Teaching capital budgeting for climate change

Jean RAAR✉
Swinburne University
Melba Avenue, Lilydale
VIC 3140, Australia
Phone: +61 3 9215 7293
E-mail: jraar@swin.edu.au

Abstract:

The paper adds to the environmental accounting education literature by providing an overview of current techniques which assist in capital budgeting decisions addressing corporate environmental issues. The premise of the paper is that accounting graduates may not have insights to and knowledge of the specific techniques required to integrate into project appraisals, the diversity of benchmarks associated with the environmental issues, risk, and economic issues. Benchmarks stem directly from the corporate strategic plan and goals, and thus strategy is an over-arching input into this decision process. The literature was examined to offer both a critical perspective and a systemic approach to capital budgeting techniques, and their propensity to assist management in considering this diversity of benchmarks in the environmental context.

Key words:

Capital budgeting, accounting and finance education, environmental risk, cash flow estimation

1. Introduction

Graham and Harvey (2001) suggested that business schools have been adept at teaching capital budgeting, as financial executives appear to have a sound understanding of net present value and the capital asset pricing model. Both of these methods underpin the maximisation of economic benefits. In 2000 Schaltegger and Burritt explored the role of real options and capital budgeting analysis, while Darabaris (2008, p. 77) reiterated that in the appraisal of investments with associated environmental benefits:

> the objective is to provide investment analysts with quantifiable environmental information that can be translated into hard financial data, which can be accomplished through discounted cash flow analysis or real option analysis techniques. Real option analysis may involve establishing the firm's competitive advantage as

defined by brand reputation value, and its impact on the ‘social license to operate.

Deegan (2008) and Burritt et al. (2009) used case studies to examine the information contained in environmental management accounting and costing systems of individual firms, including capital budgeting methods. Stout et al. (2008) provided a teaching example of the information flexibility offered by the use of real options for capital investment appraisals, and argued for inclusion in accounting curricula.

The aim of the paper is to promote deliberation over the integration of environmental-related risk associated with capital budgeting analysis into tertiary accounting and finance courses, and management training programmes. While the paper does not purport to prescribe a ‘one way fits all’ approach, it does expand on the literature by adding an overview of the appraisal techniques, and provides a systemic approach to the capital budgeting process. The focus of the discussion includes:

(a) cash flow methods
(b) uncertainty and risk
(c) methods/techniques of analysis, including real options and game theory.

Support for the paper was drawn from a range of literature topics, for example Nehrt (1996) who found that firms who invest earlier in equipment to reduce pollution have higher profit growth; Klingelhöfer (2008) who found that tradable emissions permits may not encourage investment in environmentally beneficial equipment; Chen (2008) who examined the use of discounted cash flow techniques in relation to nonfinancial measures in capital budgeting; the individual case studies undertaken by Burritt et al. (2009) and Deegan (2008) each of which included discussion on environmental issues associated with capital investment appraisal; the paper by Stout et al. (2008) recommending the inclusion of the topic of real options as a tool for capital budgeting into the curricula of accounting courses, and the evidence on capital budget decision techniques adopted by Canadian firms (Bennouna et al. 2010).

The paper is organised as follows: the first section outlines the background and fundamental reasons for emphasis on this aspect of capital budgeting. The next section provides a systemic process including insights into risk and cost information and is followed by detailed discussion and critical discussion on net present value, real options and game theory techniques. The final section of the paper concludes with an overview of the issues associated with educating future business professionals about integration of risk and environmental issues in capital budgeting decisions.

2. Background

Many firms have identified and communicated their environmental and social activities, and recognized that efficient environmental management information and systems can be beneficial to both financial and environmental performance (for example, White & Savage 1995; Nehrt 1996; Schaltegger & Synnestvedt 2002; Jasch 2006; and Nakao et al. 2007). It is now understood that business financial performance, even business survival, has an environmental dimension (Darabis 2008, p. 6; Molina-Azorin et al. 2009).

Socially responsible investment funds (SRI) represent the capital market's segregation of firms that are considered to have their operations underpinned by sound social and environmental practices. If the firm's strategic objective is simply to maximise economic performance in the short term, management may ignore the intangible benefits that accrue to shareholder value in the longer term.

As Cucvara (2009, p. 34) points out, perception is an important part of being a sustainable business and a firm's competitive advantage or disadvantage can arise as a result of the content of its report (Course & Lockie 2009). Lee et al. (2009, p. 21) studied leading and lagging corporate social performance (CSP) firms and found that leading CSP firms were trading at a returns discount premium and, hence, are valued by the markets. This suggests that management's proactive strategic stance is consistent with an 'ability to obtain a lower cost of equity capital'.

Business commitment to climate change and environmental responsibility also includes continuous improvement in energy reduction, pollution output, procurement and use of natural resources, including a proactive management approach (Watson et al. 2004; Darabaris 2008). For example, it may be necessary to reduce pollution emissions by '*x*' per cent to avoid potential regulatory penalties. Alternatively, firms electing to adopt a 'least cost' alternative to environmental responsibility in the shorter term may find they are faced with environmental risk that eventual flows into a financial outlay in the longer term (Darabaris 2008). As Nehrt (1996) pointed out, the strategic stance of the individual firm will influence the investment in technology. A taxonomy of the relationship between strategy, environmental issues and capital investment appraisals is provided (see Appendix 1).

The need to manage risk and maintain a competitive strategy which incorporates reduction of pollution, presents management with a significant challenge in the appraisal of capital investments[1]. Strategic commitments can be diverse in terms of their goals, processes and context, and the capital investment analysis methods employed will support these commitments and anticipated performance. Bennouna et al. (2010) found a trend towards more sophisticated appraisal techniques, although in their study the majority of firms still utilised net present value (NPV).

The traditional perception was that initial investments in technology to reduce a firm's carbon footprint may, in the shorter term, reduce profit levels. Cucvara (2009) highlighted the link between financial performance and emissions reduction suggesting a reduction in corporate costs and sustainability is not a difficult 'tightrope to walk', and emphasised the role of technology in achieving this duality. If 'cost-reducing or sales-enhancing technologies exist' a 'first-mover' firm can be in a relative position of competitive advantage and higher profit growth (Nehrt 1996, p. 546). Provided that a firm invests in pollution-reduction activities prior to its competitors, it can gain a competitive advantage. To gain or maintain a competitive advantage in emissions abatement and carbon trading investment in technology is a variable in any strategic plan.

However, it is not necessary for a firm to adopt a competitive 'first mover' approach to emissions reduction to benefit financial performance as research efforts indicate corporate management have gone beyond regulatory environmental requirements (Sharma 2000; Buysse & Verbeke 2003).

