculation of Option Valuation

Appendix 3A(I): Deferral Option

Deferral option allows the investment to be postponed to the next coming year (t_1) without the firm losing its opportunity and competitiveness except for an increment in investment cost of 5%.

V = €9.25 million
K = €10.5 million
Option price = €1.485 million.

$ENPV$ = €-0.56 million + €1.485 million = €0.925 million

Appendix 3A(II): Cancellation Option

The firm has the option to cancel construction at any time and earn 50% of the invested amount of capital outlays during the construction period. If the firm has spent €6 million and later decides to cancel construction at the beginning of year 1, the present value of cancellation, K_{C1}, and K_{CN} are:

$$K_{C1} = 6(50\%) = €3 \text{ million}$$
$$K_{CN} = K_{C1} + [4(50\%)]/1.12 = €4.79 \text{ million}$$

So,
V = €9.25 million
K_{C1} = €3 million, K_{CN} = 4.79 million
Option price = €0.17 million.

$ENPV$ = €-0.56 million + €0.17 million = €-0.39 million (negative ENPV)

Appendix 3A(III): Expansion Option

In order to increase production rate up to its maximum level without being penalised due to over-polluting the environment, the firm plans to add another investment of €3 million in t_4. With this additional investment, revenue will increase by 25% in a year after the project is completed, i.e. t_5. The additional cash flows received – both gross and discounted – are presented in Table B3-1**.**

Table B3-1: Revenue (*V*) of expansion option - gross and discounted (€ in millions).

Year	**Additional Gross Revenue**	**Less: Additional Variable Cost**	**Additional Net Cash Flows**	**Additional Discounted Cash Flows**
5	13.65	11.375	2.275	1.291
6	13.65	11.375	2.275	1.153
7	13.65	11.375	2.275	1.029
8	13.65	11.375	2.275	0.919
9	13.65	11.375	2.275	0.820
Total *V*				5.212

V= €5.21 million

Additional investment, K_A = €3 million / (1.05) = €2.47 million.

Option value = €3.22 million

ENPV = €-0.56 million + €3.22 million = €2.66 million

Appendix 3A(IV): Abandonment

Table B4-1. Calculation of depreciation of *V* (€ in millions).

Year	Investment *(I)*	Depreciation	Discounted depreciation at 12%
0	6		
1	4		
2		1	0.797
3		1	0.711
4		1	0.635
5		1	0.567
6		1	0.506
7		1	0.452
8		1	0.403
9		1	0.360
K (50% of *I*) = 5		Total *V*= 4.435	

V = €4.435 million

K = €5 million

Option value = €1.17 million

ENPV = €-0.56 + €1.17 = €0.61 million

Appendix 3A(V): Deferral and cancellation

Table B5-1. Deferral cost and net cash flows at t_1.

	Deferral cost		Cancellation revenue	
Year	Actual	Discounted	Actual	Discounted
1	6.3	6.0	3.0	2.8
2	4.2	3.8	2.1	1.7
		$V = 9.8$	$K_{CN} = 4.5$	

V = €9.8 million

K_{C1} = €2.8 million, K_{CN} = €4.5 million

Option price = €0.23 million.

ENPV = €-0.56 million + €0.23 million = €-0.33 million (negative ENPV)

Appendix 3A(VI): Deferral and expansion

Table B6-1. Expansion cost and net cash flows after project has been postponed to the next period.

	Investment		Net cash flow	
Year	Actual	Discounted	Actual	Discounted
5	3.150	2.468		
6			2.275	1.152
7			2.275	1.029
8			2.275	0.919
9			2.275	0.820
	$K = 2.4$		$V = 3.92$	

V = €3.92 million

K = €2.4 million

Option value = €2.12 million

ENPV = €-0.56 + €2.12 = €1.56 million

Appendix 3A(VII): Deferral and abandonment

Table B7-1. Deferral cost and depreciation.

Year	Investment *(I)*	Depreciation	
		Actual	Discounted
1	6.3		
2	4.2		
3		1.050	0.747
4		1.050	0.667
5		1.050	0.595
6		1.050	0.531
7		1.050	0.474
8		1.050	0.424
9		1.050	0.378
	10.5	V = 3.82	

V = €3.82 million

K = 50% of I = €5.25 million

Option value = €1.63 million

ENPV = €-0.56 + €1.63 = €1.07 million

Appendix 3A(VIII): Expansion and abandonment

Table B8-1: Present value of depreciation, *V* (€ in millions).

Year	Depreciation	Present Value
2	1	0.797
3	1	0.712
4	1	0.636
5	1.3	0.738
6	1.3	0.659
7	1.3	0.588
8	1.3	0.525
9	1.3	0.469
Total *V*		5.124

V = €5.124 million

K = 50% of *Investment* = €5 million

Option value = €1.81 million

ENPV = €-0.56 + €1.81 = €1.25 million

Appendix 3A(IX): Deferral, expansion and abandonment

Table B9-1: Present value of total investment, *I* and depreciation, *V* (€ in millions).

Year	Investment (*I*)	Depreciation	
		Actual	Discounted
1	6.30		
2	4.20		
3		1.050	0.747
4		1.050	0.667
5	3.15	1.365	0.774
6		1.365	0.691
7		1.365	0.617
8		1.365	0.551
9		1.365	0.492
	13.65		*V* = 4.541

V = €4.541 million
K (50% of *I*) = €6.825 million
Option value = €2.37 million

ENPV = €-0.56 + €2.37 = €1.81 million

Chapter Four

REAL OPTION AND STRATEGIC MANAGEMENT[1]

[1] A paper based on this chapter is currently under review at an academic journal specialized in management.

Many businesses are actively managing their strategy to improve corporate activities and portfolios performance but the practice is sadly uncommon in the case of small- and medium-sized enterprises (SMEs). With limited resources and capacity, requiring good measure to survive is very crucial for SMEs. While the current approach of strategic planning demands consistent consideration of environmental changes, financial policy and evaluation methodology that act as the basis of strategic formulation fail to incorporate these. With the emergence of Real Option Valuation (ROV), the problem is overcome. Taking into account uncertainties and flexibility, the methodology allows identification of value drivers and measure value creation in form of real options. Based on ROV and equipped with Option Metrics Space, managers are able to obtain quantitative and qualitative information on two main investment dilemmas, to invest or not to invest, and when, and at the same time match the decision to their limited resources and capacity. Seen as a better approach, incorporation of ROV into strategic planning values proposed project as a multi-stage operation, dynamically assessed over time rather than broken into several pieces. As a result, managers especially from SMEs are able to decide whether an investment is worth undertaken when resources are limited and critical.

4.1 INTRODUCTION

Strategic management is viewed as a process which actively developing and managing corporate portfolios. In the past decades, the development has resulted in two fundamentals which ironically contradict each other (Spenser and Brander, 1992; Ghemawat and del Sol, 1998). The first view, originating from resource-based (RBV), emphasizes that firm should invest in resources that create more advantages, efficiency and competencies (Penrose, 1959; Rumelt, 1984; Teece, 1984; Wernerfelt, 1984. The second, viewed from the point of organizations economics and game theory - resulted in understanding that strategic flexibility is valuable in assessing constantly changing business environment to obtain better opportunity, payoffs and shareholder wealth (Smit and Trigeorgis, 2006). However sometimes, the organization economists´ view that is not worth due to several tradeoffs between competencies and strategic value in competitive setting (Schelling, 1980; Shapiro, 1989). Therefore an “alignment” is needed to ensure optimum decision to react to business environment with limited capacity.

The key issue in strategic management is users emphasize more on RBV and attach it to discounted cash flow (DCF) based analysis to decide on the best investment but attaching the results are into organization economists' principles of choosing the optimum investment for the purpose of obtaining strategic value in competitive setting. Unfortunately, DCF fails to incorporate uncertainties, is very rigid and unable to connect between the two views.

The question above has flashed an obvious gap between financial and strategic management as highlighted by Myers (1984). Capital budgeting process dominated by DCF does not match to strategic approach. In order to solve the problem, real option has proven to be the methodology that links financial and strategic management.

The practice above is not only being applied by big firms. It is also being practiced by some SMEs, which along time receive an increase importance in generating the economy. In order to achieve optimal performance, growth and survival within limited capacity and resources, SMEs have to plan strategically (Berry, 1998). Despite of endless findings on the positive relationship between strategic planning and firms' performance, only small number of SMEs practice strategic planning (Orser, Hogarth-Scott and Riding 2000; Sandberg, Robinson and Pearce 2001; Beaver 2003). SMEs who practice strategic planning usually have higher probability to success and able to prevent failures (i.e. involuntarily wound up) (Gaskill, van Auken and Manning 1993; Perry 2001).

For SMEs whom do not practice strategic planning, usually they planning `system´ is more towards short term goals rather than long term (Jones, 1982; Gaskill, van Auken and Manning, 1993; Brouthers, Andriessen and Nicolaes, 1998; Stonehouse and Pemberton, 2002; and Mazzarol 2004). SMEs managers are usually reactive rather than proactive. As a result, most SMEs' strategic planning are frequently *ad hoc* and intuitive without careful analysis, thus providing less measured or analysed performance (Kelmar and Noy 1990).

Nowadays, due to the importance of SMEs in economic engine, back-up by many governmental economic policy, SMEs are seen as the entity that requires a critical strategic practice (Wang, Walker and Redmond, 2007). If SMEs continue neglecting strategic practice, full performance and potential growth are far from reach thus putting survival at risk (Berry, 1998). Therefore, with the emergence of real option, SMEs should be able to exploit the methodology for survival and growth. Real option is able to deal with high uncertainty and flexibility, providing the optimum resource allocation to reach strategic mission along time. However, seen as a sophisticated method plus the fact that the application is noticeable only among large corporations with complex activities, SMEs are drawn back from the adoption.

The objective of this chapter is to illustrate how real option valuation (ROV) contributes to overcome the missing link between corporate finance and strategic management. At the same time it suggests an approach that is feasible and practical for SMEs to overcome the apparent lack of strategic imperatives. Build on SMEs' literature towards strategic management and corporate finance; it presents an aspiration of how SMEs are able to manage their strategic activities actively by giving practical example based on a study case. It is hope that with this example, SMEs are able to obtain higher initiatives to enhance their performance, growth and survival. Indirectly, this study also hopes to contribute enriching the literature of extending the usage and application of ROV (Trigeorgis, 1993) by performing conformity test, focusing on SMEs in steel industry. In doing so, the following questions are developed to hold the research to its objectives:

- How firms (especially SMEs) can formulate flexible strategies in order to react to changes in environment?
- What is the best financial approach available to be applied for the above purpose?
- How to determine the best time to execute flexible strategies formulated?

The chapter is structured as follows. Section 4.2 highlights important literature related to the practice of strategic management in SMEs and the development of real option in strategic planning. Section 4.3 on Methodology explains analyses conducted and summarized the case study. Step by step analyses are presented in Section 4.4. Section 4.5 discusses the results and finally section 4.6 concludes the study.

4.2 LITERATURE REVIEW

4.2.1 SMEs and Strategic Management

Strategic management determines the mission, vision, goals, objectives, values, roles and responsibilities of an organization to be attained in the future. Often confused with strategic management, strategic planning is a management tool which organizations employ to focus organization's resources and capacity to achieve those goals determine in strategic formulation. Figure 4A gives an overview of the nested concepts of strategic management. From the figure, strategic planning is part of strategic management activities, which begins with strategy formulation and ends with strategy deployment (Nickols, 2011). Strategic planning in strategic management involves utilization of resources in order to enhance the organizations performance in their external environments (Nag, Humbrick and Chen, 2007).

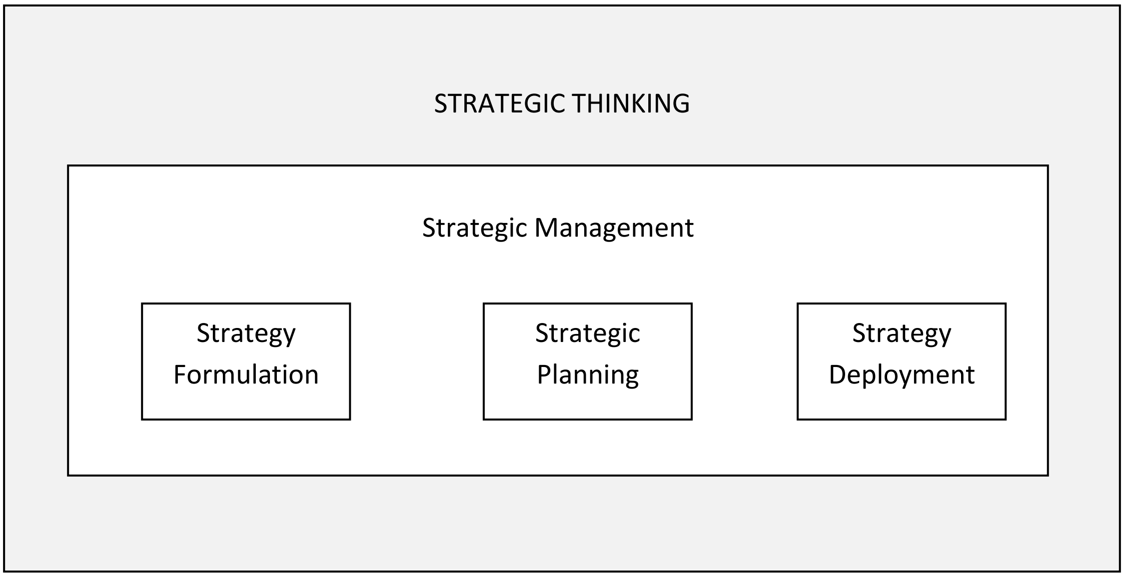

Figure 4A: The "Nested" Concepts Related to Strategy (Source: Nickols, 2011, p 7)

Strategic planning concentrates on setting financial and non-financial goals with specific allocation of necessary resources (Stonehouse and Pemberton, 2002; Nickols, 2011). Bind with RBV it aims to obtain competitive advantage and efficiency (O'Regan and Ghobadian, 2004). There are many literatures available which support the importance of strategic planning in ensuring positive business performance, for example, Rhyne (1986), Miller and Cardinal (1994) and Delmar and Shane, (2003). Firms whom employ strategic planning as part of its strategic management activities usually have higher sales growth, higher return on assets, higher profit margins and higher employee growth (Bracker, Keats and Pearson 1988; Berman, Gordon and Sussman, 1997; Carland and Carland 2003; Gibson and Casser 2005). The engagement of strategic planning also achieve better results on innovation, newly patented products and management technologies (Upton, Teal and Felan 2001; Beaver and Prince 2002; Stewart 2002; Gibbons and O'Connor 2005).

Since there are no clear reasons why SMEs oppose to strategic planning (O'Regan and Ghobadian 2002), studies are carried out to understand this phenomenon. Some of the findings state that SMEs reject strategic planning because the managers are lack of specialised expertise and possess limited knowledge of the planning processes (Robinson and Pearce, 1984). The rejection is even stronger for SMEs with complex activities as they are unsure of how to deal with high degree of uncertainty (Shrader, Mulford and Blackburn 1989; Matthews and Scott 1995; Yusuf and Saffu 2005).

4.2.2 Real Option in Strategic Management

Most activities in strategic management emphasizes more on RBV and attach it to discounted cash flow (DCF) based analysis to decide on the best investment. With the same approach, the results are fit into organization economists' emphasize of choosing the optimum investment to obtain strategic value in competitive setting. Unfortunately, DCF fails to incorporate uncertainties, is very rigid and unable to connect between the two views.

The question above has flashed an obvious gap between financial and strategic management as highlighted by Myers (1984). Capital budgeting process dominated by DCF does not match to strategic approach. In order to solve the problem, real option has proven to be the methodology that links financial and strategic management.

There are various techniques applied in strategic planning in order to achieve financial and non financial goals based on strategic resource allocation. The process of strategic planning requires continuous assessment of business environment to align with mission, strategic goals and objectives (Nickols, 2011). The approach in doing so is known as assessment of external threat and opportunities, alongside with internal weaknesses and strength (popularly known as SWOT[2] and TOWS[3] analysis). It is attached with various kinds of financial analysis and operation performance audit to measure achievement. The basis of measurement applied is usually DCF.

However, with the environment continuously changing, the approach of DCF fails to take into account certain aspects of uncertainty, particularly to link to flexibility. Firms are assumed to follow previous formulated strategy regardless of any changes in the environment, which means no hint of flexibility is considered. Planning becomes rigid. Yet, strategists claim that planning should react to the current state of environment. Eventually, obtaining competitive advantage and sustaining it is difficult if firms want to stay in the business and achieve its mission as being determined at the beginning of the process. The reason – the basis of capital budgeting employed apparently does not match with strategy formulation.

The development of real option resulted in a new approach of capital budgeting (for example, Brennan and Schwartz, 1985a, b; Trigeorgis and Mason, 1987; Trigeorgis 1988) and has enlighten strategic management approach. Capital budgeting is part of the decision making process which later is applied in strategic management to determined firm´s future path.

Since the beginning of its application, ROV is used for valuing complex investment projects. The most important aspects being considered in this valuation methodology are incorporation of uncertainty and flexibility into valuation of project investment. Kulatilaka (1988), for example, has valued flexibility in order to create a flexible manufacturing system. McDonald and Siegel (1986) have emphasized the value of

[2] Strengths – Weaknesses – Opportunity - Threat (SWOT)

[3] Threat - Opportunity - Weaknesses – Strengths (TOWS)

waiting to obtain more information about uncertainty so that firms have an option to defer or delay investments.

With many advances in ROV, several different options have been valued to suit various business characteristics and environments. Besides the option to defer an investment, there are options to alter production scale, to stage investments, to abandon business activity, to default during construction as well as growth option, just to quote some relevant cases. These options are summarized in Figure 4B following Trigeorgis, 1993.

Types	Description	Analyzed by
Operational Flexibility		
Deferral	Postponing investment for further economic justification	Tourinho (1979) Titman (1985) McDonald & Siegel (1986) Paddock, Siegel & Smith (1988) Ingersoll & Ross (1992)
Time to build option (staged investment)	Staging investment as a series of outlays to create opportunity to abandon	Majd & Pindyck (1987) Carr (1988) Trigeorgis (1996)
Option to alter operating scale	Match size of operation to market environment	Brennan & Schwartz (1985) McDonald & Siegel (1986) Trigeorgis & Mason (1987) Pindyck (1988)
Abandonment	Abandoning project when market condition becomes severe	Myers & Majd (1990)
Switching (inputs or output)	Changing of product flexibility or process flexibility	Magrabe (1978) Kensinger (1987) Kulatilaka (1993) Kulatilaka & Trigeorgis (1994)
Growth option	Early invesment is a prerequisite of related project that lead to future growth opportunity	Myers(1987) Brealey & Myers (2000) Kester(1984, 1993) Trigeorgis (1990) Pindyck (1991) Chung & Charoenwong (1991)
Financial Flexibility		
Option to default	Limiting liability to amount of invested capital when profit is less favourable than the expexted value	Black & Scholes (1973) Mason & Merton (1985)
Staged financing	Option to early exit when performance is less favourable than expected	Trigeorgis (1993b) Sahlman (1988) Willner (1995)

Figure 4B. Types of Standard Real Option (Source: Trigeorgis, 1993).

