CAPITAL BUDGETING AND POLICY EVALUATION
USING OPTION PRICING THEORY

Peter Seed
Accounting and Valuation Department
Lincoln University

Discussion Paper 134

November 1992

Agribusiness & Economics Research Unit
PO Box 84
Lincoln University
CANTERBURY

Telephone No: (64) (3) 325 2811
Fax No: (64) (3) 325 3847

ISSN 1170-7607
The Agribusiness and Economics Research Unit (AERU) operates from Lincoln University providing research expertise for a wide range of organisations concerned with production, processing, distribution, finance and marketing.

The AERU operates as a semi-commercial research agency. Research contracts are carried out for clients on a commercial basis and University research is supported by the AERU through sponsorship of postgraduate research programmes. Research clients include Government Departments, both within New Zealand and from other countries, international agencies, New Zealand companies and organisations, individuals and farmers. Research results are presented through private client reports, where this is required, and through the publication system operated by the AERU. Two publication series are supported: Research Reports and Discussion Papers.

The AERU operates as a research co-ordinating body for the Economics and Marketing Department and the Department of Farm Management and Accounting and Valuation. This means that a total staff of approximately 50 professional people is potentially available to work on research projects. A wide diversity of expertise is therefore available for the AERU.

The major research areas supported by the AERU include trade policy, marketing (both institutional and consumer), accounting, finance, management, agricultural economics and rural sociology. In addition to the research activities, the AERU supports conferences and seminars on topical issues and AERU staff are involved in a wide range of professional and University related extension activities.

Founded as the Agricultural Economics Research Unit in 1962 from an annual grant provided by the Department of Scientific and Industrial Research (DSIR), the AERU has grown to become an independent, major source of business and economic research expertise. DSIR funding was discontinued in 1986 and from April 1987, in recognition of the development of a wider research activity in the agribusiness sector, the name of the organisation was changed to the Agribusiness and Economics Research Unit. An AERU Management Committee comprised of the Principal, the Professors of the three associate departments, and the AERU Director and Assistant Director administers the general Unit policy.

AERU MANAGEMENT COMMITTEE 1992

Professor A C Bywater, B.Sc., Ph.D.  
(Professor of Farm Management)  
Professor A C Zwart, B.Agr.Sc., M.Sc., Ph.D.  
(Professor of Marketing)  

R L Sheppard, B.Agr.Sc. (Hons), B.B.S.  
(Assistant Director, AERU)

AERU STAFF 1992

Director  
Professor AC Zwart, B.Agr.Sc., M.Sc., Ph.D.  
Assistant Director  
R L Sheppard, B.Agr.Sc. (Hons), B.B.S.  
Senior Research Officer  
J. R. Fairweather, B.Agr.Sc., B.A., M.A., Ph.D.

Research Officers  
S. S. F. Gilmour, B.A., M.A. (Hons)  
T. M. Ferguson, B.Com. (Ag)  
G Greer, B.Agr.Sc. (Hons)  
G. F. Thomson, B.Com.

Secretary  
J Clark
CONTENTS

LIST OF TABLES (i)

LIST OF FIGURES (iii)

PREFACE (v)

ACKNOWLEDGEMENTS (vii)

SUMMARY (ix)

SECTION 1 INTRODUCTION

1.1 Why Policy Makers Should Know More About Option Pricing Theory 1

SECTION 2 OPTIONS PRICING BASICS 5

2.1 So What is an Option? 5
2.2 But How are Options Priced? 6
2.3 Further Reading 7

SECTION 3 CAPITAL BUDGETING PROBLEMS 9

3.1 What Can Option Pricing Do? 9
3.2 Valuing Flexibility and Strategic Options: the Case of Electricity Generation 11
3.3 Valuing Equity 16
3.3.1 Valuing the Rural Banking and Finance Corporation 17
3.3.2 The Rural Bank Debt Discounting Scheme 19
3.4 Further Reading 22

SECTION 4 VALUING GUARANTEES AND CONTINGENT LIABILITIES 25

4.1 How Can Option Pricing Theory Help? 25
4.2 Minimum Price Schemes 25
4.2.1 The New Zealand Wool Board Minimum Price Scheme 26
4.3 Export Receipt Guarantees 28
4.3.1 A Hypothetical Export Guarantee 29
4.4 Valuing Loan Guarantees 30
4.4.1 Fletcher Challenge Limited’s Guarantee of Rural Banking and Finance Corporation Debt 31
4.5 Further Reading 33