While literature highlights specific elements along the process of capital investment appraisal, there is a scarcity of literature that offers management a holistic perspective on the alternatives available that add support to and align with their strategic needs, including environmental issues.

3. A systemic approach

In practical terms, management will determine quantifiable objectives associated with strategic goals for both economic and environmental benchmarks. For pollution prevention investments, the benchmarks may differ from those used to evaluate the economic life of the project, or potential equipment to be acquired.

[1] It is accepted that other factors may influence competitive advantage, such as producer differentiation, corporate, size, etc.

3.1 Strategic risk

It is important to identify, at the strategic level, the alternative opportunities, together with their associated levels of environmental risk. For example, the decision to reduce pollution emissions by '*x*' may include alternatives, (a) to discontinue the manufacture of product AB, and close plant XYZ, or (b) modify the production process in the current plant, or (c) maintain the status quo, or close plant XYZ and build a new plant. A failure to integrate environmental issues with financial risk which may not be transferable to a third party can expose a firm to potential future claims and penalties. In a worst case scenario, the long-term viability of the firm may be at stake, particularly for smaller firms, as any increase in financial risk and uncertainty may also increase owner-manager risk. When undertaking project profitability analysis, changes to time horizons can influence the type of cost information required, and the profitability indicators chosen.

Given the dynamic and longer-term aspects associated with environmental issues and the associated risk management, the tracing of the materials flow, activities and waste are the basic issues. Undertaking this materials flow may form part of a Total Quality Management (TQM) system (de Bakker 2008) which can assist management in the identification of environmental costs alongside pollution prevention opportunities (Watson et al. 2004).

3.2 Cash flows

Decision-makers need to gain insights into cash flows over the investment's entire life (Kumaran et al. 2001), which necessitates a system that can track all costs and their associated uncertainties. Any estimation specifically involves uncertainty, environmental issues with regard to impacts, costs and cost savings in relation to their timing, amount and occurrence. Environmental impact uncertainty relates to outcomes resulting from management decisions and activities undertaken in the present time. In order to facilitate current decision-making, it is in these areas, i.e. timing of the induced costs and associated cash flows, discount rate, cost of present action versus cost of future action that uncertainty is of concern (Brooks et al. 1993; Henn & Fava 1994; Klingelhöfer 2008). A series of steps adapted from (Raar 2005) form the basis of the systemic process outlined below:

1. The first step in the capital investment process is an emissions assessment. Initially it is necessary to ascertain the life span of

the investment under consideration. The potential for environmental risk including accidents and emissions over the relevant life span can then be ascertained (SETAC 1990). These risks can then be ranked according to their probability of occurrence. A score or grade can be applied according to the level of emissions or contamination. Deegan (2008) provided the ranking for opportunities and threats, based on a five level Likert scale ranging from level 1 = Low to level 5 = Extreme. The ranking of scores is then followed by sensitivity analysis (Caspary 2008).

For those firms required to report under the Australian Government's *National Environment Protection (National Pollutant Inventory) Measure* (NPI NEPM, 1998), benchmarking may be primarily concerned with thresholds relating to greenhouse gas (GHG) emissions, energy production and consumption (Course & Lockie 2009). Schaufele and Zumoff (1993, pp. 157-158)[2] also suggested that the specific source of the emissions be considered.

Although specific details fall outside the scope of this paper, methods to assist in determining the source of the emissions can include: environmental audits and life cycle assessments (SETAC 1990; UN 1999; ISO 19011, 2002; ISO 2006). For example, Caspray (2008) provided information on strategic impact assessment (SIA) and cumulative impact assessment (CIA) as secondary methods to gain insights and assist in impact assessment. An example of the use of life cycle in relation to the reduction of GHG emissions through renewable energies was included in the study of Sarkis and Tamarkin (2008); and total emissions in Schaufele and Zumoff (1993, pp.157-158).[3] With a brief adaptation of their calculations and exponential model formula, the following information can assist firms to determine their emissions from a number of sources.

Let *$S(t)$ = the original total emissions function for one of the sources of carbon dioxide emissions = $S(t) = CO_2\ A\ (t)$; for energy, $S\ (t) = TCE\ (t)$; and for fuel consumption $S(t) = CDF\ (t)$.*

[2] The simple and understandable mathematical calculations necessary calculations of CO_2 emissions and indeed for the atmospheric concentrations of the source emissions can be found in Schaufele and Sumoff (1993).

[3] Schaufele and Sumoff (1993) and Harper Collins College Publishers copyright permits 'brief quotations embodied in critical articles and reviews'

Let Y(t)= the exponential approximation to S(t).

As capital investment decisions are being undertaken, it is necessary to consider predictions, so *S(t)* is computed for the years 2007 and 2017. Set an *x*-range with *x* at the minimum level for the *t* value of 2007, and *x* set at maximum corresponding to the *t* value for 2017. The *Y (t)* for the specific time period will closely approximate *S (t).*

Adjusting *(t)* to equal zero in 2007, the new exponential function is $Y_0\ (t) = a_0 b^t$ *where (t = 0).* This function is then used as a basis to determine the growth rate for the source of the emissions, and then the total emissions from the specific source can be determined for the period by the geometric series

$$Y_0(_0) + Y\ _0(_1) + \ldots.. + Y_0\ (_{10}). \qquad (1)$$

Once the total emissions are determined, the potential for environmental risk is established.

2. Then the second step is to ascertain the monetary inflows/outflows which are associated with environmental risk or opportunities, over the life of the specific investment, the '...cash flow should only include those costs (or savings) specifically identifiable with the investment' (Raar 2005, p. 12). These costs can include the ongoing costs/benefits, including the uncertain financial imposts that are associated with the risk of non-compliance with regulations. Probabilities can be assigned to the costs and benefits (Henn & Fava 1994). Probabilities of occurrence, estimated outcomes, and expected costs can then be determined at a specified level of statistical confidence.

   The importance of tracing and tracking environmental costs according to their particular strategic and longer-term time horizons was highlighted in the literature (Brookes et al. 1993; White et al. 1993; Henn & Fama 1994; Parker 1997). Tools to assist in establishing the interplays between the reduction of waste and pollution, and monetary cash flows are life cycle costing (LCC) (Frieberg 2007), or a similar method termed total cost assessment (TCA)[4] (see Appendix 2). These are techniques to identify, track and accumulate total project or investment costs, over longer time horizons, which can offer an improvement in productivity, at a reduced cost.

[4] Refer White et al. (1993) for more detailed discussion on Total Cost Assessment analysis compared with Net Present Value.