Apart from the options summarized above, more complex option, known as non-standard options or *exotic options* enlarge the scope. Some exotic options, such as i) *compound options* – which are options on options (Geske, 1979); ii) *Asian options* – where the payoff depends on the average price of the underlying asset during at least some part of the life of the option (Kemna and Vorst, 1990); or iii) options to exchange one asset for another, also referred to as *exchange options* (Margrabe, 1978), do not only play an important role in financial option strategies but also have proved to be extremely useful in ROV.

Different economic fields have also benefited from ROV methodology. Among the contributors are Brennan and Schwartz (1985a, b), Cortazar, Schwartz and Salinas (1998) and Trigeorgis (1990) whom analyse natural resource investments; Kellogg and Charnes (2000) value a biotechnology company; Schwartz and Moon (2000) price an Internet company; Grenadier and Weiss (1997) value investments in technological innovations; and, McGrath and Nerkar (2004) and Willigers and Hansen (2008) cope with R&D in pharmaceutical industry.

Most of the references available show the whole process of how ROV measures value created by project's characteristics and is being applied in strategic management but the highlight is concentrated on solving capital budgeting problems. While the issue of correcting undervalued investments is directly addressed, ROV approach is pricing additional value of proposed investment at the same time.

Similar to conventional NPV, ROV only accepts an investment if the value of projects (V) is larger than the expenditure required (K). However, this condition is only true for ROV when t = 0, and volatility (σ^2) and r_f do not affect the net value. Yet, if these variables affect net value of investment, the conditions change. Taking the case of a call option towards expiration, the investment is only accepted when either the value of V – K, or 0 being the highest one (Max V-K, 0).

The variables from option pricing theory are translated into NPV quotient (NPVq) where it incorporates project value, expenditure amount, risk-free rate and time dimension to risk level in form of cumulative volatility (σ√t) along time (Luehrman, 1998a, b). NPVq for a call option is calculated by:

$$NPVq = \frac{V}{K \div (1+r_f)^t} \quad [4A]$$

where; V is value of investment
K is the exercise price
r_f is risk-free interest
t is time

The transformation of this formula modifies *positive* NPV into NPVq >1, *negative* NPV into NPVq <1, *zero* NPV into NPVq of 1.

Investment Opportunity	**NPV**	**Call Option (Black-Scholes model)**	**Variables**	**Option Value Metrics**
Present value of a project's operating assets to be acquired	Present value of a project	Stock price	V	→ NPVq
Expenditure required to acquire the project assets	Cost of investment	Exercise price	K	→ NPVq
Length of time the decision may be deferred	N/A	Time to expiration	t	→ NPVq; → σ√t
Time value of money	N/A	Risk-free rate of return	r_f	→ NPVq
Riskiness of the project assets	N/A	Variance of returns on stock	σ^2	→ σ√t

Figure 4C. Linkage of NPV, Black-Scholes Model and Option Value Metrics (Adapted From: Luehrman, 1998a, p7).

The linkage among the variables of NPV, Black-Scholes model (to represent real option with call in nature) and option value metrics explained above are illustrated in Figure 4C.

4.3 METHODOLOGY

The research conducted in this study follows a stylized fact case study approach as exploratory research following Cooper and Slagmulder (2004). The approach is similar to other studies in the field of real options, such as Brennan and Schwartz (1985a;b), Dixit and Pindyck (1994) and Trigeorgis (1996), in the case of natural resource activities. This approach requires of the construction of a base case with various sources of information representative in a worldwide scenario.

4.3.1 Analyses

The strategic planning approach in this study follows Miller and Waller (2003), which integrating scenario planning and ROV. The integration is applied to keep the best of both tools by complementing each other.

Step 1: Scenario planning
Scenario planning is the platform that envisioned future states and its uncertainties. Begins with framing issues, the scenarios should have a clear objectives and focus. This step also identifies all value drivers, resources and contingencies. The basic aim of this step is to identify key environmental contingencies and their effect on performance, also to devise creative approaches towards contingencies.

Step 2: Identify Exposure
In this step, exposures are match into the three levels of environmental uncertainties; general environmental uncertainties, industry uncertainties and company uncertainties. All uncertainties should be profiled to create an overall exposure and effects are identified over the businesses' corporate portfolio. Options are created to match the circumstances of exposures.

Step 1 and Step 2 are essential providing background for creation and evaluation of real options. In short, these two steps provide the qualitative aspect of the portfolios. When both steps are performed, it should be able to match valuable resources to specific value drivers, and include the specific uncertainties for strategy formulation.

Step 3: Real Option and Valuation

With qualitative information obtained from Step 1 and 2, options are created to reflect the optimal use of resources which can bring out the best opportunity, most payoffs and shareholders' wealth. Valuation is performed not only to identify what is the best strategic investment to be employed, but also when the strategic moves should take place. For this, real options theory is adopted to link all the variables and compared against Black-Scholes Model. The results, in form of NPVq are plotted against cumulative volatility on Option Metrics Space.

Step 4: Implementation

The process above shall signal the optimum investment which produced the best returns for businesses, complete with strategic contingencies plans. However, the process does not stop here. As business environment is constantly changing, the process of strategic management shall continue too.

The whole analyses are sum up and illustrate as per Figure 4D to provide better understanding and clear relation between strategic planning in strategic management and real option.

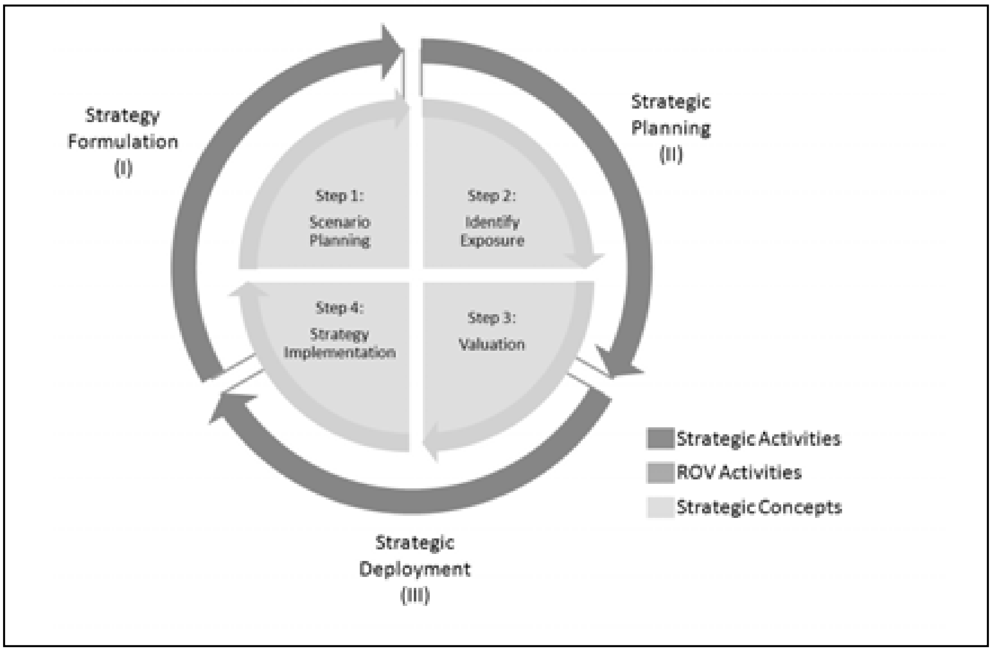

Figure 4D. Activities Conducted According to Strategic Management Concepts (Source: Own Design)

4.3.2 Research Setting

The project chosen for the evaluation is an investment in first stage steel processing, a mini-mill iron smelting project as per **Research Setting A** introduced in Chapter 1. To sum up, there is a new proposal of building up an iron smelting plan based on new process innovation, mini-mill iron smelting. The investment requires €10 million, €6 million in t_0 and €4 in t_1. By investing this amount, the firm will have a mini-mill plant with capacity of producing 182000 tons per year. However, due to Kyoto Protocol, the plant is allowed to produce only up to 75% of its capacity in order to maintain emission and effluent at minimum level.

The investment has an expected useful life of 10 years. 2 years are dedicated for construction and the rest 8 years are operational. Volatility is forecasted to be σ = 30 %. Two discount rates are employed which are 5% of risk-free rates and 12 % of adjusted-risk rate. Holding to this information, discounted investment cost is *I*, is €9.81 million while discounted net cash flows, *V* is €9.25 million resulting in NPV of €-0.56 million (*negative NPV*).

The pre-analyses conducted in assessing possible risks have resulted in embedment of 4 individual options into the case. Instead of investing €9.81 million and getting return of NPV €-0.56 million (*negative NPV*), the investment is now embedded with option to defer, option to cancel during construction, option to expand and option to abandon.

After assessing the risk and opportunity (refer to Chapter 2; Muharam, 2011) and performing financial analysis (as per Chapter 3), the current concern now is to connect all the information and analysis for strategy formulation. This is a big concern according to Popli and Rao (2009). From their study it is found that SMEs in steel sector would not be able to compete due to weaknesses such as obsolete technology, high cost of production, poor quality of goods, lack of capital, weak infrastructural facilities, plethora of labour legislation, lack of cohesion among SME units, ineffective associations, lack of up-to-date information, lack of international exposure to their products and lack of standards conforming to international standards. Therefore, with the approach of real option, risk assessment and financial analysis are capable to be connected as an input to formulate business strategy. Hence, it would be able to overcome the above managerial weaknesses of SMEs.

4.4 ANALYSES

4.4.1 Step 1: SWOT Analysis

The steel industry is facing a competitive demand from year to year. Between 1960s to late 1980s, the industry was dominated by OECD (Organization for Economic Corporation and Development) countries. However, with the new emergence of developing countries like China, India and South Korea, the domination tilts slowly to Asia. The growth is also encouraged by technology development that allows cost minimization, together with production maximization and quality improvement.

Summarizing the reports provided by Sato (2000; 2009), *Sustainability Report of the World Steel Industry 2005* and Popli and Rao (2009), steel industry is approaching its mature state with steady increment in demand. Products are generally similar with slight differences in quality. General products are priced according to trade market. Some producers are able to add special features to the product according to customers' specification, for example in the final composition of minerals and size.

In order to survive in this particular condition, Porter (1980) suggests two strategies to be adopted in order to create value and competitive advantage. First, cost advantage strategy which allows products to be priced lower than competitors. Cost reduction is obtained by having economy of scales. This is a good approach if product is more commodity-like, difficult to differentiate and demand is highly elastic. The second strategy is differentiation, which allows product to be sold at premium. This strategy works if there is strong relationship among suppliers-firm-customer, where demand is low elastic to price, sources of advantage have been exploited by competitors, and nature of product allows customers to perceive extra value.

As most SMEs are having the problem of being cost and quality competitive, the first step suggested is to invest in new innovation which allows lower cost of production and quality maintenance. The investment in a new technology of mini-mill smelting plant allows SMEs to overcome the obstacle of high cost of production. Adhere with good supervision and standard practices, it enables to improve product quality according to international standards, which opens up opportunity to market the product globally. "SWOT-wisely", this investment will simultaneously overcome SMEs´ weaknesses in lack of innovation and technology, and use to exploit the opportunity in surging demand of steel. Apart from that it also creates competitive advantage and deals with threats from competitors.

4.4.2 Step 2: Identification and Creation of Options

Investing in new mini-mill smelting plant gives managers several options to be considered (refer to Chapter 2; Muharam, 2011). The base case illustrated and summarized in Section 4.3.2, opens up to a wide array of scenarios, i.e., of flexibility. Opposing to the traditional approach of DCF without optionality, ROV approach moves from the one-path sequence to an investment proposal with various options of flexibility. The one-path sequence is the base case, while other complementary options of the investment opportunities which are embedded into the ENPV.

The complementary options lead to a multi-direction path, presenting possible future decisions available to react to changes in business environment. Based on the case, the investment project may be taken immediately or deferred to the next year of t_1, creating an option to defer. Besides that, the project has the opportunity to be cancelled during construction, which if it is exercised, the project has no opportunity to enjoy future expansion.

The purpose of having this financial flexibility option is mainly to create either a solution for the firm in case there are financing difficulties or a way out when investment is no longer competitive in the future or as such. By doing this, firms have the possibility of retreating from the pre-determined path to carry on the investment when it is no longer profitable to be continued. The options suitable for this scenario are: i) the option to cancel, and ii) the option to defer and cancel.

Firms may have the possibility of enjoying higher return in the future and benefit from prosperous business environment which causes higher demand and market growth. In case that such a scenario happens, the project is expandable in year t_4, and able to operate at its full capacity. There are two paths that lead to expansion. The first option is to invest now and expand later. The second option is the option to defer investment before expanding it when market growth becomes more evident.

In case that market and demand turn bad, it is possible to abandon the project so that further losses are avoided and salvage value can be claimed. There are four paths that open up the possibility where the option to abandon can be exercised. The path that lead to abandonment are:

i) Individual option of abandon
ii) Expand and abandon
iii) Defer and abandon
iv) Defer, expand and abandon.

The whole scenarios are presented as Figure 4E for better illustration.

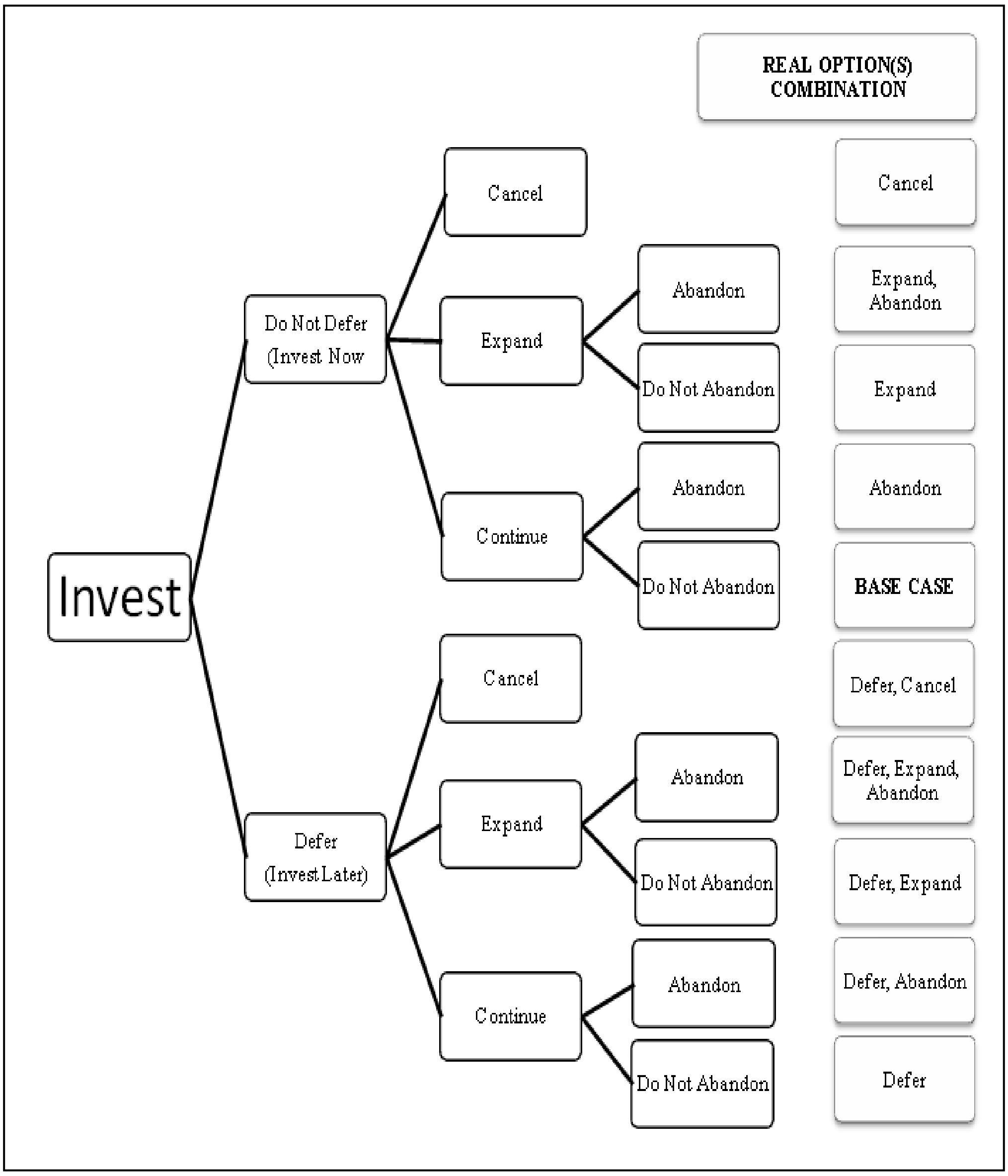

Figure 4E. Combination of Options for the Investment According to the Proposed Sequence (Source: Own design.)

4.4.3 Step 3: ROV

Besides calculating project's return in form of Enlarged Net Present Value (ENPV), ROV is able to translate NPV to NPVq. NPVq which presents the value-to-cost ratio is used to express the relationship between V and K, signifying current profitability. Proposed investment is favourable when NPVq value is larger than 1 (NPVq >1). Meanwhile, cumulative volatility, $\sigma\sqrt{t}$, is defined as the variance per period of asset returns cumulated over the time to option expiration to signify the cumulative risk observed for the proposed investment.

The NPVq and cumulative risk for the initial investment without any options embed are:

NPVq = 9.250/9.810 million €
= 0.94

$\sigma\sqrt{t}$ = 0.3*√1
= 0.3

The NPVq and respective cumulative risk for the proposed investment with each set of complementary options are shown in Figure 4F.

	V	K	**NPVq**	σ (%)	t	**$\sigma\sqrt{t}$**
D	9,250	10,500	**0,88**	30	2	**0,42**
C*	9,250	4,790	**0,52**	30	2	**0,42**
E	5,210	2,470	**2,11**	30	4	**0,60**
A*	4,435	5,000	**1,13**	30	2	**0,42**
D and C*	9,800	4,500	**0,46**	30	2	**0,42**
D and E	3,920	2,400	**1,63**	30	5	**0,67**
D and A*	3,820	5,250	**1,37**	30	3	**0,52**
E and A*	5,124	5,000	**0,98**	30	4	**0,60**
D, E and A*	4,451	6,825	**1,53**	30	5	**0,67**

D – Deferral
C – Cancellation
E – Expansion
A – Abandonment

* For these combination of options, the rule Max (V- K, 0) is change to Max (K-V, 0) due to its nature that resembles put option.