REFERENCES 34
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Comparative Data for Alternative Electricity Generation Projects</td>
<td>12</td>
</tr>
<tr>
<td>3.2</td>
<td>Net Present Values of Alternative Energy Projects</td>
<td>13</td>
</tr>
<tr>
<td>3.3</td>
<td>Application of Flexibility Options to Alternative Projects</td>
<td>14</td>
</tr>
<tr>
<td>3.4</td>
<td>Estimates of the Value of the Right to Expand the Gas Fired Station</td>
<td>15</td>
</tr>
<tr>
<td>3.5</td>
<td>Simplified Black and Scholes Valuation of the Rural Banking and</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Finance Corporation as at 31 October 1989</td>
<td></td>
</tr>
<tr>
<td>3.6</td>
<td>Adjusted Black and Scholes Estimates of Farmer Equity after Discounting</td>
<td>21</td>
</tr>
<tr>
<td>4.1</td>
<td>Implicit Value of the NZWB Minimum Price Scheme, 1982/83 to 1990/91</td>
<td>27</td>
</tr>
<tr>
<td>4.2</td>
<td>Implied Minimum Values of an Export Guarantee Scheme to Scheme</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Participants</td>
<td></td>
</tr>
<tr>
<td>4.3</td>
<td>Loan Guarantee Payoffs</td>
<td>31</td>
</tr>
<tr>
<td>4.4</td>
<td>The Value of the Fletcher Challenge Counter Indemnity (Guarantee)</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>of $1,973 Million of Rural Bank Debt as at 31 October 1989</td>
<td></td>
</tr>
</tbody>
</table>
## LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Buy a Call Option</td>
<td>6</td>
</tr>
<tr>
<td>2.2</td>
<td>Buy a Put Option</td>
<td>6</td>
</tr>
</tbody>
</table>
This report aims to increase policy makers' awareness of the potential uses of option pricing theory in evaluating capital budgeting problems and contingent liabilities. By explaining in non-technical language the potential uses, advantages and problems of the technique the report will try to provide a taste of the potential applications without being a "how-to" manual.

The basic problem with discounted cash flow (DCF) approaches to capital budgeting, and policy appraisal, is that they cannot properly account for policy makers' ability to revise their original policy, or plans, if events turn out differently from what was originally thought. Many projects and policies have "option-like" characteristics which are currently ignored by conventional discounted cash flow (DCF) approaches. An option pricing approach enables these strategic and flexibility options to be valued thereby improving the quality of information provided to decision makers.

A C Zwart
DIRECTOR
ACKNOWLEDGEMENTS

An earlier draft of this report benefited from the comments of seminar participants at Lincoln University, and the Industries Branch of The Treasury. In addition I am grateful for helpful comments from Nick Brown, Ross Cullen, Lindsay Saunders, Robin Johnson, Steve Whiteman and Bryce Wilkinson. However, the usual disclaimer applies. Sections of the report were also presented at the sixteenth annual conference of the New Zealand Branch of the Australian Agricultural Economics Society held on 25 to 28 August 1991. Lastly, I gratefully acknowledge the willingness of the Ministry of Agriculture and Fisheries Rural Policy Unit to provide financial support for this project.
SUMMARY

• Policy and project analysts often use conventional discounted cash flow (DCF) techniques (such as net present value) to evaluate policy proposals and projects. However, DCF does not adequately account for the uncertainty of future cash flows. Neither can DCF account for the ability of management, or policy makers, to react to new information.

• Option pricing theory can account for, and value, these "real options" as it models decisions makers' rights to abandon, defer or expand a project or policy based on new information. The initial capital investment is seen as buying an option on future cash flows which does not have to be exercised if future conditions are unfavourable.

• Option pricing theory is being used increasingly to evaluate two major types of policies and projects:
  * capital budgeting problems (see Section 3).
  * contingent liabilities (see Section 4).

• Option pricing theory has been used in capital budgeting problems where there are significant flexibility and strategic options involved. For example, the right to expand, abandon or defer a project or the opportunity to develop a new project or market - also known as growth options. Recent applications of the option pricing approach have included:
  * minerals and oil license valuation
  * valuing equity and risky debt
  * forestry lease valuation
  * valuing energy projects.

• In general real options in capital budgeting problems are worth most when:
  * decision makers have longer to make a decision or defer a project or policy. In general the longer the deferral time the more chance there is the project will be worth more.
  * projects are riskier. This is the opposite of how a DCF approach would value a risky project. The project will only be implemented if conditions are favourable. Therefore only the positive outcomes are valued implying that projects with greater variability have higher expected positive outcomes.
  * the opportunity cost - i.e. the interest rate - is higher. Higher interest rates reduce the present value of future costs of expansion, deferral or abandonment.
• Option pricing theory has also been used to value **contingent liabilities** where one party grants a guarantee to another, for example, performance, loan repayment or minimum price guarantees. Applications of the option pricing approach have included:

* valuing loan guarantees;
* valuing minimum price schemes;
* valuing export receipt guarantees; and
* valuing production subsidies.

• In general contingent liabilities are worth more to the person receiving the guarantee when:

* the term of the guarantee is longer. Intuitively a 5 year loan guarantee is worth more than one for a week
* the liability being guaranteed is more risky. For example, deposit insurance for a bank with a low capital adequacy ratio should be higher than for a bank with a higher ratio. Likewise, minimum price guarantees on butterfat are probably worth less than those on kiwifruit.
SECTION ONE
INTRODUCTION

For the past three decades analysts have relied primarily on discounted cash flow (DCF) techniques to evaluate projects and policies where cash flows were spread over time. However, recent developments point to DCF being superseded by techniques incorporating option pricing theory as the preferred project and policy appraisal technique, see Brennan and Schwartz (1985), Trigeorgis and Mason (1987), Myers (1987) and Kensinger (1987). Over the past five years option pricing theory has been applied to a broad range of valuation problems. For example, Bardsley and Cashin (1990) have valued the Australian Wheat Corporation's minimum price scheme. Seed and Anderson (1991a and 1991b) have suggested option pricing methodologies for evaluating New Zealand government primary sector policy, Trigeorgis (1990) has demonstrated how an option pricing approach may be used to value managerial flexibility, while Paddock, Seigle and Smith (1988) and Mason and Baldwin (1988) have described techniques for valuing petroleum leases and energy subsidies, respectively.