Adopting an ‘umbrella’ perspective to the management of environmental issues, LCC is the accumulation of the total costs associated with the entire life of an object, or a system (Long 1983). In relation to environmental issues LCC has differing perspectives. Firstly, it aligns with a life cycle Assessment in relation to meeting environmental risk and regulatory requirements (Horngren et al. 2011). That is, the physical stages in the life of the investment or product, the analysis of environmental concerns from a multi-functional perspective (Kumaran et al. 2001). Secondly the LCC allows managers to identify and manage the costs associated with an investment or a product. Lastly, LCC supports continuous improvement in the use of resources and emissions reduction within the firm’s activities (Woodward 1997).

Adopting a life cycle or total cost approach to project and investment decision-making will encourage managers to track and allocate the environmental costs that:

(a) may not be separately identified, or

(b) arise over a longer-term time horizon, or

(c) are the 'hidden' environmental costs accumulated in overhead costs pools to the project initiating the outlay. For example LCCs can include: regulatory costs (permits, fines), remediation costs (aesthetic costs), recycling and waste disposal costs, efficiency control costs, research and development costs, plant, equipment and facility costs, environmental management and control system costs, public image costs (White, Savage & Becker 1993).

3. The next step is to estimate and determine the specific cash flows associated with the time-horizons. One popular method for conducting cost estimate risk analysis is Monte Carlo simulation, which is associated with abstract populations where sampling is not economically feasible. With the objective of estimating the total system cost, and associated uncertainty, the Monte Carlo technique is used to generate a sample value, where cost factors and coefficients are assigned probabilities and are used as inputs to a cost model. A frequency distribution is determined from the set of output indicators resulting from the cost model. The frequency distribution displaying the simulated results can highlight normal or skewed shapes.

   However, Long (1983) suggested that when undertaking LCC a risk analysis should be conducted on the cost drivers. This view leads to a link with activity based costing (ABC) which assists managers to identify cost drivers, allocate costs to cost objectives, and provide performance benchmarks, either financial or nonfinancial (Kreuze & Newell 1994).

4. The next step involves the choice of techniques to be used to appraise the capital investment opportunity. Traditional evaluation of projects competing for limited or scarce capital resources is undertaken by the use of capital budgeting techniques. However, as White et al. (1993) emphasised the use of short term orientated techniques may distort outcomes, with the result that pollution prevention projects may confront a systematic bias in decisions relating to the allocation of capital resources, resulting in a potential chronic underinvestment. It is this short term aspect that is consistent with the financial tools taught in tertiary courses, such as the internal rate of return, payback period, net present value. Real options (Stout et al. 2008) and game theory offer flexibility and a longer time horizon to management's decision-making process.

   Three capital appraisal techniques are briefly discussed below:

   (a) net present value (NPV)/discounted cash flow (DCF)

   (b) real options, and

   (c) game theory.

4. Appraisal techniques

4.1 Discounted cash flow

The discounted cash flow method involves the addition of cash flows associated with investment alternatives and opportunities over the life of the investment. These involve estimations and, as such, introduce a degree of uncertainty (Flaig 2005); NPV includes a sensitivity analysis of the cash flows and accordingly includes a risk factor in the calculation. Expected present values of the investment's future cash inflows ($\tilde{Y}$), less the cash outflows or sunk costs of investment outflows (I), ($\tilde{Y} - I$) = net present value. Therefore if NPV = ($\tilde{Y} > I$) the firm would undertake the investment opportunity.

NPV is a popular method for capital investment appraisal (Ryan & Ryan 2002; Gilbert 2005). Alternatively, concerns over the criticism of the NPV method, expressed in a 'sizeable literature on the theoretical aspects of discounting' (OECD 1995, p. 126) emerged as to the use of the discounted cash flow method to evaluate alternative environmental-related projects, albeit from a predominantly macro-economic aspect. These concerns are based on: social rate of time preference; opportunity cost of capital; risk and uncertainty; intergenerational interests; and pure time preference (OECD 1995; Maas & Jantzen 1999).[5]

Criticisms of NPV include the use of assumptions which may not reflect reality (Grasselli 2007). In addition, the DCF technique is considered unreliable in the determination of a true estimate of the investment value (Phelan 1997). In relation to emissions, Farzin and Kort (2000) found that raising the discount rate can decrease the investment in abatement capital. Anderson (2006, p. 101) considered that 'the number of regulations deemed appropriate by cost benefit analysis decreases as the discount rate increases' while Siebert (2008) indicated that lower discount rates will favour future generations, and raise the costs for current users.

If the manager uses a social rate of time preference it may not correlate with the firm's short term financial costs and benefits. That is, NPV may offer the firm economic cash flow advantages in the shorter term, yet it may reduce management's longer-term investment opportunities, by ignoring the strategic value of a project.

This aspect was also emphasised by White et al. (1993), see Appendix 2. These authors argued that pollution prevention investments were disadvantaged in terms of competition for limited capital, insomuch as the benchmark for financial risk analysis for such projects is short-term orientated, instead of long-term. The problem was highlighted as follows:

> Because some economic returns to prevention projects tend to materialize in diverse and indirect forms, and occur over a longer time horizon, conventional project analyses may underestimate or omit altogether their returns to the firm. Such is the case, for example, when avoided liability reduced staff time for compliance, and enlarged market share owing to a 'green' product image are not incorporated into a project analysis. The result is that prevention projects as a group may confront systematic bias in capital allocation decisions. Resulting in potential chronic under investment in such projects (White et al. 1993, p. 2)

The literature has highlighted advantages of using a DCF method in capital investment appraisal; it incorporates a risk/return perspective, and supports a framework to consider alternative investment opportunities (Wouters 2006). Although Lin and Herbst (2004) suggested a risk neutral approach to the use of NPV for capital budgeting purposes to allow for strategic flexibility, DCF has also

[5] The discussion focused on macro-economic applications.

been criticized because of the unavailability of data when making decisions about strategic alternatives (Adler 2006).

When using DCF, a manager makes a valuation decision at a particular point in time. The key indicators relating to the investment are evaluated upfront, when the analysis is undertaken and the investment decision is made. To offset risk, the analyst makes an adjustment to the discount rates applied, and/or adjusts cash flows to reflect perceived risk, but the probabilities attached to cost estimates may be too broad. The risk aspect of DCF analysis has been the subject of a number of studies relating to probabilistic extension, a summary of which was undertaken by Carmichael and Balatbat (2008).