Note: Please refer Appendix 3A, page 64-70 for value of V and K.

Figure 4F. NPVq and Cumulative Risk for the Portfolio.

4.4.4 Step 4: Exercise Timing of Options (The Option-Value Space, OVS)

After NPVq and associated cumulative risk are obtained (as per Figure 4F), the values are plotted in an Option Value Space (OVS) following Luehrman (1998a, b). This option space has two dimensions: 1) value-to-cost ratio and 2) cumulative risk. The questions of whether to invest now or not will be answered by looking at the position of the investment against the value-to-cost dimension. Any investment which passed the 1.0 line is accepted to be undertaken. This parts the space into 2 divisions, with the right column places the favourable investment.

Later, cumulative risk will further divide the panel from 2 segments into 6. Investments are going to be categorized as "invest now" (region 1) to "invest never" (region 6) and going through "maybe now" (region 2) and "probably later" (region 3) to "maybe later" (region 4) and "probably never" (region 5). By doing this, contingent strategies against sets of uncertainty are monitored thus allowed strategic options to be exercised when needed (refer to Figure 4G).

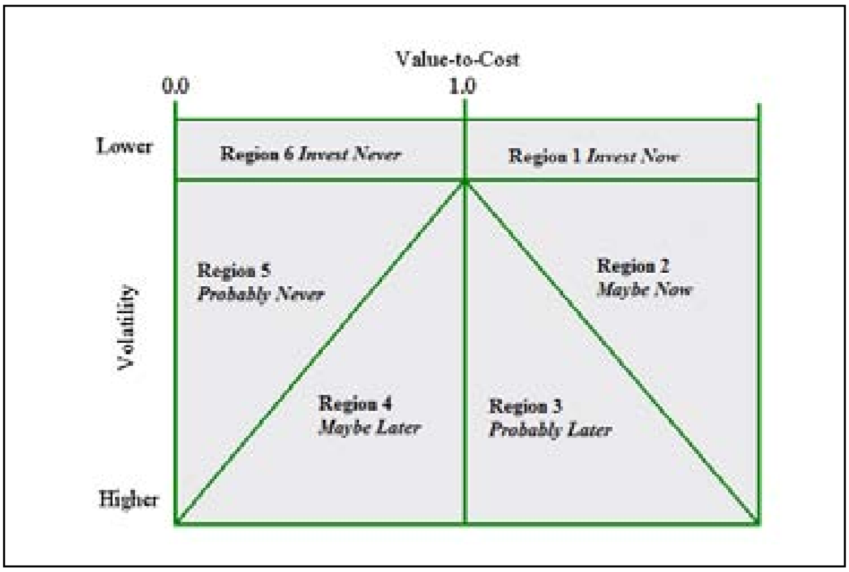

Figure 4G. Dimensions and Segmentation of Option Value Space
(Source: Luerhman, 1998, p 93).

As a result, values obtained from Figure 4F are plotted on the OVS are as follows (refer to Figure 4H).

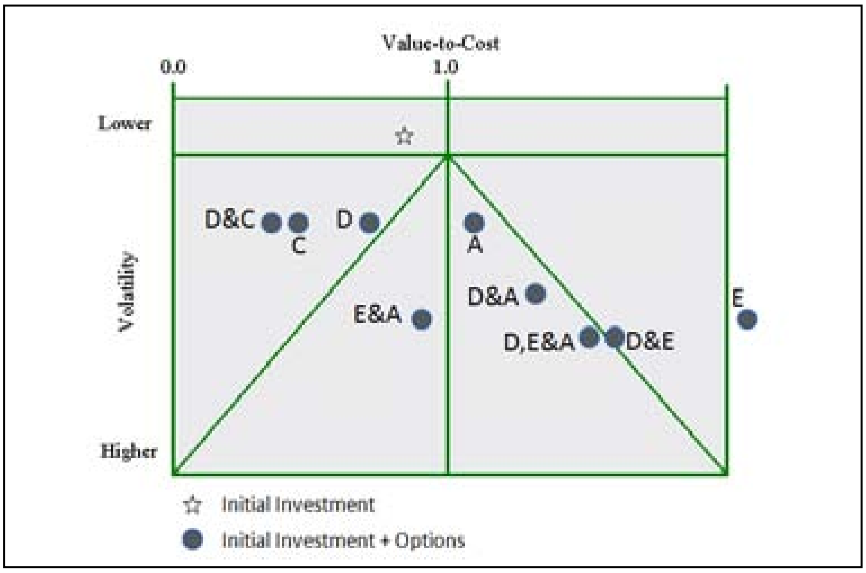

Figure 4H. Position of Initial Investment and Investment with Options Embedded.

4.5 RESULTS AND DISCUSSION

Having to link variables in option pricing and plot them against OVS answer two questions in investment strategy. First, the question of investment worthiness is answered by the calculation of NPVq which links the return on the investment, the cost of the investment, the time value of money and the time of expiration of the investment.

The initial investment is not attractive at all with negative NPV and NPVq less than 1, as plotted in Figure 4H. However, the attractiveness of the investment changes with several options being embedded. Having the options of deferral; cancellation; deferral and cancellation; and expansion and abandonment; ends up in the same negative results where investment is still not profitable. Yet, once the investment is complemented with options to expand; to abandon; to defer and expand; to defer and abandon; and to defer, expand and abandon; the investment moves from unattractive to attractive region with positive NPVq. These indicate that the ENPV of the investment with selected options results in positive returns.

Plotting NPVq against cumulative risk answers the second question of *when* the options should be exercised. Investment embedded with options of expansion; and deferral and expansion; has the possibility to be exercised now as the value-to -cost is greater than 1 and with options located in region 2 signifies that the options are in-the-money. The other combinations (abandonment; deferral and abandonment; and deferral, expansion and abandonment) are promising but should be put on hold as risk and uncertainty are still high. Consideration about exercising these options should be made once the risk level (i.e. cumulative volatility rate) improves.

On the other hand, plotting the metrics on OVS also prevents unattractive investment combinations to be totally ignored. Located in region 4 with higher volatility and lower value-to-cost, investments with options to expand and abandon signal that in worst condition they have the possibility of being considered even though the chances are low. The potential of these options is smaller compared to options located in region 3. Investment with options to defer; to cancel; and to defer and cancel; are not worth being exercised at current stage as uncertainty is low and risk level is evident, yet holding these options is beneficial as contingency plan. It is obvious that these options are out-of-money as the position signals more risk than potential. Yet, if business environment turns sour, exercising these options may curb occurrence of further losses.

This is proven by making comparisons between ENPV and NPVq. Higher ENPV does not always signal that it is the best option to be exercised. In our case, it is supported that the best option to be exercised is expansion, located at the preferable Region 2 and bearing the highest ENPV of € 2.66 million. The NPVq of this option is also the highest with value of 2.11. However, the second preferable investment is not the one with the second highest ENPV. According to ENPV, the second preferable investment option is to embed the investment with the options to defer, expand and abandon (DE&A), but according to NPVq, one with the option to defer and expand (DE) is preferable even though both choices are located at the same region. Investment with options to defer and expansion (DE) gives better value-to-cost with NPVq of 1.63 compared to 1.53 if it is embedded with options to defer, expand and abandon (DE&A). In fact, from the analysis made, all options bear different level of preference if firms are concerned about the best time to exercise and the better value-to-cost, except for the first option to embed the investment with expansion. Figure 4I, compares the ranking of the investment options according to both ENPV and NPVq.

Option	ENPV	**Rank**	NPVq	Region	**Rank**
D	0.92	**6**	0.88	5	**7**
C	-0.39	**9**	0.52	5	**8**
E	2.66	**1**	2.11	2	**1**
A	0.61	**7**	1.13	3	**5**
DC	-0.33	**8**	0.46	5	**9**
DE	1.56	**3**	1.63	2	**2**
DA	1.07	**5**	1.37	3	**4**
EA	1.25	**4**	0.98	4	**6**
DEA	1.81	**2**	1.53	3	**3**

Figure 4I. Ranking of the Investment Options according to both ENPV and NPVq.

Looking from another perspective following the path diagram in Figure 4E, the initial investment should not be taken at all. *If the investment is taken now,* embedment of options moves the position of the investment to other segment in the OVS, as illustrated in Figure 4J. According to this figure, the best investment is to be equipped with the option to expand. Investment with option to expand has positive NPV and the option is in-the-money. The location of this option signals that the investment might be worth if been exercised now and the project may benefit from early exercise.

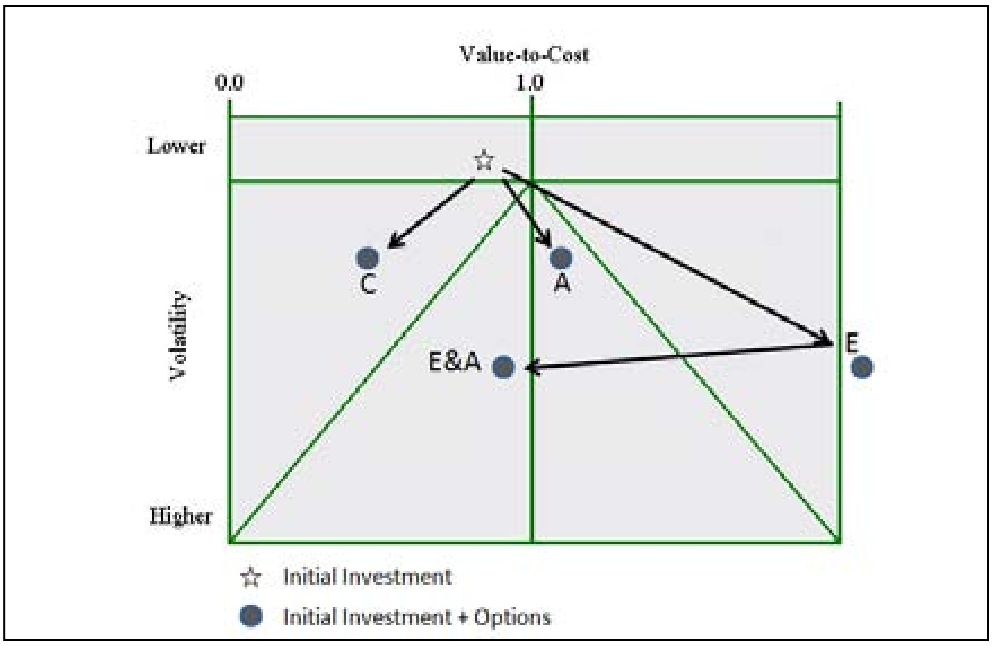

Figure 4J. Positions of the Proposed Investment if “Taken Now” with Options.

Investment embedded with option to abandon is next, while investment embedded with options to expand and abandon is worth considering. However, to embed the investment with the option to cancel seems unprofitable but worth keeping for immediate contingency.

If managers decide to *postpone the investment to next year (t_1)*, the investment changes position from "never invest" to "maybe later", which means resources are better for other investments. Hence, the investment plan should be kept on hold. This is the first effect of embedding the deferral option into the initial investment.

Then, complementing the deferred investment with options to expand and options to expand and abandon makes the investment portfolio more attractive. The investment is more profitable if taken at t_1 with the embedded options being exercised soon after that. However, the investment with deferral and cancellation options has higher probability of not being exercised compared to investment with deferral and abandonment options. Investment with options to defer and abandon in region 3 has high value-to-cost but the options are out-of-the-money due to high volatility. However, the position is worth considering once risk level (i.e. volatility rate) improves. The first and following movements of the investment portfolio on the OVS are illustrated in Figure 4K.

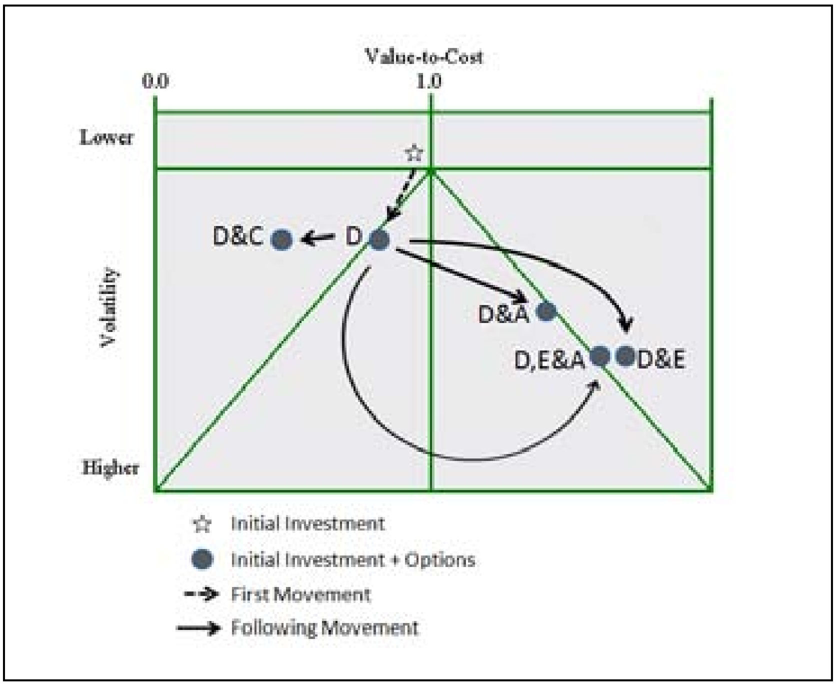

Figure 4K. Positions of the Proposed Investment if "Deferred to t_1" with Options.

Referring to the metrics as a guideline towards project development over time, SMEs managers are able to formulate strategic moves by integrating the value of waiting measured by ROV. As time passes, project reacts to more certain economic condition and industry environment, both with less volatility. Competitions change and other value creation reactions vanish over time, thus options move into more certain direction. Usually with extra information, option moves upwards and reaches maturity at the top of the options space (regions 1 and 6), at which point the investment decision must be made or the option expires. A strategy is then depicted in an option space as a sequence of options, reaching a decision whether to undertake an investment or not.

4.6 CONCLUSION

Planning based on DCF valuation methods is rigid and unable to capture uncertainties in constantly changing business environments. Given that SMEs are not excluded from the exposures, a special approach is needed to allow them to practice better planning in order to survive with limited capacity. Real option has been potentially seen as a tool that enables to solve the problem. Starting with identification of value drivers, value creation is measured. Uncertainties are dealt with by formulating proactive solutions which provide flexibility.

The advantage of ROV in the approach is its ability to assign quantitative value to qualitative intuition of SMEs´ managers. Valuation is conducted by transforming traditional NPV. Adopting ROV variables and following Luehrman’s approach, NPVq is calculated. Then, the values are plotted into a metrics space against cumulative risk so that the option values are able to be sketched in the strategic planning path.

Referring to the locations of options on the OVS, SMEs’ managers are able to formulate strategic moves. Signals and intuition whether an investment should be taken or not become more objective depending on which side of the metrics the investment option is located at. However, as the project maturity level increases, options usually become more certain and better consideration of future options is clearly seen thus helping managers to decide whether an investment is worth to be undertaken.

The advantages of the process explained in this study are several. First, it incorporates both uncertainty and flexibility and measures them, which gives more accurate information on project evaluation. Second, using the same variables in the evaluation process, values are reflected in strategic planning in form of the option space metrics. Third, since strategic variables like competitive advantage are important and a project life is continuous, this method allows managers to perform evaluation in a multi-stage option chain development (following Smit and Trigeorgis, 2006). Each stage represents options available for the next stage leading to cross time interactions over a long period of time.

Generally, this method is a helpful and comprehensive method that enriches SMEs managers' intuitive thinking by providing quantitative and qualitative information for investment decision making and strategic planning. The fact that the approach links both corporate finance and strategic management opens up to higher potential in both methodology and application to specific case studies.

Chapter Five

REAL OPTION AND ENVIRONMENTAL CORPORATE SOCIAL RESPONSIBILITY[1]

[1] A first version of this chapter has been accepted for presentation at the International Conference on Business, Management, Economics and Finance, October 2011, in Izmir, Turkey. Later, the version has also been published in International *Journal of Social Sciences and Humanities Studies*, 3(1), ISSN:1309-8063.

A subsequent version has been presented at the research seminar of the Department of Business of the Universitat Autònoma de Barcelona on 14th December 2011 and subsequently published in the Working Paper Series of the Department (11/7) under the title *SME's Environmental CSR Investment: Evaluation, Decision and Implication*.

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Corporate social responsibility (CSR) is a voluntary yet competitive activity which affects business value. Together with growing concern towards CSR related to environmental issues such as climate change, environmental CSR has attracted many to involve especially small- and medium-sized enterprises (SMEs) as they are seen as the best entity to perform it compare to large corporations. As a primary contributor to green house gas (GHG) emission, SMEs have bigger responsibility to participate for cleaner environment. However, with limited capacity, it is difficult for SMEs to decide between social responsibility and profitability. Limited investment valuation methods add to the complexity. To overcome such barrier, this chapter builds up a proposal based on real option valuation (ROV) as a solution that improves small businesses decision making processes in choosing investments that deal with both issues: profitability and CSR, with focus on climate change, a branch of environmental CSR. By incorporating uncertainties and providing flexibility, ROV is able to balance up SMEs' profitability and CSR activities through the creation of strategic options. Based on a case study, it is hope that findings of this chapter lighten up these dilemmas and none of SMEs' objectives is sacrificed.

5.1 INTRODUCTION

Corporate social responsibility (CSR) is also known in many various terms such as corporate conscience, corporate citizenship, corporate social performance and sustainable responsible business (Wood, 1991). It is a form of corporate self regulated mechanism which is integrated into business model to ensure active compliance with law, ethical standards and international norms. Managers are aware that realization towards CSR activities can mitigate corporate crises and build reputations as the perceived value of CSR upon creation of business value has increased. Upon realization on the goodwill and reputation of CSR, small- and medium- sized enterprises (SMEs) are looking forward to search for definitive, value for money based formulae to gain managerial reputation. There is also awareness that in some cases "*SMEs are better placed to take advantage of CSR programs"* (Sarbutts, 2003).

On the other hand, Lord Sieff, the former chairman of Marks and Spenser plc has stated that, *"business only contributes fully to a society if it is efficient, profitable and socially* *responsible"* (Cannon, 1992, p 33). The statement is parallel with Wood (1991) which has stated that the basic idea of CSR is when business and society are interwoven rather than distinct entities.

CSR has a wide area of coverage. CSR Europe[2] for instance has issued a guideline which segregate CSR according to focus activities in its reporting requirement. CSR activities should belong to one of these categories:

- Workplace (employees);
- Marketplace (customers, suppliers);
- Environment;
- Ethics; and
- Human rights.