Not only does this demonstrate the flexibility of the underlying theory, but it also suggests a major change has taken place in the way the rights and obligations attached to cash flows are being valued. However, while the option pricing approach has much appeal for financial theorists and academics, policy makers and officials know little or nothing about the technique. This report attempts to remedy this imbalance by outlining the strengths and weaknesses of option pricing methodologies. The report demonstrates in non-technical language that the contingent claims approach may be used to value a wide range of assets, cash-flows or policy programmes.

However, when people think of options they usually think of options on shares which give holders the right to buy or sell them. This association is largely due to the put option transactions of the "entrepreneurs" of New Zealand finance in the mid to late 1980s. The recent advent of exchange traded options on ordinary shares has also contributed to options' higher profile. While a share option's actual market price depends on supply and demand for the rights attached to the option, Fisher Black and Myron Scholes, derived a theoretical model which can be used to estimate a "fair" option price. However, Black and Scholes also suggested their model could be used to value risky debt, shareholders' equity, and even options on options. Most initial research and applications of Black and Scholes' work concentrated on pricing share options. However, it was not long before researchers were applying the underlying theory behind option pricing to a number of other valuation problems which had "option-like" characteristics. Broadly, the new applications were classes of contingent claims. That is, assets whose price is dependant on the price of some other asset or occurrence of some event.

1.1 Why Policy Makers Should Know More About Option Pricing Theory

Commonly, researchers have applied option pricing theory to two main classes of problem:
project evaluation or capital budgeting problems, and;
• contingent liabilities, or claims which involve some form of guarantee.

This is fortunate from a policy maker's point of view as many practical policy problems fall into these two broad areas. Policy makers and corporations are continually faced with the problem of allocating scarce resources among competing uses. The usual approach is to use DCF and calculate and compare the relative net present values (NPVs) of the competing projects or policies using some risk adjusted discount rate. However, how well does the risk adjusted discount rate account for investments and projects with variable and uncertain payoffs? Many researchers now consider option pricing a superior approach to take to evaluate many capital budgeting problems. Consider the following brief examples.

A property development firm has paid $100,000 as a non-refundable deposit on a building site. The deposit allows the firm to pay a further $900,000 for the building site over the next twelve months. The original $100,000 will be forfeited if the firm does not buy the land. The contract has characteristics of a call option: the $100,000 deposit is equivalent to the call premium; the $900,000 is the exercise price and the uncertain value of the land is equivalent to the price of the underlying asset. Whether or not the firm "exercises" its option and buys the land for the extra $900,000 depends on whether or not the value of the land exceeds $900,000 at the time the option is to expire.

Other contracts that both corporations and the government are involved in may be thought of, and valued as, options. For example, minimum price schemes and loan guarantees may be evaluated as put options. In the case of a minimum price scheme producers have the right, but not the obligation to sell their produce at the minimum price. That is, the minimum price is the exercise price; the underlying price is the market price of the commodity guaranteed by the scheme. Interestingly most guarantees of this type are given free, however, the actual cost of the guarantee can be substantial (See Section 4). When market prices fall below the minimum price the guarantee will be worth more to the recipients. However, the producers still have the right to sell their produce on the open market if prices rise.

Loan guarantees may also be evaluated as put options as in effect the lender is given the right to "sell" the loan to the person guaranteeing the debt. Consider this example. Say the Government wishes to encourage small business development by guaranteeing the loans made by banks to small businesses. In this case the bank is guaranteed to receive full repayment - regardless of what happens to the small business. Therefore the face value of the loan is the same as the exercise price; the underlying value of the business is equivalent to the underlying value of the asset. As with price guarantees charges are very rarely made for this form of guarantee. Nevertheless the value may be considerable if the risk of default is high.

The operating decisions faced by firms and government agencies may also be viewed as investment and growth options. For example, an oil exploration and refining company may increase or decrease its wells' output based on the current oil price and the expectations of future prices. Each decision is an option from the point of view of the oil company. Likewise, government agencies may expand or mothball a policy initiative depending on how well the policy was implemented or received. For example a health policy may be tested in a small region before being introduced nationwide. Depending on how well the trial goes
the policy may either be expanded nationally or scrapped. The flexibility and the right to abandon the policy is worth something and may be evaluated using option pricing theory.

Option pricing theory may also be applied to strategic business and policy problems. Many energy projects entered into in the 1970s and 1980s have negative net present values based on current price projections. However, this conventional DCF analysis ignores the right to mothball the plant and also the strategic value of energy self-sufficiency in the event of increased world prices for fossil fuels. Takeovers and mergers are often said to be made for "strategic" reasons. In this case a firm may buy another firm which has a promising research and development programme which it has yet to commercialise. The acquiring firm would see the purchase as a way of securing an increase in future sales based on the acquired firm's research and product portfolio.