Once the investment decision is made, potential uncertainties in competitive markets and environmental issues are ignored. For example, risks may change or opportunities may arise to further reduce emissions. DCF does not offer management the opportunity to delay the investment, or use nonfinancial evaluation criteria. So, when including environmental issues in the capital budgeting analysis, management decisions require data and tools that offer a more robust and flexible approach (Long 1983; Rodrigues undated). Survey evidence suggests that DCF methods (a) do not play a decisive role in the decision process when competitive environments and relevant strategic reactions are considered (Gilbert 2005), and (b) that firms with higher product standardization (Chen 2008), and also larger firms have a greater tendency to adopt a DCF than smaller firms (Graham & Harvey 2001).

In reviewing the body of literature addressing the use of DCF techniques Chen (2008) identified that the use of nonfinancial measures has generally been ignored. Chen’s study added value to the literature by: comparing the use of nonfinancial measures with the use of DCF, and identifying the appropriateness of DCF or nonfinancial techniques to specific conditions (Chen 2008, p. 14).

Therefore, non-financial issues require consideration, as they relate to the trade-off between the effectiveness of the investment alternatives in terms of environmental outcomes, against the financial cost outlays and benefits. A reduction in emissions may be beneficial in that it reduces the potential for the risk of regulatory non-compliance, and the propensity for environmental impact risk. However, the financial analysis may not be advantageous.

The use of real options to value capital investments offers managers the opportunity to adopt more flexibility into their decisions, and is particularly relevant as the discount rates and the risk of the project can change (McDonald 2006). Thus, real options offer managers more flexibility and a greater opportunity to develop the 'fit' between their resources related 'strategic choices' (Sirmon & Hitt 2009).

4.2 Real Options and Game Theory

Real option valuation techniques are similar to those used for financial options in the capital markets, representing the right to invest, but not the obligation. Real options form part of the analysis techniques, they are not traded in the capital markets. Real options and DCF are not mutually exclusive, but the use of real options in capital budgeting offers management flexibility, that is the opportunity to mitigate risk – to delay, reduce or reject the investment until any risk or uncertainty is resolved (Bailey & Sporleder 2000; Rodrigues undated). The flexibility offered by the technique of real options for purposes of value and appraisal, allows the integration of a number of sources of decision uncertainty (Lindinger 2006).

Luehrman (1998) provided a framework to undertake strategic investment opportunities using real options, by linking the option pricing with discounted cash flow calculations. He emphasised that option pricing should be complementary to, rather than a substitute for, other appraisal systems. Real option valuations require input to the decision making process of potential future changes and their associated level of uncertainty (Weeds 2002; Lindinger 2006). For practical insights and recent examples of real options in investment appraisal, there are practical examples of the binomial decision tree approach in Stout et al. (2008), who suggest this topic be included in accounting courses, and in Ferreira et al. (2009) who include competitive pressures in their real option analysis. Studies suggest firms are using a real options model to assist in the inclusion of GHG emissions trading information into their investment appraisals (Sarkis & Tamarkin 2005, 2008), and for modelling investment risks and uncertainties including climate policy (Yang & Blyth 2007).

Smith and Trigeorgis (2004, p. 106) consider the use of real-options as a 'helpful tool for making strategic investment decisions', insomuch as it 'enhances NPV to capture managerial decision flexibilities' and includes management's option to defer the investment. This option to defer is particularly important when there is uncertainty. Once undertaken the investment decision may not be reversible. However, if management continually default at the various stages of deferment, the investment could eventually be abandoned. Using the prior discounted cash flow example, the firm with an opportunity to invest will do so when = $(\tilde{I} - C) > \tilde{E}$.

- Where $\tilde{E}$ = the option to invest, and
- $\tilde{I}$ = the value of project or asset;

- C =strike price or investment sunk cost (adapted from Grasselli 2007).

There may be a lag or delay factor, insomuch as there is a value in waiting until the option to invest is favourable.

Management can consider the basic binomial option model,[6] particularly when there are a number of decision steps (Jankensgärd 2001; Klingelhöfer 2008). Smit and Trigeorgis (2004, p. 110) suggested that a deferral investment opportunity be considered as a call option. However, any investment opportunity will compete with itself in terms of the time deferment, as well as compete with other projects (Ross 1995). For example, if management undertakes a strategic decision to upgrade and install the new technology to reduce emissions immediately, then there is an opportunity cost, as the firm loses the option to defer. The company also incurs the financial outlays in order to pre-empt regulatory requirements. If the NPV is at $t = 0$, there is no gain on undertaking the investment immediately, but more to be gained from deferral.

Notwithstanding, in the current global competitive environment, an investment deferral may prompt competitors to undertake their own investment to reduce emissions, advance their process of continuous improvement in emissions reduction, as well as reduce the propensity to the risk of incurring regulatory penalties, and take advantage of consumer environmental values and increase their market. Research by Nehrt (1996, p. 535) found that for earlier investors who undertake emissions reducing equipment, their growth in profit is higher than for later investors. This introduces the issue of competitiveness into the capital budgeting process. In relation to the influence of environmental regulations on investment in pollution reduction equipment, the findings were not significant. According to Nehrt (1996, p. 545), when the investment in new technology is cost-reducing or sales-enhancing, the differing environmental regulations between countries are irrelevant.

The competitive situation may also introduce an opportunity cost in the deferral of an investment which has no specified time limit (Weeds 2002) thus allowing competitors time to undertake an investment in emissions reduction equipment. Therefore, the action of

[6] Examples of real options and capital budgeting can be found in Luerman (1998); Sarkis and Tamarkin, (2008); Smits and Trigeorgis (2004); and for teaching purposes, Stout et al. (2008).

competitors in relation to emission reduction may influence management's decision. As business conditions and relevant investment decision choices change over time, the use of another analytical technique, game theory, can offer management the information and opportunity to introduce competitive effects into the decision-making process. Game theory is a study of interactive decision-making between interdependent players (Weeds 2002; Smit & Trigeorgis 2004). Essentially it is

> a tool to model and thereby analyse situations involving interactions, and possibly, cooperation, between several rational and intelligent decision makers (Ray 2000, p. 3).
>
> ....Game theory is concerned with the strategic impact of investment decisions in situations where firms are aware that their strategy affects the value of investment opportunities… (Smit & Trigeorgis 2004, p. 171).

Literature supports the application of real options and game theory models to analyse investment opportunities, particularly research and development alternatives (Lindinger 2006) and to those investment opportunities which have underlying strategic interactions (Weeds 2002).[7] Combining game theory with real options Smit and Trigeorgis (2004) introduced strategic competition into investment valuation. According to Lindinger (2006, pp. 5-6) this highlighted the flexibility versus commitment trade-off 'is often neglected in real options models which recommend waiting too long'. Lindinger also suggested that the use of option games allows analysts to 'enable the quantification of qualitative strategic thinking and merge the internal (resources, capabilities) and external (industry, competition) views of the firm'. For the purposes of this paper, this context has been extrapolated to include the external environment or climate change emissions. In a competitive situation, the introduction of emissions abatement targets may prompt individual firms to develop technology which is consistent with its strategic stance. Depending on the resources available, research capabilities, and the strategic stance, each firm can undertake a dominant or a low cost strategy (Lindinger 2006).