McKinsey survey[3] which was conducted in 2008 resulted in similar segregation. The survey also found that most managers regardless of size and industry have expected that CSR relating to environmental programs create more value in the next five years.

However, the positive developments in integrating CSR among businesses have led to a problem in realizing the value stemming from such activities. The problems are faced by all firm sized, not only restricted to SMEs. CSR professionals and consultants interviewed in the McKinsey survey appeared to be unsure of what number to be put as value added resulting from the integration. Not only that, they also reported that they do not have any idea of what are the effects that such programs have on value creation. The lack of certainty in this matter has diverted CSR professionals to focus on the social benefits rather than financial value.

[2] CSR Europe is a membership organisation that consists of 70 multinationals corporations and 31 national partner organisations which initially established to address European problems of structural unemployment, restructuration and social exclusion in 1995. Today, the organisation is committed to develop innovative business practices and work together to provide solutions to emerging societal needs.

[3] McKinsey Survey was conducted in conjunction with Boston College's Center for Corporate Citizenship. It collects responses from 238 CFOs, investment professionals and finance executives from various ranges of industry and region in United States, simultaneously with 127 CSR professionals and institutional investors.

In order to see how CSR may affect business value, it is suggested that a new methodology to value the activity is explored. World Business Council for Sustainable Development (WBCSD, 1999), for example, has sought to develop a clear understanding of CSR besides to produce materials and resources on how to measure CSR and report their impact on society. For that purposes, a matrix of CSR indicators is suggested. This concern is again emphasized in the recommendations suggested by McKinsey survey which has lined that, "*A clear first step would be to develop metrics that focus on integrating the financial effects on environmental, social and governance programs with the rest of the company's finances*" (McKinsey Global Survey Result, 2009, p 9). Yet, how to measure the value or benchmark it against other is still a question mark.

To deal with the above dilemma, it is important to firstly identify how uncertainties related to CSR should be treated. Any solution to the question would allow a figure to be recognized as value added by CSR activities and, hence increase the value of the business. In order to explore into this issue, a specific CSR activity of dealing with climate change undertaken by small businesses in steel industry has been put into focus. As mentioned earlier, environmental CSR is predicted to create more value in the future. Therefore, with many growing concerns supported with the increasing number in climate change activities, such as scientific research, regulations, social awareness and education, it is worth looking into the issue. For that matter, this research intends to answer these following questions:

- How real options assist small businesses to incorporate uncertainty arisen from climate change in capital budgeting process?
- How SMEs managers are able to plan for strategic considerations arising from environmental CSR activities, especially in the issue of climate change?

In order to solve the above issues, it is suggested that real option valuation (ROV) is applied. Real option theory allows for a strategic view of CSR and suggests that CSR should be negatively related to the firm´s ex-ante downside business risk (Husted, 2005). Instead of looking at CSR issue as a whole, this research considers only a branch of CSRs – i.e. SMEs compliance to international environmental norms towards climate change. It is hope that this research is able to provide strategic intuition for SMEs managers in deciding about CSR activities. Taking investment in preventive technology towards global warming in the first step towards CSR integration as an example, ROV is applied as valuation method to provide quantitative intuition in decision making. Eventually, the valuation method is able not only to quantify CSR value added, but also to close the gap that exist between financial theory and strategic approaches (Myers, 1984), which have being admitted by many CSR professionals (McKinsey Survey).

Such approach is done by providing the element of flexibility in business activity. In order to do so, the research demonstrates how real option theory is used to obtain better understanding of environmental CSR, the related uncertainties and its impact on firm's value. It also explores the potential of real option versus discounted cash flow (DCF) valuation method in finding better ways to mitigate environmental uncertainties.

The chapter is organized as follows. The next section (section 5.2) highlights literature review on ROV related to integration of CSR investment to deal with environmental issues of climate change. Section 5.3 illustrates the research design and the case. Section 5.4 presents the analysis of the option to switch and discusses the result. Finally, section 5.5 concludes the research.

5.2 LITERATURE REVIEW

CSR activities are future investments which creates the opportunity to expand and grow (Mcwilliams and Siegel, 2001; Kogut, 1991). Real CSR options have been identified to generate direct and indirect benefits (Burke and Logsdon, 1996). Direct benefits results in measurable or quantifiable return from creation of new product and services. Indirect benefits allows firm to capture future benefits by taking specific action and development as a stepping stone.

In the case of Bank of Boston (which is now part of Fleet Boston Financial Corporation), - it has developed a product named First Community Bank (FCB) in order to reach low income areas that previously has been marginalized by consumer banking. The option has resulted in new clients, bringing USD 1.5 billion with 47 branches.

Community-wise, it is successful in contributing to regional development. FCB has also become a profitable institution with several innovations (Kanter, 1999). This case is an example of a direct benefit of real CSR options. By making an investment in developing goods and services in small scale (in this case by concentrating in a specific market) has successful in creating direct benefits. With such flexibility created, the institution now has an option to expand the products in larger scale, in the future.

However, it is quite difficult to realize intangible benefits of real CSR option. Usually, CSR investment provides strategic flexibility which fosters goodwill among the community and consumers. This approach is able to create the option but not the obligation, for example for the firm to call upon stakeholders for needed resources especially when proactive actions to deal with crucial situation are required. A reference can be made to the case of Johnson & Johnson´s Tylenol poisoning crisis. Due to sabotage in the product “Tylenol” as pain reliever, the company has performed a quick action by withdrew the entire products from the market which cost a loss of USD 100 million. After a technical solution was found, the firm has re-launched the product and it becomes a big success. Within 9 weeks from the re-launch, Johnson & Johnson has successfully regained 65% of its sales (Siomkos, 1992). The ability to success is a result from trust generated among consumers especially due to its quick action dealing with the poisoning crisis. The decision to include option to withdraw (the product) has proven to be beneficial to maintain firm´s goodwill.

The case of Johnson & Johnson is quite an irony to the case of Exxon Valdez incident in 1988 (Fombrun et al 2000). Due to extreme fall in oil prices from USD 32 to USD 12 per barrel, Exxon has decided to downsize, letting go nearly 245,000 employees from 1986 to 1988. On March 22, 1988, its oil tanker has struck a reef in Prince William Sound, causing an oil spill. It resulted in the death of more than 6000 otters and 750,000 sea birds. A report from the investigation has found that due to the downsizing the tanker has been functioning by officers who were not licensed to perform related functions. To make things worse, the containment, which supposed to be done within 5 hours has prolonged to 59 hours due the impact of downsizing. The downsizing has eliminated not only operational employees but includes the emergency response team and equipment too. The strategic option created and exercised during the 80’s oil price crisis i.e contracting operation, has cost Exxon not only their saving from the exercised option, but also additional USD 8.7 billion for cleaning up and criminal fines.

Comparing Johnson & Johnson and Exxon, both entities have formulated options that provide strategic flexibility. The time and options exercised have affected their CSR, yet in different directions. Holding to the similar principle in previous chapters, CSR option should be acquire if the benefits is higher than its cost. These two cases have shown that intangible benefits are difficult to be quantified and higher environmental uncertainty perceived in CSR activities has a positive relationship with the value of future CSR (Husted, 2005).

5.2.1 Environmental Corporate Social Responsibility (CSR) of Climate Change

Global climate change has received a critical evaluation together with energy security issue as it widely affects human health, community infrastructure, eco-system, agricultural and economic activity. Mainly caused by fossil fuels combustion, the emission of greenhouse gasses (GHG) has increased atmospheric carbon dioxide levels which contribute to additional absorption and emission of thermal infra-red.

The Intergovernmental Panel on Climate Change (IPPC), 2007 report states that "*most of the observed increase in globally averaged temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations* [4] ".

Besides the physical impacts described above, the indirect impact of climate change affects businesses' reputation and investment risk profile. The impacts are material yet unpredictable (Gars and Volk, 2003; Stern, 2006), hence they cause significant result on business environment (Cogan, 2004). Impact varies depending on business activities, location, sources of competitive advantage, existing assets portfolios and management capabilities (Austin and Sauer, 2003). Therefore, managers' strategic responses to

[4] Anthropogenic is a term denoting something caused or resulted by human activities. In this case, anthropogenic greenhouse gas concentrations is a term that indicates the portion of carbon dioxide in the atmosphere produced directly by human activities such as the burning of fossils fuels rather than by such processes of respiration and decay.

climate change are important and act as additional determinant of firm's value in the future (Gars and Volk, 2003; Innovest, 2005). This is very true when it comes to growing small businesses looking for opportunities and to striving to survive.

Nevertheless, the impact of climate change on business is highly uncertain (Austin and Sauer, 2003; Gars and Volk, 2003; Stern, 2006). Scientific and economic report has identified that climate change has increased the global temperature ranging from 1.8 to 4.0 degree Celsius (IPPC, 2007). The consequences, according to Stern (2006), are that, if no prevention measure is exercised, the increase in temperature will cost, on overall, the equivalent of losing at least 5% of global gross domestic product (GDP) each year. Even worse, the risks and impacts could lead to higher reduction in GDP with minimum 20% in near future.

On the other hand, the availability of policies and regulation taken by governments to handle climate change issues remain unclear. With specific reference to private sectors, strategic response to climate change is difficult when it comes to financial decisions relevant to investment planning and risk mitigation. The conditions are even more complicated when private firms have no motivation because they operate in countries outside the list of Annex 1 of Kyoto Protocol[5].

Since the degree of uncertainty characterized by the impact of climate change is very high, strategic responses to value investment and risk mitigation become more complicated especially in predicting future cash flows and profiling investment risk. A specific financial valuation technique able to incorporate particular dimensions and challenges of climate change becomes therefore essential. Capital budgeting techniques bear the responsibility not only to capture future cash flow patterns of proposed investment but also to highlight risk associated with the investment, hence assisting management in making *sound* judgments on investment strategies.

[5] Please refer to Appendix 5A for list of countries under Kyoto Protocol.

5.2.2 Real Option in Climate Change

In the early years, climate change valuation has been tackled with DCF valuation techniques (Austin and Repetto, 2000; Austin and Sauer, 2003: Gars and Volk, 2003), but DCF is unable to incorporate managerial flexibility to respond to the arrival of new information and to changes in business environment over time (Mun, 2002). Consequently, DCF has proven to be short in dealing with uncertainties, and fails to connect to strategic importance and flexibility (Ross, 1995). Since these limitations are observed, practitioners and academicians started to look for alternatives.

Real option valuation (ROV) arises as a more comprehensive valuation methodology, capable of pricing rights using option theory and, therefore, valuing flexibility. This valuation technique is an extension of financial options theory, developed at its beginning by Black and Scholes (1973) for European options, Merton (1973) for American options and Cox and Ross (1976) for options on real assets. Seen as alternative to DCF, ROV started to gain attention already in the early 1980s. Since then, real option literature counts with many contributions, both theoretical as well practical applications to various cases in several economic fields. Brennan and Schwartz (1985), McDonald and Siegel (1985), Kemna and Vorst (1990), Myers and Majd (1990), Schwartz and Trigeorgis (1994), Dixit and Pindyck (1994), Grenadier and Weiss (1997), and Cortazar, Schwartz and Salinas (1998) are among the contributions directly related to the evaluation of natural resource investments. Unlike DCF based valuation techniques, ROV accommodates changes and uncertainties, pricing flexibility in the processes of strategic planning and investments which are being constantly re-evaluated (Mun, 2002).

ROV solutions are theoretically very complex, thus the theoretical explanation is beyond the scope of this chapter. Sticking to the aim of tending to practical and managerial purposes, this chapter deals with the analysis in a discrete time framework where standard binomial lattices and risk neutral probabilities are applied to price real options (Mun 2002, Schwartz and Trigeorgis, 2004, among many other authors).

When looking at the value of real options, several principles may be taken into account. These principles stem from basic relationships affecting variables that determine the price of financial options. When translated to the analysis of real investments using option theory, some particularly relevant are: (i) A real option is more valuable when the expiry date is longer. Holding the option for a longer period allows firms to wait for latest information and development before making any potential investment. (ii) A real option is at its higher value when the risk is greater. Owning certain options means the business risks are hedged against downside outcomes. (iii) Exclusive ownership increases the value of a real option, for example in the case of holding an option to patent a new design, product or process. (iv) Greater importance of uncertain future cash flows of the project also increases the option value. With these perspectives, real option methodology is used to conceptualize and value existing option(s), help future creation of further options with the objectives to hedge risks, reduce business hazard and leverage investments over time (Mun, 2002).

When dealing with climate change, real option carries various potential of applications. Firms may apply an *option to delay* investment in clean technology until market forces have proven its value, price of carbon credits (CER)[6] is justified, or new policy is further regulated. *Option to contract* is available in order to reduce carbon emissions when CER is expensive and unfeasible if operation reaches optimal level. An *option to abandon* is exercised when investment is no longer profitable due to continuously high emission and expensive penalty. When abandoning is not practical because current investment has the possibility for other usage that is related but more responsive to climate change policy, then firms may apply for an *option to `scope up´*. Above all, when investment is already employed, and there are chances that firm may choose greener and cleaner technology, the first option that should come into consideration is an *option to switch*.

The application of the above options can be found in many studies related to environmental evaluation such as valuation of investments towards green technology,

[6] CER is a **carbon credit** generic term for any tradable certificate or permit representing the right to emit one tonne of carbon dioxide or the mass of another greenhouse gas with a carbon dioxide (tCO_2e) equivalent to one tonne of carbon dioxide (Collins English Dictionary, 2009).

renewable energy and carbon pricing. For example, Bastian-Pinto, Brandão and de Lemos Alves (2010) use switching option to alternate usage of fuel and ethanol as source of power. Van der Maaten (2010) uses real options to evaluate investment in a solar hot water system and Kumbaroglu, Madlener, and Demirel (2008) study the deferral option in investments of renewable power generation technologies.

In a more specific case related to climate change, Fuss, Obersteiner and Szolgayova (2008) found that a moderate increase in CER uncertainty permits a dramatic increase in investment to reduce emissions while deterministic permit pricing leads to less investment. They found that with the ability of ROV to incorporate volatility of the CER pricing in the trade system, the approach is more effective in reducing carbon emission because carbon emitters prefer to reduce emission to have stable and predictable cost structure. This is the "in the money" position due to high volatility of CER. The study is furthered by Anda, Golub and Strukova (2009), where they formulate rules for the selection of an emission target for a climate policy.

5.3 RESEARCH DESIGN

This research employs an exploratory case study (Cooper and Slagmulder, 2004) based on stylized facts as applied by various scholars in ROV (for example Brennan and Schwartz, 1985; Dixit and Pindyck, 1994; Trigeorgis, 1996). This approach is the most suitable one to be applied due to the emerging nature of climate change and scarcity of prior research, difficulty to construct principles and gathering of concrete information for the purpose of achieving deduction, (Perry, 1998).

5.3.1 Research Setting

The case refers to an operation mix of steel making process carried out by small business. According to Figure 5A, there are two types of steel making process[7] possible to be carried out by SMEs, Blast Oxygen Furnace (BOF) and Electrical Arc Furnace

[7] Steel making process refers to the small box indicated in Figure 5A.

(EAF). Firms have the alternative to operate solely in BOF or combine the production process with EAF, but not to produce solely on EAF.

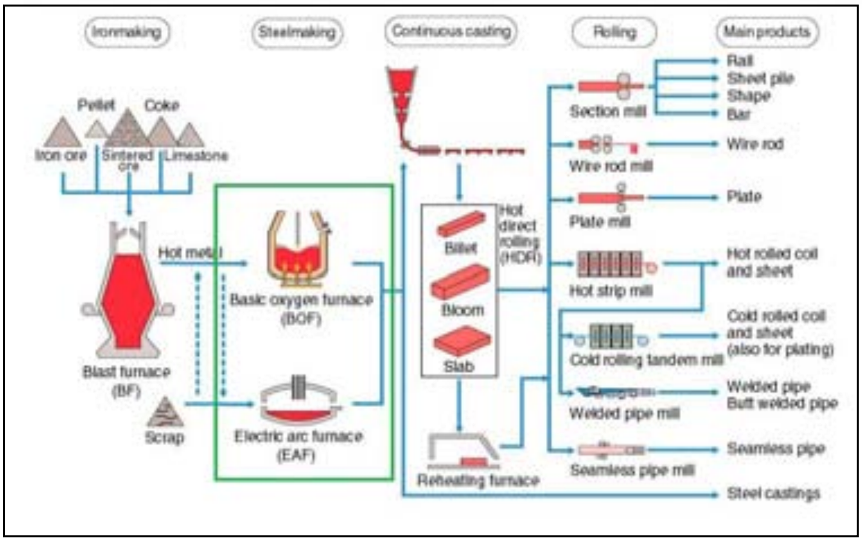

Figure 5A. Steel Making Process

(Source: Kawasaki Steel)

Generally, BOF allows bigger profit margin compared to EAF. However, with the aim to reduce carbon emission and spending on CER, EAF proves to be cleaner and greener. EAF bears the disadvantage that it depends 100% on supply of scrap, which is more limited compared to iron ores and coal that are needed in BOF process. Due to this, a firm may not depend solely on EAF but has to mix its steel making production process. The average efficient production mix ratio between BOF and EAF in percentage is 60-40[8]. Yet with growing concern to deal with climate change and positive increment in the supply of scrap metals (Terörde, 2006), it is worth to evaluate the technology in the firm´s strategic investment.

In order to decide whether it is beneficial to add EAF into the production system, a feasibility study is conducted. This study compares two production states based on BOF alone (**method A**) or BOF combined with EAF (the combination between two processes with ratio of 60-40 ratio is **method B**). For illustrative purpose, method B is rigid in the sense that once EAF is employed, the plant production has to be continuously based on

[8] Obtained from Energy Efficiency Guide for Industry in Asia

60-40 ratio. However, if scrap is not available, the plant could not reverse back to produce 100% on method A, but would have to rely on producing at only 60% of the full capacity. If this is happening, the firm will lose sales.

For a plant with capacity of producing 3933 tonnes, Method A generates €1774000 gross profit but the cost of CER is €94392. For the same production quantity, method B generates only €1605000 of gross profit but is able to lower cost of CER by 35.5% to €60880. The lower profit margin is due to increase in the production cost especially related to raw material, because currently the price of scrap is higher than the price of iron ores (Steelonthenet.com, London Metal Exchange). In addition the cost of clean energy per Btu[9] is still expensive. The detailed production accounting for both methods are summarized in Figure 5B.

	Method A	Method B		
	BOF (100%)	BOF (60%)	EAF (40%)	Total
Revenue	3067740			3067740
less:				
Primary Production Cost				
Raw Material & Related Var. Cost	916793	541810	503428	1045238
Direct Energy Consumption	376947	224180	193322	417502
Production Gross Profit	1774000			1605000
CER Cost	94392	52480	6700	60880

Figure 5B. Production Accounting for Method A and Method B[10].