Therefore it seems that the value of option pricing theory is that it incorporates the discretion available to policy makers or managers. It does not naively assume that all costs and revenues are known with certainly or that managers and politicians never change their minds based on new information. Therefore the value of the discretion seems to depend on:

- How long the project or policy may be deferred. The longer the deferral the more time there is to evaluate the policy, avoid costly errors and make a better decision. Therefore the longer the deferral time the more chance there is that even a negative NPV policy will have time to turn into a positive NPV policy due to fluctuations in revenues and costs.

- The risk of the project. With conventional DCF analysis cash flows from more risky projects are discounted at higher discount rates. This usually results in the project having a lower NPV. However, options on riskier projects are worth more than options on less risky projects or policies. Only the positive payoffs from the policy are valued as the "option" does not have to be exercised if doing so results in a loss.

- Interest rates. As mentioned above higher discount rates - often associated with risky projects - mean lower NPVs. However, higher discount rates also reduce the present value of any future cash outlays needed if the policy is to go ahead. Therefore higher interest rates usually raise the value of projects with imbedded growth or strategic options.

To demonstrate potential uses of option pricing theory this report will be divided into three major sections. Section 2 will briefly introduce the fundamentals of option pricing and explain the link between the theory and capital budgeting and contingent claim problems. Section 3 will examine how policy makers can evaluate capital budgeting problems using an option pricing approach. In this section an option pricing approach will be compared and contrasted to the conventional DCF capital budgeting techniques using a series of case studies. Section 4 will also use a series of case studies to examine ways in which policy makers can use an option pricing approach to evaluate contingent claims such as guarantees.

Before going further it must be pointed out that in this report contingent claims and option pricing theory means the theory as introduced by Black and Scholes (1973) and Brennan and Schwartz (1985) - not the option price and option value concepts stemming from contingent
valuation methods which are often applied to environmental problems. For example, a contingent valuation technique is often used to calculate the willingness to pay for a certain level of environmental quality or preservation of an endangered species. However, the approach here involves evaluating the strategic and flexibility options which are often attached to government policies.
SECTION 2
OPTION PRICING BASICS

2.1 So What is an Option?

An option gives its holder the right, but not the obligation, to buy or sell some underlying asset, at a given price, for a given period of time. The underlying asset could be anything from a building to a financial contract such as a share. The important thing is that options are exercisable at the choice of the option buyer (also called the option holder). That is, the holder does not have to buy or sell the underlying asset if they would be better off not doing so.

There are two types of option - calls and puts. Call options give holders the right to buy the specified asset at a price for a given period of time: put options give holders the right to sell a specified asset for a given period of time at a specified price. Call option holders will benefit if the value of the underlying asset rises. For example, suppose you hold a call option to buy a share for $1.00. By the time the option expires - say 90 days - the value of the share rises to $1.50. Recall that the call option gives you the right to buy the share for 50 cents less than the market price. Therefore the right to buy the share - the call option - is worth 50 cents. In this case you would exercise the option and buy the share for $1.00. Where does this 50 cents difference come from? In effect, from the person who sold (or granted) the call option to you. The grantor of the option has to buy the share in the market for $1.50 and sell it to you for $1.00 - therefore incurring a 50 cent loss.

However, what happens if the price of the underlying share falls to 20 cents. You have the right to buy the share for $1.00 but would you do so if you could buy the share on the stock exchange for 20 cents? The answer should be no. That is you would let your option expire worthless and buy the share yourself on the stock exchange. Therefore the value of the option, C, at its expiry will be either zero or the difference between the market price, S, and the exercise price, X. That is, the maximum of zero or (S - X) or:

\[ C = \max[0, S - X] \]

Put options work in the opposite way to call options. Put option holders benefit if the price of the underlying asset falls. For example, you buy the right to sell a building for $100,000. Six months later when the option expires the building is worth $80,000. Therefore as you still have the right to sell the building for $100,000 to the person that granted you the put option, the option is worth $20,000.

Now what would have happened if the value of the building had in fact risen to $125,000? In this case you could sell the building for $25,000 more than what you could by exercising the put option. Therefore despite the fact that you have an option you would be better off to let the option expire worthless and sell the building on the open market. In a similar manner to call options the value of the put option, P, at its expiry will be either zero or the difference between the exercise price, X, and the market price, S. That is, the maximum
of zero or \((X - S)\) or:

\[ P = \max[0, X - S] \]

The payoffs for holding put and call options are shown in the following diagrams. The difference between the exercise price and the market price of the underlying asset is shown on the vertical axis. The market price of the underlying asset is shown on the horizontal axis. As the market price of the underlying asset increases the value of the call option also increases. At a market price less than $1.00 the call option is worthless and will not be exercised - which would result in the loss of the 20 cent premium. At a market price above $1.20 the value of the option covers both the exercise price and the cost of the premium. That is, the option is in-the-money. In both cases - the put and the call option - the holders of the options do not have to exercise the option if they are worse off doing so.

![Figure 2.1](image1.png) buy a call option

![Figure 2.2](image2.png) buy a put option

### 2.2 But How are Options Priced?

Pricing options at expiry is straightforward. The options have a positive value depending on the relation between the exercise and market prices. As long as the market price is greater than the exercise price call options will be worth something and put options worth nothing. If the exercise price is greater than the market price put options will be worth something but call options will be worth nothing.