Ray (2000) highlighted the use of game theory as a modelling tool, which can assist management to model the interactive decision making associated with environmental problems. The decision makers are the 'players' in game theory, while the decisions are 'the

[7] A detailed discussion on the history and principles of game theory can be found at: http://www.referenceforbusiness.com/encyclopedia/For-Gol/Game-Theory.html (accessed 27th August 2011).

game'. In relation to environmental issues, Ray (2000) examined the reduction of global emissions, albeit from the perspective of two countries. The abatement involves a cost, and the marginal environmental damage will result from the total cost functions.

Prior research has also modelled real options valuation and game theory in relation to asymmetric costs (refer Smit & Trigeorgis 2004); strategic investment (Huisman et al. 2003); and investment strategies (Smit & Ankum 1993)[8]. A practical example of the process was demonstrated by Ferreira et al. (2009).

Combining the above discussion and adapting the models of Grasselli (2007) the very simple investment decision rule is as follows:

$$(\tilde{I} - C) + \tilde{Y} > \tilde{E}. \qquad (2)$$

where

$\tilde{I}$ = the present value of future cash flows

C = the sunk cost of the investment

NPV = $\tilde{I} - C$.

At this stage of the analysis the investment decision would be made when $\tilde{I} > C$. Adding the tool of real options, $\tilde{E}$ = the option to invest, provides management with the decision rule where $(\tilde{I} - C) > \tilde{E}$, then adding a competitive effect and assigning a strategic value $(\tilde{Y})$ to alternative investment decisions.

5. Discussion

Each firm will have diversity in strategic choices, and investment alternatives. As discussed earlier, DCF can add to risk and uncertainty, as the method reduces the flexibility for managers to delay their decisions. Similar to a call option in the capital markets, the use of the real options technique in investment analysis can offer management a more sophisticated and flexible 'right' to (a) invest in a project immediately, (b) alternatively wait and reduce uncertainty, or (c) even abandon the project or investment completely, if the risk is perceived as too great.

It is recognised in the business community that the public image and profit (Nehrt 1996, p. 535) of a firm can be enhanced if it undertakes

[8] The interested reader is referred to the papers by Lindinger (2006) and Grasselli (2007) for more detailed insights into the topical research efforts combining real options pricing and game theory modelling.

expenditure in abatement projects. This introduces the issue of competitiveness into the investment decision. In game theory a set of strategies or equilibrium can offer management a best response to competitive strategies. Game theory and real options are techniques that can incorporate flexibility and competitiveness into analysis. However, game theory requires expertise in mathematics, and the costs of obtaining the information may be high.

6. Limitations

The paper introduces a conceptual and a systematic approach towards analysis of the trade-off between economic benefits and emissions reduction in capital budgeting analysis. Managers will then adapt these alternatives to their specific decision-needs. As this study is based on a literature review, it does not include case study support for the analytical techniques discussed. In consequence, the paper does not offer a method of linking these interdisciplinary techniques with decisions relating to environmental emissions, for their specific decision-needs require information that also represents business reality in terms of the trade-off between emissions reduction and financial outcomes. The techniques employed to assist in the provision of such information cross interdisciplinary boundaries. However, this is not new, as uncertainty in cash flows and estimation techniques have long been topics in management accounting educational programmes.

The paper highlights a range of capital budgeting analysis techniques. The coverage of these techniques is generic, although it is recognised that their individual depth and range is varied. In so doing it emphasises that the application of the characteristics of these techniques to environmental issues in capital budgeting, requires an associated need to broaden the education and training of accounting professionals. Therefore, the paper offers opportunities for further research efforts to equate these techniques and the knowledge, to specific environmental-related circumstances.

7. Conclusion

Increasingly business communities are recognising that natural resources are not plentiful and inexhaustible, and that emissions and associated externalities are no longer isolated from the economic and financial aspects of business operations. Estimations regarding cost savings, cost effectiveness, cost avoidance, discount rates and risk management and environmental issues are necessary input to investment appraisals. Without relevant awareness and training future managers may fail to optimise decisions, even to the extent of exposing the firm to uncertain future liabilities.

The traditional NPV does not appear to support management benchmarks fully and the associated cash flows which intersect environmental and economic benefits. In this paper a particular emphasis was placed on cash flows, and the differing outcomes associated with methods used to estimate financial cash flows associated with investment alternatives.

The paper draws upon a range of interdisciplinary literature and techniques, for example life-cycle costing methods; capital budgeting techniques, (management accounting); Monte Carlo method to include uncertainty; real options (finance); and game theory (economics). Systemic insights are provided to assist management in reducing uncertainties in the growing international impetus to increase corporate environmental responsibility and reduce carbon emissions. Although business decision-makers may be familiar with specific aspects of the techniques discussed in the paper, the interaction of fundamental and baseline concepts stemming from various disciplines reflects the ongoing significance of sound management decisions on the firm's reputation.

It is suggested that accounting and finance education courses, and staff training programmes on capital appraisal, resource allocation, and cash flow analysis consider the interdisciplinary relationships associated with both environmental and financial performance benchmarks: including associated risk and uncertainty aspects. The use of real options and game theory will add versatility and more exactitude than the DCF analysis alone. It will however require expertise in mathematics, finance and management accounting. The use of total cost or life cycle costing (refer Appendix 2) can map the characteristics, and generate more insights into the risk aspects of a project. To assist trainers and educators, a potential course outline is provided in Appendix 3. Thus, the challenge to the business education and training curriculum is to provide practitioners with the skills to recognise the mechanisms necessary to provide management with the relevant information to assess risk and reduce uncertainties in this evolving climate of corporate environmental responsibility. In the future failure to adapt may reflect critically on the educational institution, the relevant professional bodies, and business decisions.

References

Adler, RW 2006, 'Why DCF budgeting is bad for business and why business schools should stop teaching it', *Accounting Education: an international journal*, vol. 15, no. 1, pp. 3-10.

Anderson, DA 2006, *Environmental economics*, Pensive Press, Kentucky.

Atkinson, AA, Kaplan, RS, Matsumura, EM & Young, SM 2012, *Management accounting information for decision-making and strategy execution*, Pearson, New Jersey, pp. 324-329.