Figure 5B also has underlined the cost of CER for each method of production. The CER from BOF production is nearly 2 tonnes for every tonne of crude steel produced compared to only 0.357 tonne by EAF. Combination of both EAF and BOF in method B

[9] BTU or Btu is British thermal unit, a traditional unit of energy equal to about 1055 joules. It is approximately the amount of energy needed to heat 1 pound (0.454 kg) of water, which is exactly one tenth of a UK gallon or about 0.1198 US gallons, from 39°F to 40°F (3.8°C to 4.4°C).

[10] Based on the calculation made of historical data obtained from both , MEPS, Steelonthenet.com and London Metal Exchange, the average steel price is €780 per tonne.

The direct production cost structure is obtained from several cases at Energyefficiencyasia.com and the basic principles are provided as Appendix 5B.

Some figures have been rounded up to ease calculations and understanding.

is able to reduce the cost of CER by 35.5%, which is nearly €34000 (€33512 in exact). On the other hand, the uncertain future of CER prices affects the amount of future CER saving or spending; and net profits too. With the current CER price of 12€ per tonne (Reuters) the saving of carbon credit from method B is still insufficient to compensate for the reduction of gross profit of €169000.

The manufacturer has to choose whether to continue with production method A - emitting €94392 worth of CER, or save €34000 but has lose only 10% of the production profit in the initial year. The parameters of the case are as follows:

Time steps

A time step of 1 year for each node, thus $\delta t = 1$.

Option time frame

Bearing the assumption that t_0 is 2011; the time period for the analysis is 5 years. In principle CER market will expire in 2012. However, due to current policy and regulations development on climate change and increase participation from countries all over the world, together with human realization towards climate change impact, it is assumed that the policy will continue into practice and become more stringent. Therefore, the CER market is expect to resume in existence. Most recent agreements reached at the 17th UNO Conference on Climate Change, held in Durban and closed on December 11th 2011, will have to confirm the scope of this policy.

Uncertainty

Only uncertainty and volatility of CER prices are considered in the analysis. Other sources of uncertainty, such as cost and availability of iron ores, coal and scrap are ignored. Uncertainty and volatility of CER prices affect firm's decision towards investment in green technology. Besides that, a CER price is able to be proximate towards non-quantified environmental cost and benefits, especially towards realization the value of pollution. The relationship between uncertainty and volatility of CER prices is applied to derive towards a more transparent and understandable valuation method which later assists understanding on how CER price is incorporated into the valuation.

Volatility Estimate of CER

The volatility of CER prices has been calculated based on historical data and represented by σ = 56.5%. Data are obtained from EU Emission Trading Scheme (EU ETS) price from 11 February 2005 to 6 September 2006 from Reuters. EU ETS is used as proxy of CER price because CER price is seldom disclosed. Furthermore, Emission Reduction Purchase Agreements links CER prices to EU ETS, suggesting that the volatility of these two units (EU ETS and CER) is comparable. Once CER has been issued, it has to fulfil the technical requirements of International Transaction Log of Kyoto Protocol, 1997, which is theoretically fully fungible with an EU ETS unit.

Up and Down Factors

The up and down steps in the lattice present neutral probabilities and are determined by volatility. As usual in option theory, the up and down factors affect assets value. These values are required in order to calculate the lattice of projected CER, according to the following equations:

$$\text{Up step, } u = e^{\sigma\sqrt{\delta t}} \quad [5Ai]$$

$$\text{Down step, } d = \frac{1}{e^{\sigma\sqrt{\delta t}}} \quad [5Aii]$$

Risk-free Rate

Risk-free rate, r_f, is 5%.

Probability Factor

Probability factors for good and bad condition are represented by *p* and *q* respectively. *p* is calculated as:

$$p = \frac{e^{\delta t r_f} - e^{-\sigma\sqrt{\delta t}}}{e^{\sigma\sqrt{\delta t}} - e^{-\sigma\sqrt{\delta t}}} \quad [5B]$$

Using this equation, the probability factor:

p = 0.4054 (≈ 0.4), and

1- *p* = *q* = 0.5945 (≈ 0.6).

From the above data and information the projection of production of gross profit for both method A and B for the next 5 years are illustrated in Figure 5C.

5.3.2 Analyses to be Conducted

The process begins with analysing the proposed operation mode using DCF techniques before ROV follows. Then, ROV is performed according to generic analysis of binomial tree approach as Kulatilaka and Trigeorgis (1994). The approach analyses switching possibility between two modes of operation. With the presence of switching cost (taken as the difference of CER spending/saving between the two modes), the compound effects exist in the options are captured. The value obtained from ROV analysis is later attached to present value based on DCF approach for results interpretation.

5.4 ANALYSES AND RESULTS

5.4.1 Decision Rule of DCF

According to DCF rule, the decision is made based on the highest total present value (PV) of net revenue (in round up figures) between the two proposed production states, Method A and B. Since the projection is forecasted till 5th year using risk-free rates, the PV of the cash flows available in Figure 5C is solved by totalling the present value obtained from binomial algebraic expansion as follows.

t_0: $(a + b)^0 = 1$ [5Ci]

t_1: $(a + b)^1 / 1+r_f = a + b/ 1+r_f$ [5Cii]

t_2: $(a + b)^2/ (1+r_f)^2 = a^2 + 2ab + b^2/ (1+r_f)^2$ [5Ciii]

t_3: $(a + b)^3 / (1+r_f)^3 = a^3 + 3a^2b + 3ab^2 + b^3/ (1+r_f)^3$ [5Civ]

t_4: $(a + b)^4 / (1+r_f)^4 = a^4 + 4a^3b + 6a^2b^2 + 4ab^3 + b^4/ (1+r_f)^4$ [5Cv]

t_5: $(a + b)^5 / (1+r_f)^5 = a^5 + 5a^4b + 10a^3b^2 + 10a^2b^3 + 5ab^4 + b^5/ (1+r_f)^5$ [5Cvi]

Method A

t0	t1	t2	t3	t4	t5
					10209
				7194	
			5069		5069
		3572		3572	
	2517		2517		2517
1774		1774		1774	
	1250		1250		1250
		881		881	
			621		621
				437	
					308

Method B

t0	t1	t2	t3	t4	t5
					6509
				4919	
			3718		3718
		2810		2810	
	2124		2124		2124
1605		1605		1605	
	1213		1213		1213
		917		917	
			693		693
				524	
					396

Figure 5C. Five-Year Production Gross Profit Projection for Method A and Method B in Good and Bad Condition (round-up figures in ´000 €)

In this case, the results are:

PV method A = PV (A)
= € 9 328 882 [11] (≈ €9.329 million)
PV method B = PV (B)
= € 7 570 897 [12] (≈ €7.571 million)

Therefore, method A: producing on single production process of BOF is profitable compared to the proposal of employing production process with reduced emission. Production process mix of method B shall be ignored.

5.4.2 ROV of Switching Option

Following the DCF result in previous section, method A is more profitable compared to method B. However, by employing this method the firm will have to spend €94392 for carbon emission. At current state, the price of CER of 12€ is not a liability but the realization that environmental laws are getting stringent; an early approach to reduce emission seems beneficial. The firm is interested in reducing CER spending. At the same time, the firm is aware that scrap supply is limited and managers are not ready to forgo the potential sales in PV of € 1757985 (or nearly 19% reduction in PV) if method B is chosen. Therefore, a switch between production processes from method A to method B is evaluated, by applying ROV through binomial lattice approach.

The cost of switching from method A to B, and vice versa, is calculated as the difference between the amounts of CER spending on each method. From method A to B, the firm will have CER saving of 34000€, while to switch back to method A the firm has to incur additional 34000€ again.

[11] Refer to Appendix 5C.

[12] Refer to Appendix 5D.

In short, the switching costs are:

S(A→B) = + 34 000€ (CER saving)
S(B→A) = - 34 000€ (CER loss)

Switching cost not only affects the current payoff and optimal operating decision but also alters exercise cost. It also will cause a "chain effect" on the future decision. As future outcomes are depending on prior decision (i.e. which option has been exercised earlier), the flow creates a series of *nested options* which is analogous to a *compound option*. Different to options without switching cost - which resemble European options with additive value-, there are some interaction occuring in compound options.

Therefore, let I (A→B) be switching cost from Method A to B. The incremental cash flow of switching from A to B is calculated by:

$$C_t^s(A \rightarrow B) \equiv [\max C_t^s\ (B) - C_t^s\ (A) - I(A \rightarrow B), 0] \qquad [5D]$$

The value of the flexibility to switch operation from A to B is denoted by F (A→B) while the reverse operation is denoted by F (B→A). The sum of switching value is obtained by performing the following operation.

$$F\ (A \rightarrow B) = S_0\ (A \rightarrow B) + S_1\ (A \rightarrow B) + S_2\ (A \rightarrow B) + \ldots\ldots\ldots + S_n\ (A \rightarrow B). \qquad [5E]$$

Where switching cost does not exist, the calculation of S_n (A→B) is calculated by:

S_n (A→B)

- C_n^+ (A→B) = max (cash flow $_{b,+,n}$ - cash flow $_{a,+,n}$, 0)
- C_n^- (A→B) = max (cash flow $_{b,-,n}$ - cash flow $_{a,-,n}$, 0)

Taking the same direct approach, maximum cash flow between Method A and B is obtained by deducting switching cost from the initial operation. So instead of:

$$C_n^+\ (A \rightarrow B) = \max\ (\text{cash flow}_{b,+,n} - \text{cash flow}_{a,+,n}, 0),$$

the inclusion of switching cost would alter the equation to:

$$C_n^+ \text{ (A→B) = max (cash flow}_{b,+,n} \text{ - cash flow}_{a,+,n}\text{, 0) - I (A→B).} \qquad [5F]$$

By applying equation [5E] and summing all the values derived from it according to equation [5F] the switching costs are:

F (A→B) = S_0 (A→B) + S_1 (A→B) + S_2 (A→B) + S_3 (A→B) + S_4 (A→B) + S_5 (A→B)
= 0 + 0 + 22808 + 19798 + 32677 + 11723[13]
= € 86 996.

F (B→A) = S_0 (B→A) + S_1 (B→A) + S_2 (B→A) + S_3 (B→A) + S_4 (B→A) + S_5 (B→A)
= 135000 + 138830 + 164509 + 163514 + 177646 + 174495[14]
= € 953 993.

When a project bears no switching cost, the value of flexible option will be additive as for example PV (A) + F (A→B) = PV (B) + F (B→A) to resemble European options. However, with the existence of switching cost the condition does not hold[15]. In Kulatilaka and Trigeorgis (1994), switching cost resulted in options interactions since the cost to switch from a technology is difference from the cost of switching back. In this case, similar effect is noted. Since current decision to switch or not affects future technology employment (i.e. method A or B), it also would affect future switching cost. In such cases, flexible value, *V*, must be determined simultaneously with the schedule of optimal operating modes.

To count for optimal operating modes, management has two choices, either to continue in current mode or to switch immediately. By opting for continuing with current mode

[13] Refer to Appendix 5E.

[14] Refer to Appendix 5F.

[15] Proof: with switching cost,
PV (A) + F (A→B) ≠ PV (B) + F (B→A)
9328882 + 86996 ≠ 7570897 + 953993
9415878 ≠ 8524890

for the next period, the project will receive current payoffs C_t^s(A), plus any expected future benefits with the assumption of having optimal future operation. Yet, if operation switches immediately, the project has to incur into switching cost to allow receiving an alternative current cash flow and expected future benefits. The switching mode would be optimal only if the value of switching exceeds the value of delaying potential switching.

For that, the following conditions must hold.

$$V_t^s(\text{A}) = \text{Max}\ (C_t^s(\text{A}) + \hat{\text{E}}\ [V_{t+1}^s(\text{A})]/(1+\text{r}),\ C_t^s(\text{B}) + \hat{\text{E}}\ [V_{t+1}^s(\text{B})]/(1+\text{r}) - \text{I}(\text{A}\rightarrow\text{B})$$

where;

$$\hat{\text{E}}\ [V_{t+1}^s(i) \equiv pV_{t+1}^+(i) + (1\text{-p})\ V_{t+1}^-(i),\ i = \text{A or B};$$

$C_t^s(m)$: cash flow at time *t* and state *s* when operating in mode *m*

$V_t^s(m)$: flexible project value as of time *t* given that state *s* is entered while operating in mode *m*, assuming optimal future switching decisions

$m_t^s(i)$: optimal operating mode at time *t* given that state *s* is entered while operating mode *i*

Ê [.] : risk-neutral expectations operator

The backward iterative process begins from the terminal time, T (in this case T=5) by simplifying previous equation to:

$$V_t^s(\text{A}) = \text{Max}\ (C_t^s(\text{A}),\ C_t^s(\text{B}) - \text{I}(\text{A}\rightarrow\text{B})$$

$$V_t^s(\text{A}) = C_t^s(\text{A}) + \max\ ([C_t^s(\text{B}) - C_t^s(\text{A})] - \text{I}(\text{A}\rightarrow\text{B}),0) \qquad [5G]$$

By performing the backward iterative process, the terminal values for each state then become:

<u>If Method A is entered</u>

V_5^{+++++}(A) = Max (10209, 6509 + 34) = 10209 (stay in A)

V_5^{++++-}(A) = Max (5069, 3718 + 34) = 5069 (stay in A)

V_5^{+++--}(A) = Max (2517, 2124 + 34) = 2517 (stay in A)

V_5^{++---}(A) = Max (1250, 1213 + 34) = 1250 (stay in A)

V_5^{+----}(A) = Max (621, 693+34) = 727 (switch to B)

V_5^{-----}(A) = Max (308, 398 +34) = 432 (switch to B)

(Note: Figures are in €'000)

The results of the iterative process is as shown in Figure 5D. Referring to the figure, comparing switching mode from A→B is entered using method A versus method B at t0,

$$V_0 \text{ (A)} = \max [m_0 \text{ (A)}, m_0 \text{ (B)}]$$

$$= [9348247, 9213247]$$

$$= € \, 9348247 \text{ i.e. } m_0 \text{ (A)}.$$

Thus, if entered using Method A, the operation should stay at method A.

The process is later repeated for Method B.

<u>If Method B is entered</u>

V_5^{+++++}(B) = Max (6509, 10209-34) = 10175 (switch to A)

V_5^{++++-}(B) = Max (3718, 5069-34) = 5035 (switch to A)

V_5^{+++--}(B) = Max (2124, 5069-34) = 2483 (switch to A)

V_5^{++---}(B) = Max (1213,1250-34) = 1216 (switch to A)

V_5^{+----}(B) = Max (693, 621-34) = 693 (stay in B)

V_5^{-----}(B) = Max (396, 308-34) = 396 (stay in B)

(Note: Figures are in €'000)

Figure 5E shows the results of the iterative process which compares switching mode from B→A is entered using method B versus method A at t0. The results are:

$$V_0 (B) = \max [m_0 (B), m_0 (A)]$$

$$= [9009115, 9144115]$$

$$= € 9144115 \text{ i.e. } m_0 (A).$$

Thus, if the production is entered using Method B, the operation should switch to method A. Yet, if immediate switching is not possible, then V_0 (B) is € 9009115.

If method A is entered at (t_0)

					10209
				13979,64	
			14361,75		5069
		13118,79		6941,731	
	11262,03		7131,691		2517
9348,247		6557,188		3447,143	
	5746,914		3597,616		1250
		3497,937		1810,029	
			2015,267		727
				1047,965	
					432

If method B is entered at (t0)

					10209
				13979,64	
			14361,75		5069
		13118,79		6941,731	
	11262,03		7131,691		2517
9213,247		6557,188		3447,143	
	5746,914		3597,616		1250
		3497,937		1810,029	
			2015,267		727
				1047,965	
					432

Figure 5D. Value of Project with Flexible Method A/B if Method A versus B is Entered at t_0.

<u>If method B is entered at (t_0)</u>

					10175
				13913,26	
			14264,53		5035
		12992,2		6875,35	
	11107,46		7034,471		2483
9009,115		6430,598		3380,762	
	5552,225		3518,899		1216
		3301,125		1776,029	
			1948,886		693
				1013,965	
					396

<u>If method A is entered at (t_0)</u>

					10175
				13913,26	
			14264,53		5035
		12992,2		6875,35	
	11107,46		7034,471		2483
9144,115		6430,598		3380,762	
	5552,225		3518,899		1216
		3301,125		1776,029	
			1948,886		693
				1013,965	
					396

Figure 5E. Value of Project with Flexible Method B/A if Method B versus A is Entered at t_0.

From the whole process, the compound effect introduced by switching option A/B can be identified by comparing the direct approach and the backward iterative process, i.e. by comparing results obtain from equation 5Fi and 5G. The results are shown in Figure 5F.

	Direct Approach	**Backward Iterative Approach**
F(A→B)	86996	= V(F) – PV(A) = 19365
F(B→A)	953993	= V(F) - PV(B) = 1573218
F(B→A) excluding immediate switching	$\sum S_{t=5}^{t=0}$ - S_0 = 779449	= 9009115 – PV(B) = 1438219

Figure 5F. Compound Effect in Flexibility Option with Optimal Operation.

As a whole, operation with flexibility to switch from Method A to B with optimal production schedule increases the project value by €19365. Even though the increment over PV (A) is small, counted only for 0.2%, it gives the ability to the business to be flexible and able to have the opportunity to reduce CER cost up to 35.5%. If the firm stays at Method A, any uncertainty related to the increment of future CER price will cause the firm to pay higher CER credit. However, the optimal production schedule (Figure 5G) allows the firm to enjoy maximum cash flow at a particular time while at the same time cushions the business if such CER increment occurs.