However, what happens when we try to price options which still have some time to run before expiry? Should the option be worth more or less given that we have to wait until expiry to exercise it? What about the effect on the option price of the underlying volatility, or variability, of the asset price? Fortunately, a robust option pricing formula has been available for pricing options for almost two decades. The original option pricing model was suggested by Fisher Black and Myron Scholes in 1973 and was based on the notion that the payoffs described above could be replicated by borrowing to buy the underlying share. Since then researchers have refined and tinkered with the model nevertheless the basic principal
remains the same. The pricing model relies on arbitrage - selling in an overpriced market and buying in an underpriced market - to make sure the option price is fair.

Although the model appears complex it is framed in such a way that there are only four major factors which influence the value of a call option. In fact the value of the call option will rise if:

- the asset's price becomes more volatile
- the time to expiry increases
- short term interest rates rise
- the ratio of the market price to the exercise price, i.e. \( S/X \), increases.

Interestingly there is nothing in the Black and Scholes model which asks anything about either investor risk aversion or expected returns on the underlying asset. The only variable which cannot be directly quoted, or measured, is the volatility, or variability, of the underlying asset. Therefore we are left with the following results:

- Options on assets which are more risky are worth more than options on less risky assets. Intuitively this is due to there being more chance that the option - be it a put or call - will end up worth something.

- Options with longer to expiration are worth more. In this case the option with the longer expiration has a greater chance to end in-the-money.

- When short term interest rates rise the present value of paying a call option's exercise price falls. Therefore the value of the option rises.

- The ratio of the market price of the asset to the exercise price, \( S/X \), becomes very large when a call option is very "in-the-money".

As we will see in sections 3.0 and 4.0 these results also apply to the values of real options involved in capital budgeting problems and contingent liabilities.

2.3 Further Reading

The following texts all provide a good introduction to option pricing theory:


For more advanced treatments see:


For a survey of the major option pricing literature see:


SECTION 3
CAPITAL BUDGETING PROBLEMS

3.1 What Can Option Pricing Theory Do?

Suppose the government is concerned about future energy demand and decides to evaluate a number of energy proposals. The policy advisors might calculate expected cash flows for the projects and then work out the net present values of the costs and benefits of each policy. If the policy makers are rational and all relevant costs and benefits have been priced, the best unambiguous choice will be the policy with the greatest net present value (NPV). Unfortunately, however, no one has yet discovered a fool proof way of forecasting the future. Therefore the expected cash flows "plugged" into the NPV calculation by the policy analyst can only ever be that - expected. Now, usually the word expected conjures up the notion of probability and weighting possible cash flow outcomes by the probability that they will occur. Say there was a 60 per cent chance of a positive $100 cash flow and a 40 per cent chance of negative cash flow of $200 for a policy in year 1. The expected cash flow can be quickly calculated as -$20. However, what if the policy makers know they can opt out of the policy if the negative $200 cash flow is about to occur? That is, the policy makers can make strategic choices. In such a situation how can the policy analyst build in the value of flexibility? One method which has been demonstrated in the literature, and which this paper will spend some time describing, is the method stemming from option pricing theory which values the project as a contingent claim.

DCF's inability to adequately account for strategic flexibility is a major shortcoming which most practitioners know about but, usually, ignore. Academics point to theoretical reasons why DCF fails to account for decisions which may play a large part in determining the final cash flow profile. According to Trigeorgis (1988) conventional time value of money concepts such as NPV fail to recognise either operating flexibility or the "strategic", or flexibility, value of some policies. Clearly the most appropriate valuation model is the one with the most structural similarity to what is being valued. According to Brennan and Schwartz (1985) DCF's major failing is that it compares project costs and benefits to the cash flows from a portfolio of riskless (i.e. default free government) bonds. The comparison is even less appropriate when examining public policy initiatives where the cash flows depend on climatic events, commodity prices, land values or even the rate of economic growth. Although DCF analysis adequately accounts for the time value of money, when calculating the present value of a project or investment, the technique treats policies' expected cash flows as given. More specifically, Paddock et al. (1988) have listed DCF's weaknesses as:

- the exact timing of cash flows is unknown and is therefore often arbitrary.
- choosing the "right" discount rate is subjective and prone to error.
- even if the cash flows used in a DCF analysis are probability weighted to incorporate expected values, this may be inappropriate if managers have the option of aborting or postponing a loss.

Therefore DCF may be unsuitable for assessing policies where decision makers' choices at each stage of the policy process play a large part in determining the final cash flow profile.
Given DCF's shortcomings why use option pricing theory instead of DCF? Much of option pricing theory's appeal is that it provides techniques and methods for pricing assets and evaluating cash flows or policies which more fully reflect the ability of decision makers to respond to future events. The DCF approach presupposes a static approach to decision making. However, realistically, the operating policy and cash flow profile of many policies will depend on outcomes that are unknown when the policy is promulgated. Furthermore, the ability of politicians to make decisions contingent on new information is central to the way most public policy develops. For example, the second year of a policy programme may be increased, left the same or cut depending on the policy's outcome and the operating environment at the end of the first year. The ability to discontinue a policy, or restart a temporarily moth-balled one, has a positive value which DCF analysis cannot incorporate. Myers (1987) summarises this by pointing out that DCF ignores the problem of estimating the links between today's investments and tomorrow's opportunities. That is, the project's impact on the firm's future investments. For example, a firm may undertake a negative NPV project in order to establish a hold in an attractive market. The second stage of the project - i.e. increasing market share - is therefore used to justify the first decision of adopting a project which would be otherwise rejected. What is important to note here is that this type of problem cannot be evaluated by simply taking the NPV's of both projects - the first and second stage - and summing them. The second stage is an option. That is, the firm does not have to expand into the market if it does not want to. The second stage will only go ahead if the first stage works and the market is still attractive. In effect if the present value of this option offsets the negative NPV of the first stage the decision would be justified. However, the problem then becomes one of evaluating the option.