Bailey, MD & Sporleder, TL 2000, 'The real options approach to evaluating a risky investment by a new generation cooperative: further processing', paper presented at *Cooperative Finance Issues, NCR-194-Research on Cooperatives*, Las Vegas, December, 12-13, viewed 12 June, 2008, <www.agecon.ksu.edu/acc/ncr/94>.

Bennouna, K, Meredith, GG & Marchant, T 2010, 'Improved capital budgeting decision making: evidence from Canada', *Management Decision*, vol. 48, no. 2, pp. 225-247.

Brooks, P, Davidson, LJ & Palamides, JH 1993, 'Environmental compliance: you better know your ABCs,' *Occupational Hazards*, vol. 55, no. 2, February, pp. 41-46.

Burritt, RL, Herzig, C & Tadeo, BD 2009, 'Environmental management accounting for cleaner production: The case of a Philippine rice mill', *Journal of Cleaner Production*, vol. 17, pp. 431-439.

Buysse, K & Verbeke, A 2003, 'Proactive environmental strategies: a stakeholder management perspective', *Strategic Management Journal*, vol. 24, no. 5, pp. 453-470.

Carmichael, DG & Balatbat, MCA 2008, 'Probabilistic DCF analysis and capital budgting and investment – a survey', *Engineering Economist*, vol. 53, no. 11, pp. 84-103.

Caspary, G 2008, 'Assessing decision tools for secondary risks of capital projects', *Management Decision*, vol. 46, no. 9, pp.1393-1398.

Chen, S 2008, 'DCF techniques and nonfinancial measures in capital budgeting: a contingency approach analysis', *Behavioral Research in Accounting*, vol. 20, no. 1, pp. 13–29.

Course, A & Lockie, D 2009, '*Climate change carbon and environmental essentials*', Professional Development Course supported by SPIAS Training Academy, Bond University and National Institute of Accountants, 14 December.

Cucvara, S 2009, 'A win-win situation', *CFO Financial Review*, July, pp. 34.

Darabaris, J 2008, *Corporate environmental management*, RC Press, Boca Raton.

de Bakker, D 2008, ‘Product-oriented environmental management: lessons from total quality management’, *Journal of Industrial Ecology*, vol. 5, no. 2, pp.55-69.

Deegan, C 2008, ‘Towards the implementation of environmental costing to inform capital investment decisions: the case of Australian electricity distributors and their choice of power poles’, *Australian Accounting Review*, vol. 18, no. 44, pp. 2 - 15.

EPA (Victoria) 2007, *Environmental auditor guidelines for the preparation of environmental audit reports on risk to the environment*, EPA Publication 952.2, viewed 2008 <http://epanote2.epa.vic.gov.au/EPA/publications.nsf/PubDocsLU/952.2?OpenDocument>.

Farzin, YH & Kort, PM 2000, ‘Pollution abatement investment when environmental regulation is uncertain’, *Journal of Public Economic Theory*, vol. 2, no. 2, pp. 183-212.

Ferreira, N, Kar, J & Trigeorgis, L 2009, ‘Option games: the key to competing in capital-intensive industries’, *Harvard Business Review*, March, pp.101-107.

Flaig, JJ 2005, ‘Improving project selection using expected net present value analysis’, *Quality Engineering*, vol. 17, no. 4, pp. 535-538.

Frieberg, F 2007, ‘Concept of product life cycle costing’ in Czech Technical University in Prague (ed), CTU Reports: proceedings of workshop 2007 part B, Czech Technical University in Prague, Prague, pp. 758-759.

Gilbert, E 2005, ‘Capital budgeting: a case study analysis of the role of formal evaluation techniques in the decision making process’, *SA Journal of Accounting Research*, vol.19, no. 1, pp.19-36.

Graham, JR & Harvey, CR 2001, ‘The theory and practice of corporate finance: evidence from the field’, *Journal of Financial Economics*, vol. 61, pp.1-25.

Grasselli, MR 2007, ‘Combining real options and game theory in incomplete markets’, paper presented at “*Further Developments in Quantitative Finance*, Edinburgh, 11 July 2007, viewed 14 December 2009, <http://icms.org.uk/downloads/quantfin/grasselli.pdf>.

Grenadier, SR 2004, ‘Option exercise games: the intersection of real options and game theory’, *Journal of Applied Corporate Finance*, vol. 13, no.2, pp. 99-107.

Henn, CL & Fava, JA 1994, ‘Life cycle analysis and resource management’, in RV Kolluru (ed), *Environmental Strategies handbook*, McGraw-Hill, New York, pp. 541-641.

Hesselbarth, C 2008, ‘Emissions trading and Corporate Sustainability Management’, in R Antes,, B Hansjürgens, & P Letmathe. (eds.), *Emissions trading: institutional design, decision making and corporate strategies*, Springer Science+Business Media, Dordrecht, pp. 167-179.

Horngren, CT, Wunder, M, Maquire, W, Tan, R, Data, SM, Foster, G, Rahan, MV & Ittner, C 2011, *Cost accounting – a managerial emphasis*, Pearson Australia, Frenchs Forest.

Huisman, KHM, Kort, PM, Pawlina, G & Thijssen, JJJ 2003 ‘Strategic investment under uncertainty: merging real options with Game Theory’, *CentER Discussion Paper No 2003-06*, Tilberg University, Tilburg.

ISO (International Organisation for Standardization) 2002, *Guidelines for environmental management audit, ISO 19011*, viewed 12 September 2011, <http://infostore.saiglobal.com/store/Portal.aspx?publisher=ISO&gclid=CLyx2c-rqKsCFahS4godT1170Q>.

ISO (International Organisation for Standardization) 2006, *Environmental Management ISO 14063; and Environmental management, life cycle assessment, ISO 14040;* viewed 11 December 2009, <http://infostore.saiglobal.com/store/Portal.aspx?publisher=ISO&gclid=CLyx2c-rqKsCFahS4godT1170Q>.

Jankensgard, H 2001, *The option to defer, modeling the opportunity cost under competition*, Bachelor’s Thesis, Department of Economics, Dalarna University, Borlange, viewed 12 November 2009, <http://www.puc-rio.br/marco.ind/contrib1.html#strategic_defer>.

Jasch, C 2006, ‘How to perform an environmental management cost assessment in one day’, *Journal of Cleaner Production*, vol.14, no. 14, pp. 1194-1213.

Klingelhöfer, HE 2008, ‘Investment decisions and emissions trading’, in R Antes, B Hansjurgens, & P Letmathe (eds), *Emissions trading: institutional design, decision making and corporate strategies*,.Springer Science+Business Media, Dordrecht, pp. 149-164.