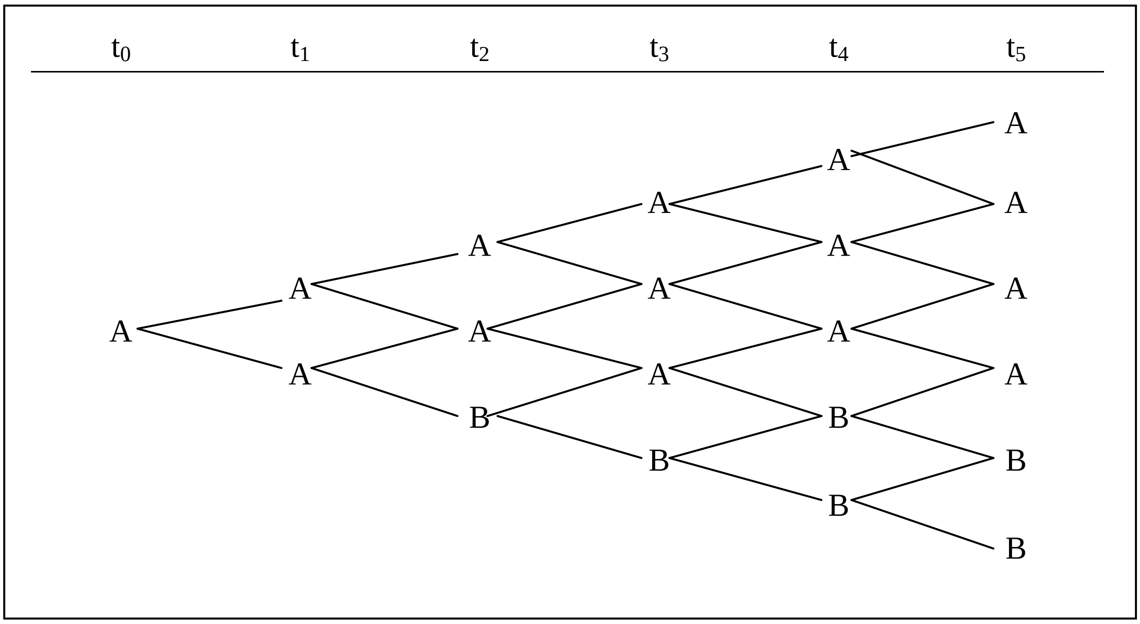

Figure 5G. Optimal Production Schedule with Flexible Production Method A/B Option.

5.5 DISCUSSION AND CONCLUSION

CSR activities affect businesses in direct and indirect ways. Real CSR options, regardless of nature and size of the practitioners are able to create goodwill and reputation, which affects business value. Direct benefits are easy to be quantified, while indirect benefits are difficult thus resulting in dilemma among practitioners. Unquantifiable uncertainty adds to the complexity. Even though attaching financial value to indirect benefits of CSR activities reduce the difficulty, it is easier for most CSR professionals to promote CSR investment by focusing the importance towards social benefits rather than assessing the impacts towards firm´s value.

With various types of CSR available to be integrated into business practices, environmental CSR - like activities related to climate change - has captured attention of many. A lot of studies available are successful in highlighting the significant impact among climate change, business value and reputation (among them, Austin and Sauer, 2003; Gars and Volk, 2003; Innovest, 2005). The participation is increasing with the realization that in most cases SMEs is the best candidate to fulfil it (Sarbutts, 2003). However, environmental issue bears a very high uncertainty, thus requires a valuation method which is able to incorporate the related factors and development into capital budgeting, strategic planning and risk mitigation.

Real option is able to integrate flexible production methods through switching option of European options to analogue switching process without cost, and compound option to analogue switching option with cost. Through the case study presented, it is proven that regardless of size, real option is able to deal with complex activities with high uncertainties. Therefore drawing conclusion from this case, SMEs are able to evaluate their CSR activities by applying ROV and realize it.

As the post effect of Kyoto Protocol 1997 is getting significant, any activities related to the environment should be taken seriously. With target to reduce GHG emission starting with countries listed in Annex 1, public and privates parties are committed to reach the target. The introduction of carbon credit also contributes to such motivation. Industries and firms who emit more GHG than allowable are required to fund development of green technology that aims to reduce carbon emission and increase energy saving projects.

Since such participation is voluntary plus the fact that in some cases SMEs are better off to fulfil the responsibility (Sarbutts, 2003), businesses are further encouraged with the existence of CER and EU ETS markets where carbon credits are tradable. As the target of GHG reduction is set, steel industry together with the SMEs component in the network being major contributor of GHG (Gelen and Moriguchi, 2001) are motivated to innovate and invest on new technology so that the target is achievable.

Improvement from BOF to EAF is able to reduce carbon emission. However, with the scarcity of scrap as the main input in the EAF production of crude steel, manufacturers are still relying on BOF to cope with world demand. On the other hand, the scarcity of scrap should not form a barrier for steel manufacturers to perform their social responsibility to reduce carbon emission. Through the approach of real option, SMEs, being part of steel producers are able to evaluate the advantages of switching from rigid mode of BOF to combine mode of BOF and EAF.

The analysis shown in this chapter has also proved that by incorporating the uncertainties of climate change using as proxy the carbon credit in CER units, SMEs are able to have an initial quantitative intuition of how the switching option has positive impact on profitability. In our case analysis, the flexibility to switch from one state to another and the capability of switching back, namely from method A (rigid production of BOF) to B (combine production of BOF and EAF) and to A again, increase additional return value of €19365 (compared to rigid production of Method A).

The research approach is conducted in a simplistic way to enhance transparency and easy understanding, following Kulatilaka and Trigeorgis (1994). With CER difference between both methods taken as the amount of switching cost, plus the incorporation of CER prices volatility and uncertainty, the compound effects of the operations are analysed. The interaction identified through simultaneous analysis of both production methods is able to provide the optimal production state. Despite of the simple analysis, the process is capable to capture hysteresis effects.

Taking uncertainty and volatility of CER prices as representative of climate change in the valuation technique as a whole is insufficient. In reality, holding the same focus and objective laid in this research, there are other variables that worth considering to be included in the model. As prices and availability of iron ores, coal and scrap embed uncertainty and volatility, a more comprehensive model that iterate these variables would bring deeper and more meaningful quantitative intuition. Nevertheless, the analysis conducted in this study is capable of triggering managers´ realization that ROV is able to incorporate variables relevant to strategic concern when it comes to climate change. Uncertainty is transferred to flexibility of switching between production processes.

The application of real option analysis and the way it responses to the many uncertainties surrounding climate change have contribute to economic and policy perspective towards the issue (Toman, 1998; Heal and Kristom, 2002; IEA, 2006). Many analysts have started to incorporate the real option analysis in the valuation of climate change impact, for example, in energy sector analysis (IEA, 2006). Supported with findings from this research, together with the statement above, real option bears the potential to address climate change issue and connects to environmental strategic responses. Overall, with such alignment, SMEs are able to fulfil their CSR to the society and environment.

APPENDIX 5A: List of Countries under Annex 1 of Kyoto Protocol.

Australia	Lithuania
Austria	Luxembourg
Belarus	Malta
Belgium	Monaco
Bulgaria	Netherlands
Canada	New Zealand
Crotia	Norway
Czech Republic Denmark	Poland
Estonia	Portugal
European Union	Romania
Finland	Russian Federation
France	Slovakia
Germany	Spain
Greece	Sweden
Hungary	Switzerland
Iceland	Turkey
Ireland	Ukraine
Italy	United Kingdom of Great Britain and Northern Ireland
Japan	United States of America
Latvia	
Liechtenstein	

APPENDIX 5B: Integrated Steel Making – Crude Steel Cost Model

Item $/unit	Factor	Unit	Unit cost	Fixed	Variable
Iron ore	1.435	t	124		177.94
Iron ore transport	1.435	t	20		28.7
Coking coal	0.519	t	200		103.80
Coking coal transport	0.519	t	19.5		10.12
Steel scrap	0.162	t	330		53.46
Scrap delivery	0.162	t	5		0.81
Oxygen	83	m 3	0.085		7.06
Ferroalloys	0.014	t	1650		23.10
Fluxes	0.59	t	45		26.55
Refractories	0.011	t	650		7.15
Other costs	1		14.25	3.56	10.69
By-product credits					-21.6
Thermal energy, net	-2.67	GJ	12.50		-33.38
Electricity	0.122	MWh	100	1.83	10.37
Labour	0.48	Man hr	37	4.44	13.32
Depreciation				48.00	

APPENDIX 5C: Calculation of Method A's Present Value, PV (A).

	t0	t1	t2	t3	t4	t5
Cash Flow						10208,67
					7193,92	
				5069,47		5069,47
			3572,40		3572,40	
		2517,43		2517,43		2517,43
	1774,00		1774,00		1774,00	
		1250,12		1250,12		1250,12
			880,94		880,94	
				620,79		620,79
					437,46	
						308,275
PV(Cash Flow)						111,837
					194,3834	
				337,8569		407,2153
			587,2276		566,2232	
		1020,657		738,1124		593,0926
	1774		855,2732		618,5109	
		743,2732		537,5155		431,9077
			311,4177		300,2787	
				130,4783		157,264
					54,66797	
						22,90487
	1774	1679,934	1590,856	1506,501	1426,619	1350,973
Total PV(A)			**€9328,882**			

APPENDIX 5D: Calculation of Method B's Present Value, PV (B).

	t0	t1	t2	t3	t4	t5
Cash Flow						6508,60
					4919,09	
				3717,77		3717,77
			2809,83		2809,83	
		2123,62		2123,62		2123,62
	1605,00		1605,00		1605,00	
		1213,03		1213,03		1213,03
			916,79		916,79	
				692,90		692,90
					523,68	
						395,7881
PV(Cash Flow)						71,30237
					132,9163	
				247,7721		298,637
			461,8773		445,3566	
		860,9954		622,649		500,3148
	1605		0		559,5885	
		721,2245		521,5705		419,0955
			324,0902		312,498	
				145,6335		175,5305
					65,44204	
						29,40711
	1605	1506,876	712,8957	1328,258	1247,054	1170,813

Total PV(B) **€7570,897**

APPENDIX 5E: Switching Cost from Method A to B

$F(A\rightarrow B) = S_0(A\rightarrow B) + S_1(A\rightarrow B) + S_2(A\rightarrow B) + S_3(A\rightarrow B) + S_4(A\rightarrow B) + S_5(A\rightarrow B)$
where;

$S_0(A\rightarrow B) = 0$

-135,00 Max (1605-1774+34,0)

$S_1(A\rightarrow B) = 0$

-359,80 [Max (2124 -2517+34, 0)]
0
-3,08 [Max (1213-1250+34, 0)]

$S_2(A\rightarrow B) = 22808$

-728,57 [Max (2810-3572+34,0)]
0
22,808 -135,00 [Max (1605-1774+34,0)]
39,913
69,85 [Max (917-881+34,0)]

$S_3(A\rightarrow B) = 19798$

-1317,70 [Max (3718-5069+34,0)]
0
0 -359,80 [Max (2124-2517+34,0)]
19,798 0
34,646 -3,08 [Max (1213-1250+34,0)]
60,631
106,11 [Max(693-621+34,0)]

S_4 (A→B) =32677

				-2240,83
				[Max (4919-7194+34,0)]
			0	
				-728,57
		0		[Max (2810-3572+34,0)]
	13,032		0	
				-135,00
32,677		22,807		[Max (1605-1774+34,0)]
	48,496		39,913	
				69,85
		69,664		[Max (917-881+34,0)]
			95,303	
				120,22
				[Max (524-437+34,0)]

S_5 (A→B) = 11713

					-3666,07
					[Max(6509-10209+34,0)]
				0	
					-1317,70
			0		[Max (3718-5069+34,0)]
		0		0	
					-359,80
	0		0		[Max (2124-2517+34,0)]
11,713		0		0	
					-3,08
	20,498		0		[Max (1213-1250+34,0)]
		35,871		0	
					106,11
			62,775		[Max (693-621+34,0)]
				109,857	
					121,5132
					[Max (396-308+34,0)]

APPENDIX 5F: Switching Cost from Method B to A

F (B→A) = S_0 (B→A) + S_1 (B→A) + S_2 (B→A) + S_3 (B→A) + S_4 (B→A) + S_5 (B→A)
where;

S_0 (B→A) = 135000

135,00 [Max (10209-6509-34,0)]

S_1 (B→A) = 138830

	359,80 [Max (2517-2124-34,0)]
138,830	
	3,08 [Max (1250-1213-34,0)]

S_2 (B→A) = 164509

		728,57 [Max (3572-2810-34,0)]
	354,692	
164,508		135,00 [Max (1774-1605-34,0)]
	51,428	
		-69,85 [Max (881-917-34,0)]

S_3 (B→A) = 163514

			1317,70 [Max (5069-3718-34,0)]
		707,583	
	348,887		359,80 [Max (2517-2124-34,0)]
163,514		138,829	
	53,5588		3,08 [Max(1250-1213-34,0)]
		1,174	
			-106,11 [Max (621-693-34,0)]

S_4 (B→A) = 177645

				2240,83 [Max (7194-4919-34,0)]
			1269,975	
		686,481		728,57 [Max (3572-2810-34,0)]
	355,521		354,692	
177,645		164,508		135,00 [Max (1774-1605-34,0)]
	73,865		51,428	
		19,5918		-69,85 [Max (881-917-34,0)]
			0	
				-120,22 [Max (437-524-34,0)]

S_5 (B→A) = 174495

					3666,07 [Max(10209-6509-34,0)]
				2149,572	
			1223,218		1317,70 [Max (5069-3718-34,0)]
		665,351		707,583	
	346,904		348,887		359,80 [Max (2517-2124-34,0)]
174,495		163,514		138,829	
	74,096		53,558		3,08 [Max (1250-1213-34,0)]
		20,659		1,174	
			447		-106,11 [Max (621-693-34,0)]
				0	
					-121,513 [Max (308-396-34,0)]

Chapter Six
CONCLUSION

Myers (1984, p. 126) has pointed out that finance theory has a “scant impact” on strategic planning based on three explanations:

1. Finance theory and traditional approaches to strategic planning may be kept apart by differences in language and “culture”.
2. Discounted cash flow (DCF) analysis may have been misused, and consequently not accepted in strategic applications.
3. DCF may fail in strategic applications even if it is properly applied.

He emphasizes that part of these explanations are true and signal that a big gap does exist between finance theory and strategic management practices.

With the focal point concentrated on the weaknesses of DCF, especially in the issue of coping up with strategic objectives, real option valuation (ROV) has emerged as a new methodology which is able to offer solutions. Instead of discarding DCF in total, real option complement the weaknesses of DCF by measuring uncertainties and adding up the value of flexibility into NPV.

Originating from standard pricing model for financial options (Black & Scholes 1973; Merton, 1973), the theory is extended to real assets and non-financial investments. The term “real options” has been accepted widely in academic and industry as to differentiate the options on real assets from financial options traded in the market. Since then it has been applied extensively to solve many problems such as those related to risk management, capital budgeting, strategic management and corporate social responsibility (CSR) of various backgrounds and industries. The development covers wide extensions from theory to methodology, and from application to practical issues (Trigeorgis, 1993a).

Despite of proven studies on the ability of real options to solve strategic dilemmas (Dixit & Pindyck, 1994; Trigeorgis, 1996; Smit & Trigoergis, 2006), SMEs are still far from realization of the real option usefulness. Even worst, SMEs also ignore too often the importance of strategic management practices (Gibson & Casser, 2005; Wang, Walker & Redmond, 2007). Perry (2001) proves that SMEs which practice strategic management activities survive better compared to those that do not. The findings are further strengthening by findings by Sandberg, Robinson & Pearce (2001) that laid out the importance of practising strategic management in SMEs´ activities.

To fit real option into the framework of strategic management activities is not easy and to reach recent milestone is very challenging. Connecting real options to investment decisions is complex especially when it comes to modelling, ownership of options and market characteristics of assets (Pinches, 1998). Any studies on real option have to consider these issues. For example, modelling of specific cases has to deal with the areas of across-time strategic interdependencies and the compoundness of multiple options within similar capital project. In formulating strategies, consideration of competitors’ movements needs to be taken into account as option’s ownership is usually non-exclusive and affected by pre-empted action. The underlying asset of most real options is often not traded and, if it is, this happens mostly in imperfect markets. In short, these complexities were already stated in the 1990’s and nowadays there are still wide avenues available for research and development of real options.

This thesis tackles a list of managerial issues experienced by SMEs – risk assessment, capital budgeting decisions, strategic management and fulfilment of CSR – all with the objective to plan for strategic moves capable of boosting up business value by enhancing appropriate strategy evaluation. Adopting real option in the course gives not only solutions to SMEs but also contributes to fill in the gap between finance theory and strategic practices.

6.1 SUMMARY OF THE THESIS

The research is conducted by four inter-dependent studies with the first three papers related to each other through the same research setting and the fourth paper extending the study to the next strategic managerial level. The papers are presented individually in Chapters Two, Three, Four and Five.

Chapter Two: Real Option and Risk Management focuses on how SMEs are able to approach and manage risk in a highly uncertain condition of economic perspectives. Different to normal practice, real option has flipped threats into opportunity that should be grabbed once weaknesses and business conditions are improving. The possibility is "bought" through the development of strategic options. By embedding options into the investment evaluation process, SMEs´ managers are able to mitigate risk and help firms either to enhance firms' value or to curb occurrences of loss (Bettis, 1983).

By aligning Miller & Waller's framework (2003) to Chapman's approach (2006) in managing risk, business environment is analysed trying to identify possible risks associated to the investment. Then, risk is assessed and several future scenarios are forecasted following future anticipation in order to allow options to develop accordingly. Through development of scenarios, risks are able to be incorporated into the option and flexibility values are assessed using real option valuation (ROV).

The adoption of ROV in risk management is able to complement SWOT analysis since the early stage of risk management process by providing quantitative intuition to qualitative evaluation to enhance investment decision making. The result from this chapter proves that real option has high potential to quantify uncertainty in risk and is able to price flexibility as part of the proactive solutions towards constantly changing environment. Real option provides a "hedging platform" and therefore, very beneficial in risk management. The potential results support the negativity of risk return paradox (Bowman, 1980).

Chapter Three: Real Option and Capital Budgeting shows how uncertainties are able to be incorporated into the capital budgeting process. By applying real options to a SME in the steel industry, it illustrates how DCF investment assessment results in undervaluation and ROV corrects the result by adding the value of flexibility into NPV. This section also highlights DCF weaknesses for not being able to link financial theory to strategic management.

The valuation process is initiated by adopting option theory where the present value of the project under analysis is the proxy of the stock price and the initial cost of the investment becomes the proxy of the strike price. Then, the time value of money is integrated, taking terms of discount rates. The risk level of the project understood as volatility and the time line to indicate the length of time where the decision is able to be deferred are integrated too. Every option which has been developed based on risk assessment and factors identified from environmental scanning in the previous step are used to determine the set of parameters. Later, following the log-transformed binomial lattice approach (Trigeorgis, 1991), valuation of each option embedded in the project is performed. The value obtained – which prices flexibility – is added to NPV to generate the Enlarged NPV (ENPV).

ROV used in this stage proves that, besides improving the undervaluation of investment obtained from the NPV, this method is also feasible to be applied as valuation tool independently from the size of investment. Even though the approach is simplified, it does not alter the efficiency. In fact, it is able to illustrate to SMEs' managers that ROV can be adopted without requiring expensive training or excessive spending on professional consultancy.

Besides improving project valuation, the benefits of ROV are further enhanced with the complementary of sensitivity analysis to further study the impact of volatility of related uncertain variables. It highlights the elasticity of the investment to certain risks thus SMEs are able to eliminate some risks which show no significant effect towards the investment.