Kensinger (1987) has suggested that option pricing theory could be used to value the following claims:

- the right of abandonment. That is, the option to shut down temporarily, or to abandon the entire project if events turn against the firm or government.

- the right of asset redeployment. Should business conditions change assets may be given other uses. For example, alternative fuels or other inputs may be used in the production process. On the other hand different outputs may be manufactured.

- options on future growth. Current research and development programmes provide future growth opportunities for firms which the firm may, or may not, choose to adopt.

Kensinger also suggests that option pricing could be useful for contingency planning, i.e. creating and managing a portfolio of strategic "real options".

This all implies that DCF analysis which incorporates "expected value" estimates, subject to some statistical distribution, will undervalue projects, cash flows or policies. DCF analysis assumes a given policy or project will go ahead regardless of future events and therefore incorporates expected values of both positive and negative outcomes. Even if expected values of each project cash flow are calculated using some simulation technique, the expected value will include the expected values of positive and negative cash flows for a range of scenarios. However, DCF analysis cannot select one range of outcomes in one period
contingent on the outcome in a prior period. Therefore by using DCF techniques analysts will probably undervalue projects and resources which may increase the chance that feasible projects are incorrectly rejected, or infeasible projects accepted, and assets misallocated as a result.

3.2 Valuing Operating Flexibility and Strategic Options: the Example of Electricity Generation

Let's expand the simple example given at the start of this section. Consider the case of an electrical utility such as the Electricity Corporation of New Zealand. Electricorp has four operating subsidiaries:

- PowerDesignBuild - also known as PDB which, as the name implies, looks after technical and engineering aspects;
- Electricorp Production which manages the hydroelectric, coal, gas and oil fired generation facilities;
- Electricorp Marketing which is responsible for selling the output and;
- Transpower which is responsible for maintaining the distribution network.

Currently Electricorp generates about 28,000 gigawatt hours of electricity i.e. 28 billion kilowatt hours. Assume that the SOE wishes to expand electricity output. Potentially, there are several ways Electricorp could increase its generating capacity. For example, the company could increase its hydro-electric capacity by constructing another hydro-electric station. Hydro-electric schemes are a familiar feature of New Zealand's landscape which, although being costly to establish, have low running costs and long economic lives once operating. Many of Electricorp's existing hydro stations were built over 50 years ago. On the other hand, Electricorp could build a combined-cycle gas fired power station. The combined-cycle plants have gas turbines which generate electricity in their own right. The hot exhaust gas from the gas turbines is then used to make steam which is used to generate more electricity. Combined-cycle plants are quicker and less costly to build than hydro plants but have shorter economic lives and are more costly to run.

Assume, for the moment, that two projects are under consideration. One project involves a major hydro-electric development in a geologically suitable area, while the other project under consideration involves a combined-cycle gas fired station closer to areas of major electricity demand. Both "base-scale" projects consist of two main phases: construction and production. The engineering and financial data is summarised in table 3.1.

The construction phase of the hydro-electric project involves $40 million of expenditure on consultants' fees spread evenly over the first four years of the project. This work is undertaken to obtain planning consents and water rights. Construction is planned to start in

---

1 This example is merely an illustration. However, it does draw heavily on Spicer et.al (1991) for financial data. Steve Whiteman of Electricorp provided helpful technical and engineering information and comments on an earlier draft.
year 5 and take 4 years. The capital cost of the station is spread relatively evenly over years 5 to 8. Year 5 expenditures are $200 million, $250 million is spent in years 6 and 7 and $300 million is spent in year 8. The hydro station is designed to have an installed capacity of 350 megawatts (MW) and an annual generating capacity of 1,500 gigawatt hours (GWh), i.e. 1.5 billion kilowatt hours (kWh) of electricity. Given a bulk price of about 7.5 cents per kWh this will produce annual gross operating revenues from the station of $112.5 million which are forecast to begin in year 9. However, one of the most significant expenses for the hydro scheme is the cost of transmission, which is estimated to be 2 cents per kWh or around $30 million per year for a station of this size once fully operational. The annual operating expenses once the station is running are $2.0 million and the station is forecast to have an economic life of 50 years. Electricorp depreciates hydro stations on a straight line basis at 1 per cent per year.