Kreuze, JG & Newell, GE 1994, ‘ABC and life-cycle costing for environmental expenditures’, *Management Accounting*, vol. LXXV, no. 8, pp. 38-42.

Kumaran, DS, Ong, SK, Tan, RBH & Nee, AYC 2001, 'Environmental life cycle cost analysis of products', *Environmental Management and Health*, vol. 12, no. 3, pp. 260-276.

Lee, DL, Faff, RW & Langfield-Smith, K 2009, 'Revisiting the vexing question: does superior corporate social performance lead to improved financial performance?', *Australian Journal of Management*, vol. 31, June, pp 21 – 51, viewed 23 November 2009, <http://infotrac.Galegroup.com/itw/informark/755/537/85267934w16 /purl=rcl _BCPM>.

Lin, JB & Herbst, AG 2004, 'An instructional case on real options', *Journal of Financial Education*, vol. 30 (Winter), pp. 64-81.

Lindinger, A 2006, Real options & game theory, *Methodologie der Wirtschaftswissenschaften, Matr. Nr. 0508782*, Universität Wien, Vienna, viewed 12 June 2009, <http://www.andreaslindinger.net/downloads/methwiwis-lindinger.pdf>.

Long, JA 1983, *Life cycle costing in a dynamic environment*, unpublished PhD Thesis, Department of Industrial and Systems Engineering, Ohio State University, Ohio.

Luehrman, TA 1998, 'Investment opportunities as real options: getting started on the numbers', *Harvard Business Review*, July-Aug, pp. 51-67.

Maas, K & Jantzen, J 1999, *Life-cycle costing: a survey of methods to account for financial and external life cycle costs in water management*, TME Institute for Applied Environmental Economics, RIZA Document 99.107X, The Hague.

McDonald, RL 2006, 'The role of real options, in capital budgeting: theory and practice', *Journal of Applied Corporate Finance'*, vol. 18, no. 2, pp. 28-39.

Molina-Azorin, JF, Claver-Cortés, E, López-Gamero, MD & Tari, JJ 2009, 'Green management and financial performance: a literature review', *Management Decision*, vol. 47, no. 7, pp. 1080-1100.

Nakao, Y, Amano, A, Matsumura, K, Genba, K & Nakano, M 2007, 'Relationship between environmental performance and financial performance; an empirical analysis of Japanese corporations', *Business Strategy and the Environment*, vol. 16, no. 2, pp. 106-18.

NGER 2007, *National Greenhouse and Energy Reporting Act*, Act Compilation (current) - C2009C00478, viewed 13 January 2010, <http://www.comlaw.gov.au/ComLaw/Legislation/ActCompilation1. nsf/0/DF4560F81C30D582CA25764F007AC6E9?>.

Nehrt, C 1996, 'Timing and intensity effects of environmental investments', *Strategic Management Journal*, vol. 17, pp. 545-547.

NPI NEPM (National Environment Protection (National Pollutant Inventory) Measure), 1998 *National Environment Protection (National Pollutant Inventory) Measure*, Department of the Sustainability, Environment, Water, Population and Communities, viewed 11th November 2009, < http://www.npi.gov.au>.

OECD (Organisation for Economic Cooperation and Development) 1995, *The economic appraisal of environmental projects and policies: a practical guide*, OECD Publishing, Paris.

Parker, LD 1997, 'Accounting for environmental strategy: cost management, control and performance evaluation', *Asia-Pacific Journal of Accounting*, vol. 4, no. 2, pp. 145-173.

Phelan, SE 1997, 'Capital budgeting: decision making: finance: investment analysis; strategy', *Management Decision*, vol. 35, no. 2, pp. 163-168.

Raar, J 2005, **'**Financial reporting for environmental and social responsibility: a normative strategic concept', *The ICFAI Journal of Accounting Research*, April, pp. 7-27.

Ray, I 2000, 'Game theory and the environment: old models, new solution concepts', *Journal of Economic Literature*, vol. 7, pp. 1–21.

Rodrigues, A, undated, *Real options analysis for risky projects*, viewed February 2011, <http://www.thebusinessfarm.com.au/LeftMenu/Real+Options+Analysis+For+Risky+Projects.html>.

Ross, SA 1995, 'Uses, abuses, and alternatives to the net-present-value rule', *Financial Management*, vol. 24, no. 3, pp. 96-102.

Ryan, PA & Ryan, GP 2002, 'Capital budgeting practices of the Fortune 1000: how have things changed?', *Journal of Business and Management*, vol. 8, no. 4, pp. 355-364.

Sarkis, J & Tamarkin, M 2005, 'Real options analysis for 'green trading' the case of greenhouse gases', *The Engineering Economist*, vol. 27, no. 4, pp. 274-289.

Sarkis, J & Tamarkin, M 2008, 'Real option analysis for renewable energy technologies in a GHG emissions trading environment', in R Antes, B Hansjürgens, & P Letmathe,. (eds.), *Emissions Trading: institutional design, decision making and corporate strategies*, Springer Science+Business Media, Dordrecht, pp. 105- 119.

Schaltegger, S & Burritt, R 2000, *Contemporary environmental accounting: issues and concepts*, Greenleaf Publishing Limited, Great Britain.

Schaltegger, S & Synnestvedt, T 2002, 'The link between 'green' and economic success: environmental management as the crucial trigger between environmental and economic performance', *Journal of Environmental Management*, vol. 65, pp. 339-346.

Schaufele, C & Zumoff, N 1993, *Earth Algebra*, preliminary version, HarperCollins College Publishers, New York.

Sharma, S 2000, 'Managerial interpretations and organization context as predictors of corporate choice of environmental strategy', *Academy of Management Journal*, vol. 43, no. 4, pp. 681-697.

Siebert, H 2008, *Economics of the environment theory and policy*, Seventh Edition, Springer, Berlin.

Sirmon, DG & Hitt, MA 2009, 'Contingencies within dynamic managerial capabilities; interdependent effects of resource investment and deployment on firm performance', *Strategic Management Journal*, vol. 30, pp. 1375-1394.

Smit, H & Ankum, LA 1993, 'A real options and game-theoretic approach to corporate investment strategy under competition', *Financial Management*, vol. 22, pp. 241-250.

Smit, HTJ & Trigeorgis, L 2004, *Strategic investments*, Princeton University Press, Princeton.

SETAC (Society of Environmental Toxicology and Chemistry) 1990, *A technical framework for life-cycle assessments*, Society of Environmental Toxicology and Chemistry, Vermont.

Stout, DE, Howard, Q, Yan, X & Sheen, L 2008, 'Incorporating real-options analysis into the accounting curriculum', *Journal of Accounting Education*, vol. 26, no. 4, pp. 213-230.