The chapter on Real Option and Capital Budgeting concludes that ROV is able to improve choices of investment. First, it overcomes the problem of undervaluation. Second, it improves project acceptance by assigning value in numbers to support subjective choices. Finally, after complementing the approach with a sensitivity analysis, ROV enables to cross out some uncertainties with no significant impact on the investment value in the future.

Chapter Four: **Real Option and Strategic Management** concentrates in bridging the gaps between finance theory and strategic management practices (Myers, 1984). Taking into account that SMEs often lack strategic planning and adding to this the results obtained in the two previous chapters, this chapter illustrates how ROV is capable of closing the mentioned gap.

With ROV, SMEs are able to formulate flexible strategies and pre-empt actions to face uncertainties once it becomes more evident. Results and findings from risk management and strategic capital budgeting activities are incorporated into strategy formulation to signals the best strategy portfolios to be exercised and suggest the most appropriate time for exercise.

With the assistance of Option Value Space (OVS) (Luehrman, 1998), SMEs' managers shall have better intuition on the best option portfolios to be exercised. Switching the marker from NPV to NPVq while holding to the same principle[1] indicates whether the investment should be taken or not. Further assessment on the value of investment and its relationship to volatility signals the most suitable time for the investment and its embedded options to be exercised. In this case, the most valuable portfolio is not necessarily the best portfolio to be exercised at a specific time period. Depending on the location of the options on OVS, SMEs' managers are able to formulate the optimal strategic moves for the firms. This chapter proves that ROV is very powerful to fill in the gap that exists between finance theory and strategic management practices through the incorporation of uncertainties and the measurement of flexibility.

Finally, the study moves to a specific investment condition. **Chapter Five: Real Option and Corporate Social Responsibility** tackles the issue of climate change in steel industry with the aim to reach an optimum production scheme with lower green house gasses (GHG) emission. In this chapter, green technology is evaluated to be incorporated into the production system. Even though the profitability margin is not as favourable as with current technology, ROV allows for the adoption of new technology in the form of an optimal production switching mode and, thus, opens an opportunity to perform environmental CSR in the future.

The assessment is slightly different from the previous studies conducted in Chapters Two, Three and Four. In the fifth chapter, the assessment is made based on binomial lattice approach, which is more similar to Kulatilaka & Trigeorgis (1994). The approach

[1] The more positive the value, the higher is the return on investment.

is chosen in order to better illustrate the switching mechanisms between two operating modes.

The investment which is being evaluated shows high uncertainty and volatility of carbon credit prices. Furthermore, management has to incur into additional cost of switching in order to obtain switching flexibility. The existence of switching cost in the option involves a iterative process to be conducted, as the option is not a simple European option anymore. Switching cost in switching option resembles a compound option where the option value shall depend on previous options being exercised. In short, the value of flexibility is not a sum of total option values. This process results in the suggestion of an optimal operating condition.

From this chapter, it is proven that the adoption of real options is able to deal not only with low and moderate level of uncertainties (as per the previous chapters) but also with high uncertainties by providing optimal analysis of operating conditions which combine both existing and new green technology. The conditions are well fit into the uncertainties in environmental related issues such as climate change. With such results, it opens opportunities for SMEs to contribute to both economy and society (Toman, 1998; Heal & Kristom, 2002; IEA, 2006).

6.2 CONTRIBUTION OF THE THESIS

The present thesis has important implications for literature, management and public policy which are explicitly developed in the following sections.

6.2.1 Contribution for Literature

Theoretically, by addressing the relationship between the importance of strategic financial and management practices in SMEs, this thesis gathers notions from previous academic evidence, seeking for synergies in both disciplines. The basic theories of SMEs management stem from strategic management, namely resource-based view (RBV) (Penrose, 1959; Rumelt, 1984; Teece, 1984; Wernerfelt, 1984) and organization economy (Schelling, 1980; Shapiro, 1989). Meanwhile, from the aspect of financial theory, this thesis explores the weaknesses of NPV (Ross, 1995) and complements it with real option analysis (Bowman & Hurry, 1993; Trigeorgis, 1991, Kulatilaka & Trigeorgis, 1994, Luehrman, 1998) to add quantitative value towards qualitative intuitions in decision making.

With such connection between financial theories and strategic management, the evaluation is able to incorporate environmental changes in strategic capital budgeting process. Such valuation is important to assess risk, formulate strategies and evaluate suitable corporate social responsibility activities. The inter-connection is seen as a positive approach to contribute to close the gap that exists between financial theories and strategic management practices, as highlighted by Myers (1984).

As this thesis focuses on SMEs, it also enriches the literature of SMEs' strategic management practices where the level of strategic management adoption is still at low (Gibson & Casser, 2005; Wang, Walker & Redmond, 2007). Despite of the fact that strategic planning improves the survival rate of small businesses, only a small number of firms are practicing it. Strategic management is sometimes seen by SME's managers as a sophisticated practice requiring of a high level of expertise. The findings of this thesis aim to motivate managers, especially from SMEs, to apply ROV in their strategic management practices, which cover activities ranging from risk assessment, capital budgeting and strategic formulation to CSR. To each of these four fields this thesis contributes with one chapter applied to the performance of SMEs in the steel industry. The analyses undertaken show how ROV provides a pushing factor to understand constantly changing business environments and enhance the way in which SMEs are evaluating their future investments.

This thesis has focused on the first stage of the steel industry because i) it is operated nowadays mainly by SMEs in many countries around the world; and ii) this economic sector does not count with real option analyses contributions, compared to other sectors such as land and real estate development, mining exploitation and offshore oil field concessions, electric sector, construction of large-scale infrastructures and energy-generating plants, R&D intensive industries (especially pharmaceutical and biotechnological industries), start-up ventures, Internet companies, capital intensive industries (such as airlines and railroads) and other industries subject to volatile demand (consumer electronics, toys, machine parts) or supply (oil and electric power facilities, chemicals, crop switching) (Trigeorgis, 1993a and 1993b; Brennan and Schwartz, 1985; Smit, 1997; Alonso, Azofra and de la Fuente, 2009; Kellogg and Charnes, 2000; Schwartz and Moon, 2000; Grenadier and Weiss, 1997; and Willigers and Hansen, 2008, just to quote some contributions among the many existing).

In addition, this thesis also has answered the "call" to conduct additional conformity test of the theoretical ROV and its implication on management's intuition (Trigeorgis, 1993a), applying it to a new specific economic sector, the first stage of the steel industry production. This thesis is a new contribution which proves that, independently of size, various levels of uncertainties are able to be integrated into complex investment proposals and the flexibility derived from the evaluation is able to be measured. Hence, the quantitative valuation results are complementing qualitative intuition previously used to support strategic investment decision. Quantification through ROV introduces higher precision into decision making.

As options related to real assets are more complex than financial assets, modelling is very challenging (Pinches, 1998). The mathematical principles of real option applied in this research have shown the wide coverage of usage despite of its straightforward modelling. The first model illustrated in Real Option and Risk Management (Chapter Two) and Real Option and Capital Budgeting (Chapter Three) is based on a log transformed binomial algorithm (Trigeorgis, 1993b). Chapter Five, with the focus on Real Option and Corporate Social Responsibility, applies a simple binomial model (Kulatilaka & Trigeorgis, 1994). However, both models possess its own iterative process which demonstrates the stochastic process in discrete time.

The models are rather generic than specific which aims to demonstrate to SMEs' managers the basic idea of ROV and how it is possible to incorporate uncertainties and pricing flexibility. Nevertheless, simplicity still allows for hysteresis effect which states that, in some cases, short term results appear more attractive although in fact in longer periods it is optimal to wait. Despite being "smothered", the model presented is able to incorporate the across-time strategic interdependencies and compound effects.

6.2.2 Contribution to Management

Studies from Gibson & Casser (2005) and Wang, Walker & Redmond (2007) have found that SMEs are still far from realization of the importance of strategic management practices. Since SMEs which practice strategic management activities survive better compared to those that do not (Perry, 2001), this thesis has opened the path for SMEs' managers to apply a sophisticated methodology which is able to "kill (more than) two birds with a stone".

The importance of having a proper valuation method is highlighted to SMEs' managers. The need to apply a good valuation method is stressed upon many levels of managerial activities with the main aim to connect the two (i.e. financial approach and strategic approach) by incorporating uncertainties and measure flexibility. This is done by complementing the traditional NPV with real options. NPV is rigid thus impossible to be integrated into strategic management activities appropriately, while the real option approach is feasible to assist strategic management activities since the very beginning. The same methodology, i.e. ROV, is applied in risk management, capital budgeting, strategic management and CSR activities.

Real option improves SMEs decision making in strategic investment. The approximation of real option parameter to NPV parameters illustrates the connection between the two sets of parameters. Instead of benchmarking based on NPV value, NPV quotient (NPVq) replaces the "ruler". NPVq complements qualitative intuition resulting from evaluation of risk management, strategic management and corporate social responsibility activities with quantitative intuition, which is more objective. The whole approach of real option allows SMEs' managers to decide better as investment value is corrected through capital budgeting activities and transmitted signals on the optimal time to exercise options embedded in each investment through the practice of OVS.

Therefore, it is concluded that by holding to real option approach, SMEs' managers are able to apply one sophisticated methodology capable of fulfilling various needs in business management.

6.2.3 Contribution for Public Policy

Often ignored as an aspect in business environment, public policy is often viewed only as exogenous to the competitive forces that affect the attractiveness of broad industries and specific opportunities within those industries (Porter, 1980). Being one of the most important nation's economic drivers (Birch, 1989; Storey, 1994) public policy formulations may be divided into two-prongs: First, to strengthen the role and increase the contribution of SMEs in economic development and, second, to encourage businesses to adapt greener technology that shall result in better environment for society.

If policy makers realize that real option analysis is able to overcome the problem of undervaluation of investments, they may encourage higher participation of SMEs by giving more incentives and reduce taxes related to SMEs development activities according to national preferences. Training may be given to SMEs' entrepreneurs to improve their performance. This training should include the basic methodology of real options in order to get SME's managers acquainted with real options as a method of managing business and evaluating strategic issues. With this, it is hoped that SMEs are able to improve their chances to survive and grow along time.

In order to achieve to the second objective to care for the environment, policy makers should induce some desire towards green investment behaviour. Better tax allowance may be given to businesses that employ green technology or are involved in promoting greener environment, such as afforestation, green land usage and organic agricultural. By reducing uncertainty related to public policy, evaluation of strategic investment may focus on market uncertainties. These policies would be favourable and add more flexibility in the long run.

All in all, formulations of public policy have their own targets. However, in designing the "prongs", attention must be paid to the design of subsidy schemes and public announcements. Knowledge of real options helps to improve the strategic decision analysis inside SMEs and investments related to the environment, thus policy makers may exploit it to obtain better efficiency in the pursuit of policy goals.

6.3 AVENUES FOR FUTURE RESEARCH

The study conducted and presented in this thesis has not been able, unfortunately, to rely on a "real" case study. This would have required from a joint work with a SME or a group of SMEs performing in this stage of the steel industry interested in applying ROV to their business activity, which is beyond the scope of this doctoral programme. Even though the approach of stylized case studies is supported by Cooper and Slagmulder (2004) and Perry (1998), and also widely applied in many previous papers, such as Brennan and Schwartz (1985), Dixit and Pindyck (1994) and Trigeorgis (1996), the author of this thesis feels that it could have been more meaningful to conduct the research using real data of a specific case, such as in Trigeorgis (1993a), but current links to the steel industry have not enabled this degree of deep cooperation. In addition, as the study focuses on SMEs and the regulation for SMEs' public reporting is very minimal, without a co-author practitioner of the steel industry such an approach is beyond academic scope. Notice that often private membership is required so that some mechanisms of operation are able to be disclosed under anonymity, given high competition among participants in this industry.

In relation to this, data are mostly obtained through consultancy agents and associations that help the development of small businesses in steel industry. Data used in this thesis have been stylized to fit small scale business activities, based on various reports (such as Sato, 2000; 2009; Popli & Rao, 2009), to act as the basis of an average worldwide case. In complement to these weaknesses, other related parameters such as prices, market volatility, and industry environmental criteria are obtained from real sources and commodity markets directly. With this approach, the findings only generalise the feasibility and benefits of real options on small scale activity. From this doctoral thesis it is to infer that real option analysis is suitable and appropriate to be applied by SMEs' managers.

For future research lines, it would be interesting to be able to create a specific model to study the exact impact of the application of real options into dealing with strategic issues of SMEs generically and/or SMEs performing in the steel industry. By replicating these investigations in distinctive geographical contexts, more uncertain parameters are able to be identified thus enriching the ROV model. In addition to that, a future model should be able to emphasize the area of across-time strategic interdependencies, compoundness effects, pre-empted movements of competitors and the nature of valued assets in imperfect markets, as highlighted by some academicians in the field of real options.

Encouraging more SMEs to practice ROV in their strategic management issues may also open up new focuses for the relevance of ROV and the impact of its implementation in business management. The effectiveness and efficiency of the real option approach are worth and feasible to be studied, hence generalization of factorial aspects of industry, size and activities can be identified.

This doctoral thesis has tried to add another contribution in this direction by i) choosing an economic sector – the first stage in the steel industry processing – which has not been analyzed with this methodology before; ii) applying ROV to four different management issues – risk assessment, capital budgeting, strategic formulation and CSR policy implementation – all of them related through the same industry in two different case studies; and iii) performing the analysis in a context of SMEs' management in order to prove that, despite its complexity and required knowledge of option theory, ROV is a useful tool suitable to be applied to improve firm's performance independently from the size of firm.

REFERENCES

Abdullah, MAH and Bakar, MIH. (Eds.) (2000). *Small and Medium Enterprises in Asian Pacific Countries—Volume 1: Roles and Issues*. Huntington, NY: Nova Science Publishers Inc.

Alonso, S, Azofra, V and de la Fuente, G. (2009). The value of real options: The case of Endesa's takeover of Enersis. *Journal of Finance Case Research*, 10.

Amram, M and Kulatilaka, N. (1999). Disciplined decisions: Aligning strategy with the financial markets. *Harvard Business Review*, January-February: 95-104.

Anda, J, Golub, A and Strukova, E. (2009). Economics of climate change under uncertainty: Benefits of flexibility. *Energy Policy*, 37(4): 1345–55.

Austin, D and Repetto, R. (2000). *Pure Profit: The Financial Implications of Environmental Performance,* World Resources Institute: Washington, DC.

Austin, D and Sauer, A. (2003). *Changing Oil: Emerging Environmental Risks and Shareholders Value in the Oil and Gas Industry*, World Resources Institute: Washington, DC.

Australian Mining. Available at www.miningaustralia.com.au/

Bastian-Pinto, C, Brandão, L and de Lemos Alves, M. (2010). Valuing the switching flexibility of the ethanol-gas flex fuel car. *Annals of Operation Research*, 176(1): 333-348.

Beaver, G. (2003). Management and the small firm. *Strategic Change* 12: 63-68.

Beaver, G and Prince, C. (2002). Innovation, entrepreneurship and competitive advantage in the entrepreneurial venture. *Journal of Small Business and Enterprise Development* 9(1): 28-37.

Benaroch M, Lichtenstein, Y and Robinson, K. (2006). Real options in IT risk management: An empirical validation of risk-option relationships. *MIS Quarterly,* 30(4): 827-864.

Berman, J, Gordon, D and Sussman, G. (1997). A study to determine the benefits small business firms derive from sophisticated planning versus less sophisticated types of planning. *The Journal of Business and Economic Studies* 3(3): 1-11.

Berry, M. (1998). Strategic planning in small high tech companies. *Long Range Planning* 31(3): 455-466.

Bettis, R. (1983). Modern financial theory, corporate strategy, and public policy: Three conundrums. *Academy of Management Review,* 8: 405–414.

Bierman, H. (1988). *Implementing Capital Budgeting Techniques*, revised edition. Cambridge.

Bilous, J and Hon, K. (2004). *North American Steel Industry Study*. Toronto: DBRS

Birch, D. (1989). Change, innovation and job generation. *Journal of Labor Research,* 10(1):33-38.

Black, F and Scholes, M. (1973). The pricing of options and corporate liabilities. *Journal of Political Economy,* 3, 637-659.

Boer, F. (2002). *The Real Options Solution: Finding Total Value in a High-Risk World.* NY: John Wiley and Sons.

Bonmo, F. (1998). Summary: Technological innovation. In: Ranieri, R and Aylen, J (eds) *The Steel Industry in the New Millennium*. Maney Publishing.

Bookstaber, R. (1981). *Option Pricing and Strategies in Investing.* Reading, MA: Addison-Wesley Publishing Company.

Bowman, E. (1980). A risk/return paradox for strategic management. *Sloan Management Review,* 21(3): 17–31.

Bowman, E and Hurry, D. (1993). Strategy through the option lens: An integrated view of resource investments and the incremental-choice process. *Academy of Management Review,* 18(4):760–782.

Bracker, J, Keats, B and Pearson, J. (1988). Planning and financial performance among small firms in a growth industry. *Strategic Management Journal* 9(6): 591-603.

Brennan, M and Schwartz, E. (1985a). Evaluating natural resource investments. *Journal of Business* 58(2): 135-157.

Brennan, M and Schwartz, E. (1985b). A new approach to evaluating natural resource investments. *Midland Corporate Finance Journal* 3: 37-47.

Brennan, M and Trigeorgis L. (Eds.) (2000). *Project Flexibility, Agency and Competition: New Development in Theory and Application of Real Options*. New York: Oxford Press.

Brouthers, K, Andriessen, F and Nicolaes, I. (1998). Driving blind: Strategic decisionmaking in small companies. *Long Range Planning*, 31(1): 130-138.

Burke, L and Logsdon, J. (1996). How corporate social responsibility pays-off. *Long Range Planning*, 29: 495-502.

Cannon, T. (1992). *Corporate Responsibility*, 1st edition. Pitman Publishing: London.

Carland, J and Carland, J. (2003). A model of entrepreneurial planning and its effect on performance. In: *ASBE Annual Conference* - Building Bridges to the Future, Houston, Texas.

Chapman, R. (2006). *Simple Tools and Techniques for Enterprise Risk Management*. West Sussex: John Wiley and Sons.

Center for Interuniversity Research and Analysis on Organizations, CIRANO (2003) Value Creation, Risk Management and Real Option. *Burgundy Report*, July 2003.

Cogan, D. (2004). *Investor Guide to Climate Risk: Action Plan and Resource Plans for Sponsors, Fund Managers and Corporations*, Investors Network on Climate Risk, commissioned by CERES: Boston, MA.

Collins English Dictionary (2009). 10th Edition. William Collins Sons and Co., Ltd / Harper Collins Publishers.

Cooper, R and Slagmulder¸ R. (2004). Inter - orgasational cost management and relating context. *Accounting, Organizations and Society*, 29(1): 1-26.

Copeland, T, Antikarov, V and Copeland, T. (2001). *Real Options: A Practitioner´s Guide*. London: Texere.