The combined-cycle plant can be built more quickly than the hydro station. The turbines - which are the major components - are imported and bolted into position. However, planning consents and water rights applications will take three years and involve a cost of $30 million spread evenly over that time i.e. $10 million per year. Construction will take three years with the $300 million capital cost spread evenly over years 4, 5 and 6.

| Table 3.1 |
| Comparative Data for Alternative Electricity Generation Projects |

<table>
<thead>
<tr>
<th></th>
<th>Hydro-electric</th>
<th>Combined-cycle gas-fired</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed Capacity</td>
<td>350 MWs</td>
<td>300 MWs</td>
</tr>
<tr>
<td>Annual generation</td>
<td>1,500 GWhs</td>
<td>2,300 GWhs</td>
</tr>
<tr>
<td>Planning period</td>
<td>Years 1 to 4</td>
<td>Years 1 to 3</td>
</tr>
<tr>
<td>Construction time</td>
<td>Years 5 to 8</td>
<td>Years 4 to 6</td>
</tr>
<tr>
<td>Economic life</td>
<td>50 years i.e. years 9 to 58</td>
<td>25 years i.e. years 7 to 31</td>
</tr>
<tr>
<td>Capital cost</td>
<td>$1,000 million</td>
<td>$300 million</td>
</tr>
<tr>
<td>Operating costs</td>
<td>$2 million per year</td>
<td>$6 million per year</td>
</tr>
<tr>
<td>Fuel costs</td>
<td>nil</td>
<td>$64 million</td>
</tr>
<tr>
<td>Transmission costs</td>
<td>2 cents per kWh i.e. $30 million</td>
<td>2 cents per kWh i.e. $46 million</td>
</tr>
<tr>
<td>Revenue</td>
<td>7.5 cents per kWh i.e. $112.5 million</td>
<td>7.5 cents per kWh i.e. $172.5 million</td>
</tr>
<tr>
<td>Depreciation</td>
<td>1 per cent Straight Line</td>
<td>4 per cent Straight Line</td>
</tr>
</tbody>
</table>

Assume the combined-cycle plant under investigation is designed to have an installed capacity of 300 MW and an annual generating capacity of 2,300 GWhs, i.e. 2.3 billion kWhs. This additional capacity, compared to the hydro station, is due to the combined cycle plant being able to more closely match electricity demand. The station will produce gross annual
revenues of $172.5 million. As with the hydro station the transmission costs are 2 cents per kWh and therefore amount to $46 million. As well, the gas used to generate the electricity costs 2.7897 cents per kWh of generation - or a total of $64 million per annum. Other operating expenses are $6 million per annum and the station is estimated to have an economic life of around 25 years. Combined cycle plants are depreciated on a straight line basis at the rate of 4 per cent per annum. Electricorp's required real post-tax required rate of return is 7 per cent per annum based on a weighted average cost of capital (WACC) approach.

The usual method of appraising such projects is to calculate the NPVs of the two projects and accept the project with the highest. The rationale for this is that the project with the highest NPV adds the most value to share holder wealth. Assume that the utility's analysts perform a standard cost benefit study and come up the costing shown in the results shown in the following table:

Table 3.2

<table>
<thead>
<tr>
<th></th>
<th>Net Present Values $ million</th>
<th>Capital Outlay $ million</th>
<th>Gross Project Value $ million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro-electric plant</td>
<td>(202.45)</td>
<td>(639.47)</td>
<td>437.02</td>
</tr>
<tr>
<td>Combined cycle gas plant</td>
<td>92.90</td>
<td>(214.22)</td>
<td>307.12</td>
</tr>
</tbody>
</table>

The gross project value of the hydro-electric project is $437.02 million while the present value of known capital outlays planned for the construction phase of the project is $639.47 million. Therefore the NPV of the hydro-electric project is -$202.45 million ($437.02 million - $639.47 million). On the other hand the gas-fired station has a positive NPV of $92.90 million ($307.12 million - $214.22 million). Based on the net present value criterion the utility's management should accept the combined cycle project and reject the hydro project. That is, by accepting the combined cycle project the utility's management will increase Electricorp's value by $92.90 million.

However, the analysis has so far overlooked the operating flexibilities embedded in the two projects. Now assume that after some discussion, the utility's analysts, engineers and executives determine that there are four types of operating flexibility which may or may not apply to the two projects:

- **Cancellation** during construction. If costs rise too high Electricorp could cancel the project prior to the construction phase. The engineers decide both projects could be cancelled.

- **Expansion.** At some time in the future management may elect to increase the generating capacity of the project in response to increases in electricity demand. The engineers point out that the capacity of the combined cycle plant can be increased by one third at a cost of $100 million in year 8. Costs and revenues would both increase by one third. The hydro scheme cannot be made bigger.
• **Abandonment.** The engineers point out that either project could be abandoned due to unforeseen adverse events.

• **Deferral.** Initiating the project may be deferred for a period of time while further analysis is undertaken. This will have no detrimental impact on the utility's overall business as long as the combined cycle plant is not deferred for more than two years and the hydro project is not deferred for more than 4 years.

### Table 3.3
Application of Flexibility Options to Alternative Projects

<table>
<thead>
<tr>
<th>Operating Flexibility</th>
<th>Gas-fired Station</th>
<th>Hydro-electric Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancellation during construction</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Expansion of generating capacity</td>
<td>Yes - in year 8</td>
<td>No</td>
</tr>
<tr>
<td>Abandonment of project for salvage</td>
<td>Yes</td>
<td>Possible</td>
</tr>
<tr>
<td>Deferral of project</td>
<td>Yes, for three years</td>
<td>Yes, for two years</td>
</tr>
</tbody>
</table>

Therefore the combined cycle project appears to have greater operating flexibility than the hydro-electric project. For example, the combined cycle project may be cancelled during construction if gas prices rise or the project becomes unfavourable. However, the executives are of the opinion that once the utility is committed to the hydro-electric project there is no turning back.