Truong, G, Partington, G & Peat, M 2008, 'Cost-of-capital estimation and capital-budgeting practices in Australia', *Australian Journal of Management*, vol. 33, no. 1, pp. 95-122.

United Nations 1999, *International accounting and reporting issues: 1998 review*, Report by the Secretariat of the United Nations Conference on Trade and Development.

Watson, K, Klingenberg, B, Pllito, T & Geurts, TG 2004, 'Impact of environmental management system implementation on financial performance', *Management of Environmental Quality: An International Journal*, vol. 15, no. 6, pp. 622-628.

Weeds, H 2002, 'Strategic delay in a real options model of R&D competition', *Review of Economic Studies*, vol. 69, pp. 729-747.

White, AL, Savage, DE, & Becker, M 1993, *Alternative approaches to the financial evaluation of industrial pollution prevention investments*, Tellus Institute, Boston.

White, AL, Savage, DE & Dierks, A 1995, 'Environmental accounting: principles for the sustainable enterprise', paper presented at the *1995 TAPPI International Environmental Conference*, Atlanta, May 7-10.

White, AL & Savage, DE 1995, 'Budgeting for environmental projects: a survey', *Management Accounting,* October, pp. 48-54.

Woodward, DG 1997, 'Life-cycle costing – theory, information acquisition and application', *International Journal of Project Management*, vol.15, no. 6, pp. 335-344.

Wouters, MJ F 2006, 'Teaching capital budgeting as multi-attribute decision-making: A Commentary on "Why DCF capital budgeting is bad for business and why business schools should stop teaching it', *Accounting Education, an international journal*, vol. 15, no. 1, pp. 29-33.

Yang M & Blyth, W 2007, 'Modeling investment risks and uncertainties with real options approach', Working Paper (LTO/2007/WP 01), *International Energy Agency Working Paper Series*, Paris.

Yakhou, M & Dorweiler, VP 2004, 'Environmental accounting: an essential component of business strategy', *Business Strategy and the Environment*, vol.13, pp. 65-77.

Acknowledgements

Comments and suggestions on earlier versions and sections of this paper by participants at the Financial Educators' Conference, Deakin University, Melbourne 2000; the Hawaii Conference on Business, Honolulu, Hawaii 2001, and A-CSEAR 2008, University of South Australia are gratefully acknowledged.

Appendix 1

A taxonomy: environmental emissions

integrates with

Strategy: proactive or reactive - identifies environmental and financial opportunities and risk

links to

The theoretical expectation underpinning emissions reduction is that firms will implement systems that will support both compliance and continuous improvement in the firm's use of environmental resources.

influences

Motivation for capital expenditure. Theoretically, organisations that believe their activities may contribute to environmental problems will have implications for expenditure patterns.

dictates type of information and appraisal methods

Environmental Information **Financial Informaiton**

Information systems will support the estimation of environmental and cash flows over the time span of the investment

includes

Capital investment appraisal process and methods.

Management decisions to provide a circular effect on shareholder value

Appendix 2

Pollution prevention investment analysis: a comparison of financial evaluation approaches

	Project 1			Project 2		
	Traditional Analysis	**Total Cost Assessment**	**Diff.**	**Traditional Analysis**	**Total Cost Assessment**	**Diff.**
Total Capital Costs	$893,449	$923,449	3%	$19,659	$19,733	0%
Financial Indicators						
Annual Savings (BIT)**	$118,112	$79,127	-33%	$4,583	$5,234	14%
NPV Years 1-10	($314,719)	($480,512)	-53%	$3,860	$6,227	61%
NPV Years 1-15	($203,643)	($394,625)	-94%	$9,332	$12,436	33%
IRRYears 1-10***	6%	0%	-6%	17%	20%	3%
IRRYears 1-15***	11%	6%	-5%	20%	23%	3%
Simple Payback	7.6 years	11.7 years	54%	4.3 years	3.8 years	-12%

Source: '*Evaluation approaches to the Financial Evaluation of Industrial Pollution Prevention Investments*', White, A. L, Savage, D., Becker, M. (1993) Risk Analysis Group, Tellus Institute, p.10 *Printed with permission A.L. White..*

Extract.
** Before Interest and taxes
***Differences are expressed as percentages.

Appendix 3

Suggested Course Outline: Third year: Post Graduate Unit

Content	*Suggested Readings*
Module 1 Strategic investment in environmental protection.	
Topic 1.1: Role of environmental accounting in business strategy. Corporate sustainability management and emissions trading.	Schaltegger and Burritt (2000); Parker (1997); Yakhou & Dorweiler (2004) Hesselbarth (2008).
Topic 1.2 Product-orientated environmental management.	de Bakker (2008); Burritt, Herzig & Tadeo (2009).
Topic 1.3 Environmental costing and investment: • Life cycle analysis • Materials flow cost accounting.	Brooks, Davidson & Palmides (1993); White , Savage & Bccker. (1993); White, Savage & Dierks (1995); Kreuze & Newell (1994); Woodward (1997); Jasch (2006); Schaltegger & Synnestvedt (2002); Caspary (2008); Horngren et al. (2011); Atkinson et al. (2012).
Module 2 Environmental assessment: tools	
Topic 2.1 Environmental audits: life cycle assessments; risk analysis.	Kumaran et al. (2001); EPA (Victoria) (2007); Deegan (2008);
Topic 2.2 Pollution abatement investment. Regulation uncertain • Timing and intensity • Emissions trading.	Nehrt (1996); Farzin & Kort; (2000); Klingelhöfer (2008).
Module 3 The Role of Real Options in Capital Budgeting Analysis	
Topic 3.1 Teaching capital budgeting. Why not DCF:NPV • Budgeting practices • Non financial measures.	Adler (2006); Wouters (2006); Chen (2008); Carmichael & Balatbat (2008); Truong, Partington & Peat (2008); Bennouna, Meredith & Marchant (2010).
Topic 3.2 Incorporate real-options analysis into Capital investment decisions • Teaching case study • Analysis and examples.	Lin & Herbst (2004); Lindginer (2006); McDonald (2006); Stout et al. (2009); Sarkis & Tamarkin (2008); Ferreira, Kar & Trigeorgis (2009).
• Real options and emissions trading	Sarkis & Tamarkin (2008).
Module 4 Real Options and Game Theory	
Topic 4.1 Game theory and environmental issues	Ray (2000)
Topic 4.2 Real options and game theory	Jankensgard (2001); Weeds (2002); Hauisman et al. (2003); Grenadier (2004); Smit & Trigeorgis (2004); Grasseli (2007).