Corex Technology. Available at http://www.industry.siemens.com/industrysolutions/metals-mining/en/metals/ironmaking/corex/Pages/home.aspx

Cortazar, G and Schwartz, E. (1993). A compound option model of production and intermediate inventories. *Journal of Business,* 66(4): 517-540.

Cortazar, G, Schwartz, E and Salinas, M. (1998). Evaluating environmental investments: A real options approach. *Management Science*, 44(8): 1059-1070.

Cox, J and Ross, S. (1976). The valuation of options for alternative stochastic processes. *Journal of Financial Economics*, 3: 145-166.

Cox, J, Ross, S and Rubenstein, M. (1979). Option pricing: A simplified approach. *Journal of Financial Economics,* 7: 229-263.

Crone, M and Watts, D. (2000). Supply linkages and the local SME sector: Evidence from Yorkshire and Humberside. *Local Economy,* 15(4): 325-337.

Culkin, N and Smith, D. (2000). An emotional business: A guide to understanding the motivations of small business decision takers. *Qualitative Market Research: An International Journal,* 3(3): 145-157.

CSR Europe. Available on the Internet at http://www.csreurope.org/pages/en/about_us.html

Delmar, F and Shane, S. (2003). Does business planning facilitate the development of new ventures? *Strategic Management Journal*, 24: 1165–1185.

Dixit, A and Pindyck, R. (1994). *Investment under Uncertainty*, Princeton University Press.

Energy Efficiency Guide for Industry in Asia, available on the Internet at http://www.energyefficiencyasia.org

Environmental Law of United States. Available at: www.en.wikipedia.org/wiki/Environmental_policy_of_the_United_States

European Commission (2003) Business registers and SMEs : A qualitative definition of SMEs. *OECD Recommendation 2003/361/EC.* OECD Meeting Document 6.1.

Fombrun, C, Gardberg, N and Barnett, M. (2000). Opportunity platforms and safety nets: Corporate citizenship and reputational risk. *Business and Society Review*, 105(1): 85–106.

Fuss, S, Obersteiner, M and Szolgayova, J. (2008). Assessing the effects of CO_2 price caps on electricity investments - A real options analysis. *Energy Policy*, 36(10): 3974–3981.

Gars, H and Volk, C. (2003). *Carbonomics – Value at Risk through Climate Change*, West LB Pan European Equity, Strategy, SRI: London.

Gaskill, L, Van Auken, H and Manning, R. (1993). A factor analytic study of the perceived causes of small business failure. *Journal of Small Business Management* 31(4): 18-31.

Geske, R. (1979). The valuation of compound options. *Journal of Financial Economics*, 7: 63-81.

Ghemawat, P and del Sol, P. (1998). Commitment versus flexibility? *California Management Review*, 40(4): 3-42.

Gibbons, P and O'Connor, T. (2005). Influences on strategic planning processes among Irish SMEs. *Journal of Small Business Management*, *43*(2): 170-186.

Gibson, B and Casse, G. (2005). Longitudinal analysis of relationships between planning and performance in small firms. *Small Business Economics*, 25(3): 207-222.

Gielen, D and Moriguchi, Y. (2001). *Environmental Strategy Design for the Japanese Iron and Steel Industry: A Global Perspective*, Tsukuba National Institute for Environmental Studies.

Glader, P. (2006). High U.S. steel inventories stir fears of falling prices: Seen as possible omen of weakness in other parts of manufacturing sector. *The Globe and Mail*, 28 September, 2006, p. B19

Grenadier, S and Weiss, A. (1997). Investment in technological innovations: An option pricing approach. *Journal of Financial Economics*, 44(3): 397- 416.

Heal, G. and Kristom, B. (2002). Uncertainty and climate change. *Environmental and Resource Economics*, 22: 3-39.

Hull, J. (2010). *Options, Futures and Other Derivatives* (7th edition). Upper Saddle River, New Jersey :Pearson Prentice-Hall.

Husted, B (2005). Risk management, real options, and corporate social responsibility. *Journal of Business Ethics*, 60: 175-183.

IEA. (2006). *Impact of Climate Change Policy under Uncertainty in Power Investment*, IEA SLT 2006, II, Paris.

Innovest. (2005). *Carbon Disclosure Project (CDP)*. Innovest Strategic Value Advisors.

International Iron and Steel Institute. (2005). *Steel: The Foundation of a Sustainable Future*. Sustainability Report of the World Steel Industry 2005.

IPPC. (2007). *Intergovernmental Panel on Climate Change (IPPC) Fourth Assessment Report: Climate Change 2007* (AR4).

Jones, W. (1982). Characteristics of planning in small firms. *Journal of Small Business Management*, 20(3): 15-19.

Kanter, R. (1999). From spare change to real change. *Harvard Business Review*, 77(3): 122–132.

Kawasaki Steel 21st Century Foundation. (1997). *An Introduction to Iron and Steel Processing.* Reproduced 2003, JFE 32st Century Foundation.

Kellogg, D and Charnes, J. (2000). Real-options valuation for a biotechnology company. *Financial Analyst Journal* May/June: 76-84.

Kelmar, J and Noy, S. (1990). Perceptual differences in small business strategic planning. In: 5th *National Small Business Conference: Growing Small Business*, Toowoomba.

Kemna, A and Vorst, A. (1990). A pricing method for options based on average asset values. *Journal of Banking and Finance*, 14: 113-129.

Kogut, B. (1991). Joint ventures and the option to expand and acquire. *Management Science*, 37(1): 19–33.

Kulatilaka, N. (1988). Valuing the flexibility of flexible manufacturing systems. *IEEE Transactions in Engineering Management*, 35(4): 250-257.

Kulatilaka, N and Trigeorgis, L. (1994). The general flexibility to switch: Real options revisited. *The International Journal of Finance*, 6(2): 778-798.

Kumbaroglu, G, Madlener, R and Demirel, M. (2008). A real options evaluation model for the diffusion prospects of new renewable power generation technologies. *Energy Economics*, 30(4): 1882–1908.

London Metal Exchange. Available on the Internet at http://www.lme.com

Luehrman, T. (1998a). Investment opportunities as real options: Getting started on the numbers. *Harvard Business Review* July-August: 3-15.

Luehrman, T. (1998b). Strategy as a portfolio of real options. *Harvard Business Review* September-October: 89-99.

Majd, S and Pindyck, R. (1987). Time to build, option value, and investment decisions. *Journal of Financial Economics*, 18(1):7-27.

Margrabe, W. (1978). The value of an option to exchange one asset for another. *Journal of Finance*, 33: 177-186.

Matthews, C and Scott, S. (1995). Uncertainty and planning in small and entrepreneurial firms: An empirical assessment. *Journal of Small Business Management*, 33(4): 34-52.

Mazzarol, T. (2004). Strategic management of small firms: A proposed framework for entrepreneurial ventures. In: *17th Annual SEAANZ Conference - Entrepreneurship as the Way of the Future*, Brisbane, Queensland.

McDonald, R and Siegel, D. (1985). Investment of the firms when there is an option to shut down. *International Economic Review*, 26(2): 331-349.

McDonald, R and Siegel, D. (1986). The value of waiting to invest. *Quarterly Journal of Economics* 101(4): 707-727.

McGrath, R. (1997). A real options logic for initiating technology positioning investments. *Academy of Management Review*, 22(4): 974–996.

McGrath, R. (1999). Falling forward: Real options reasoning and entrepreneurial failure. *Academy of Management Review*, 24(1): 13–30.

McGrath, R and Nerkar, N. (2004). Real options reasoning and a new look at the R&D investment strategies of pharmaceutical firms. *Strategic Management Journal*, 25: 1-21.

McKinsey Global Survey Result. (2009). *Valuing Corporate Social Responsibility*. The McKinsey Quarterly, McKinsey and Co.

McWilliams, A and Siegel, D. (2001). Corporate social responsibility: A theory of the firm perspective. *Academy of Management Review*, 26(1): 117–127.

MEPS. n.d. *Steel Reports and Publications*. Available on the Internet at http://www.meps.co.uk/meps_publications.htm

Merton, R. (1973). The theory of rational option pricing. *Bell Journal of Economics and Management Science*, 4(1): 141-183.

Miller, C and Cardinal, L. (1994). Strategic planning and firm performance: A synthesis of more than two decades of research. *Academy of Management Journal*, 37(6): 1649–65.

Miller, K and Reuer, J. (1996). Measuring organizational downside risk. *Strategic Management Journal*, 17: 671–691.

Miller, K and Waller, H. (2003). Scenarios, real options and integrated risk management. *Long Range Planning*, 36(1): 93-107.

Ministry of Environment, Government of Japan. Available at: www.env.go.jp/en/laws/policy/basic/index.html.

Muharam, F. (2011). Assessing risk for strategy formulation in steel industry through real option analysis. *Journal of Global Strategic Management,* 5(2): 5-15.

Mun, J. (2002). *Real Option Analysis: Tools and Techniques for Valuing Strategic Investments and Decisions*, Wiley: Hoboken, NJ.

Myers, S. (1984). Finance theory and financial strategy. *Interfaces*, Vol. 14(1): 126-137; reprinted in *Midlands Corporate Finance Journal*, Spring 1987: 6-13.

Myers, S and Majd, S. (1990). Abandonment and project life. *Advances in Futures and Options Research,* 4: 1-21.

Nag, R, Hambrick, D and Chen, M. (2007). What is strategic management, really? Inductive derivation of a consensus definition of the field. *Strategic Management Journal,* 28(9): 935-955.

Nichols, N. (1994). Scientific management at Merck: An interview with CFO Judy Lewent. *Harvard Business Review,* 72(1): 88-99.

Nickols, F. (2011). *Strategy, Strategic Management, Strategic Planning and Strategic Thinking,* Distance Consulting LLC.

O'Regan, N and Ghobadian, A. (2002). Effective strategic planning in small and medium sized firms. *Management Decision,* 40(7): 663-671.

Oracle White Paper. (2009). *Managing Portfolios, Projects and Risk in the Steel Industry during an Economic Downturn*, September, 2009.

Orser, B, Hogarth-Scott, S and Riding, A. (2000). Performance, firm size and management problem solving. *Journal of Small Business Management*, 38(4): 42-58.

Paddock, J, Siegel, D and Smith, J. (1988). Option valuation of claims on real assets: The case of offshore petroleum leases. *The Quarterly Journal of Economics,* 103(3): 479-508.

Penrose, E. (1959. *The Theory of the Growth of the Firm*. New York: John Wiley.

Perry, C. (1998). Processes of case study methodology for postgraduate research in marketing. *European Journal of Marketing*, 32(9/10): 785-802.

Pinches, G. (1998). Real options: Development and applications. *The Quarterly Review of Economics and Finance*, 38, Special Issue: 533-535.

Pindyck, R. (1988). Irreversible investment, capacity choice and the value of the firm. *American Economic Review*, 78: 969-985.

Pindyck, R. (1991). Irreversible, uncertainty and investment. *Journal of Economic Literature*, 29(3): 1110-1148.

Pogue, M. (2004). Investment appraisal: A new approach. *Managerial Auditing Journal*, 19(4): 565-570.

Popli, G and Rao, D. (2009). *Strategic Options for SMEs in Steel Sector in Post WTO Era: An Empirical Study in the Indian Context*. Available at: www.ssrn.com/abstract=1465087

Porter, M. (1980). *Competitive Strategy*. New York: Free Press.

Reuters. (2006). *EU Emission Trading Scheme Carbon Prices Spreadsheet*, available at www.reutersinteractive.com/CarbonNews.

Rhyne, L. (1986). The relationship of strategic planning to financial performance. *Strategic Management Journal*, 7(5): 423–36.

Robertson, D. (2008). Consumers will pay as iron ore price rise hits cost of steel. *The Times*, 19 February, 2008.

Robinson, R and Pearce, J. (1984). Research thrusts in small firm strategic planning. *Academy of Management*, 9(1): 128-137.

Ross, S. (1995). Uses, abuses, and alternatives to the Net-Present-Value rule. *Financial Management*, 24(3): 96-102.

Rumelt, D. (1984). Towards a strategic theory of the firm. In: Lambrecht, R. (ed) *Competitive Strategic Management*. Englewood Cliffs, NJ: Prentice Hall.

Sanchez, R. (1993). Strategic flexibility, firm organization, and managerial work in dynamic markets: A strategic-options perspective. *Advances in Strategic Management*, 9: 251–291.

Sandberg, W, Robinson, R and Pearce, J. (2001). Why small businesses need a strategic plan. *Business and Economic Review,* 48(1): 12-15.

Sarbutts, N. (2003). Can SMEs “do” CSR? A practitioner’s view of the ways small- and medium-sized enterprises are able to manage reputation through corporate social responsibility. *Journal of Communication Management*, 7(4): 340 – 347.

Sato, H. (2000). How did the crisis affect small and medium-sized enterprises? From a field of study of the metal-working industry in Java. *The Developing Economies,* 38(4): 572-595.

Sato, H. (2009). The iron and steel industry in Asia: Development and restructuring. *IDE Discussion Paper*, No. 210. Japan: Institute of Developing Economies.

Schelling, T. (1980). *The Strategy of Conflict* (2nd Ed). Cambridge: Harvard University Press.

Schütz, D. (2003). Steel industry risks. *Regards*, 6, May 2003, 1-3.

Schwartz, E and Moon, M. (2000). Rational pricing of internet companies. *Financial Analyst Journal*, May/June: 62-75.

Schwartz, E and Trigeorgis, L. (2004). Real option and investment under uncertainty: An overview (in: Schwartz, E and Trigeorgis, L. (Eds), *Real Options and Investments under Uncertainty, Classical Readings and Recent Contributions*,), MIT: Cambridge, MA, 1-17.

Sector-based Portal of Walloon Export Enterprises. Available at www.sectors.wallonia-export.be

Shapiro, A. (1989). The theory of business strategy. *RAND Journal of Economics,* 20(1): 125-137.

Shrader, C, Mulford, C and Blackburn, V. (1989). Strategic and operational planning, uncertainty and performance in small firms. *Journal of Small Business Management*, 27(4): 45-60.

Siomkos, G. (1992). Conceptual and methodological propositions for assessing responses to industrial crises. *Review of Business*, 13(4):, 26–42.

Smit, H. (1997). Investment analysis of offshore concessions in the Netherlands. *Financial Management*, 26(2): 5-17.

Smit, H and Trigeorgis, L. (2006). Strategic planning: Valuing and managing portfolios of real options. *R&D Management*, 36(4): 403-419.

Spenser, B and Brander, J. (1992). Pre-commitment and flexibility application to oligopoly theory. *European Economic Review*, 36(8): 1601-1626.

Steelonthenet.com (2006). Available on the Internet at http://www.steelonthenet.com

Stern, N. (2006). *The Economics of Climate Change*, HM Treasury: London.

Stewart, K. (2002). Formal business planning and small business success: A survey of small businesses with an international focus. *Journal of American Academy of Business*, 2(1): 42-46.

Stonehouse, G and Pemberton, J. (2002). Strategic planning in SMEs - Some empirical findings. *Management Decision*, 40(9): 853-861.

Storey, D. (1994). *Understanding the Small Business Sector*. London: Routledge.

Teece, D. (1984). Economic analysis and strategic management. *California Management Review*, 26(3): 87-110.

Terörde, F. (2006). *Stainless Steel Recycling: Data and Scenarios – Availability of Scraps*, ELG Haniel.

Toman, M. (1998). Research frontiers in the economics of climate change. *Discussion Paper 98-32*, Resource for the Future: Washington, DC.

Tourinho, O. (1979). The option value of reserves of natural resources. *Working Paper*, 94. Berkeley: University of California.

Triantis, A. (2000). Real options and corporate risk management. *Journal of Applied Corporate Finance*, 13(2): 64-73.

Trigeorgis, L. (1988). A conceptual options framework for capital budgeting. *Advances in Futures and Options Research*, 3: 145-167.

Trigeorgis, L. (1990). A real options application in natural resource investments. *Advances in Futures and Options Research*, 4: 153-164.

Trigeorgis, L. (1991). A log-transformed binomial numerical analysis method for valuing complex multi-option investment. *Journal of Financial and Qualitative Analysis*, 26: 309-326.

Trigeorgis, L. (1993a). The nature of option interactions and the valuation of investments with multiple real options. *Journal of Financial and Quantitative Analysis*, 28(1): 1–20.

Trigeorgis, L. (1993b). Real options and financial interactions with financial flexibility. *Financial Management*, 22(3): 202-224.

Trigeorgis, L. (1996). *Real Options, Managerial Flexibility and Strategy in Resource Allocation*, MIT Press.

Trigeorgis, L and Mason, S. (1987). Valuing managerial flexibility. *Midland Corporate Finance Journal*, 5(1): 14-21.

Tufano, P. (1996). Who manages risk? An empirical examination of risk management practices in the gold mining industry. *The Journal of Finance*, 51(4): 1097-1137.

UK Statistics Authority. (2009). Small and medium size enterprise statistics for the UK and regions, 2008. *Statistical Press Release of Department of Business Innovation and Skill*, URN 09/92.

UK Environmental Law Association. Available at: www.ukela.org/rte.asp?id=14.

United Nations Framework Convention on Climate Change (1997). *The Kyoto Protocol*, available on the Internet at http://unfccc.int/essential_background/kyoto_protocol/background/items/1351.php.

United States Small Business Administration. Available at www.sba.gov/

Upton, N, Teal, E and Felan, J. (2001). Strategic and business planning practices of fast growth family firms. *Journal of Small Business Management*, 39(1): 60-72.

US Bureau of Labor Statistic, US Department of Labor. (2010). *Career Guide to Industry* (2010 – 2011 Edition): Steel Manufacturing. Available at www.bls.gov/oco/cq/cqs014.htm

Van der Maaten, E. (2010). Uncertainty, real option valuation, and policies toward a sustainable built environment. *Journal of Sustainable Real Estate*, 2(1): 161-180.

Wang, C, Walker, E and Redmond, J. (2007). Explaining the lack of strategic planning in SMEs: The importance of owner motivation. *International Journal of Organisational Behaviour*, 12(1): 1-16.

WBCSD. (1999). *Corporate Social Responsibility*, World Business Council for Sustainable Development.

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal*, 5: 171–80.

Willigers, B and Hansen, T. (2008). Project valuation in the pharmaceutical industry: A comparison of least-squares Monte Carlo real option valuation and conventional approaches. *R&D Management*, 38(5): 520-537.

Wood, D. (1991). Corporate social performance revisited. *The Academy of Management Review*, 16(4): 691-718.

World Steel Industry. Available at: www.economywatch.com/world-industries/steel-industry/?page=full.

Yusuf, A and Saffu, K. (2005) Planning and performance of small and medium enterprise operators in a country in transition. *Journal of Small Business Management*, 43(4): 480-497.