Likewise engineers estimate that in response to an increase in demand for electricity the gas-fired project could be expanded in year 8 at a cost of $100 million in real terms. This expansion will increase generating capacity and output and increase post-tax real cash flows from year 9 by $13.94 million to $55.76 million per year. The increased cash flows increase the gross value of the project in year 8 by $157.12 million and in year 0 by $97.84 million. Therefore the gross value of the project in year 0 rises from $307.12 million to $404.96 million. The engineers also point out that the hydro-electric project may not be expanded due to the engineering and geological problems likely to be encountered.

The gas fired project may be abandoned at any time during the project's life. In fact management may be quite enthusiastic about the opportunity that exists for gas-fired generation to be abandoned and an alternative fuel used should gas prices rise. Apart from recreational uses the hydro-electric project may have few alternative commercial uses and therefore has limited salvage value. Lastly, both projects may be deferred without endangering generating consistency. However, the hydro-electric project can only be deferred for two years due to its four year construction phase compared with the gas-fired project's three year construction phase which allows a three year deferral.
The engineers and analysts decide that the real option to expand is most relevant to the analysis. The values of operating flexibilities may be very large. One possible, but incorrect, method of evaluating the real option to expand would be to evaluate the NPV up to the point of, say, expansion and then evaluate the NPV of the rest of the expanded project. Another, also inferior, method would be weight the cash flows of the unexpanded and expanded projects with the probabilities that they may occur. Then the NPV of the probability-weighted cash flows may be calculated. However, in neither case does the conventional NPV approach adequately value the flexibility. Both approaches ignore the fact that the project does not have to be expanded. Only if electricity demand increases will the utility expand the plant. Summing the first and second expanded stage of the project assumes explicitly that the project will be expanded. This is not the case. Likewise, the probability weighted approach calculates a weighted average of cash flows. Clearly, if electricity demand does not increase then the expansion will not occur therefore it will be a case of "all or nothing" - not an average of the before and after expansion cash flows.

The operating flexibilities are real options and can be valued using option pricing theory. Trigeorgis (1990) suggests that the values of these real options should be added to the traditional NPV values to make a better comparison of projects. The option to expand the generating capacity of the gas fired project may be valued as a call option on part of the project. In fact each component of operating flexibility may be valued separately as either put or call options. Recall that by spending $100 million in year 8 generating capacity would increase and the annual cash flows of the project would rise by $13.94 million starting in year 9. In other words the utility has an option to buy another $13.94 million of annual cash flow, with a present value of $157.11 million in year 8 by paying $100 million in year 8. Therefore, in this case the exercise price is the $100 million capital expansion cost while the $157.11 million increase in the gross project value, discounted back to year 0, is equivalent to the market value of the underlying asset. The time to expiry of the option is the 8 years the utility has before it has to pay the $100 million. If we assume the real risk free rate is 3 per cent then the value of the right to expand will depend solely on our estimate of the variability of the gross project value. Estimates of the value of the right to expand and overall project NPV are shown in Table 3.4.

Table 3.4
Estimates of the Value of the Right to Expand the Gas Fired Station

<table>
<thead>
<tr>
<th>Volatility of the underlying gross project value $ m</th>
<th>Value of the &quot;real option&quot; to expand the gas fired project $ m</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 per cent</td>
<td>22.30</td>
</tr>
<tr>
<td>20 per cent</td>
<td>30.64</td>
</tr>
<tr>
<td>30 per cent</td>
<td>39.48</td>
</tr>
</tbody>
</table>

Note: The flexibility option was valued as a european call option with an exercise price of $100 m, and underlying price of $97.84 million, time to expiry of 8 years, real risk free rate of 3 per cent and annualised standard deviations of 10, 20 and 30 per cent.
The most important point to note here is that despite the level of project value variability, or volatility, the right to expand is of considerable value. Taking a base case of 20 per cent underlying volatility in the underlying gross project value the right to expand is worth around $30 million. This emphasises the importance and relevance of, at the very least, considering the potential value of flexibility.

It should be noted, of course, that this analysis has only considered the strategic option associated with expansion of the gas project. In practical capital budgeting problems there are likely to be a number of real options whose values may be interdependent. Trigeorgis (1990) offers a more advanced example where a project has several strategic options whose values interact. A suggested solution technique is offered by Trigeorgis (1991).

Nevertheless, the implication for policy makers remains the same. Conventional DCF analysis, which ignores the value of strategic and real options, is likely to undervalue projects and lead to incorrect resource allocation.

3.3 Valuing Equity

One way of valuing a firm is to calculate the present value of the future income. As the earnings streams are assumed to be perpetuities the firm can be valued as such by simply capitalising the annual cash flows, $C_F$, at a suitable discount rate, $k$. Subtracting the value of debt, $B$, leaves the value of the shareholder's equity, $S$. To make the valuation model a little more realistic we could also assume that cash flows and values increase (or decrease) at some constant rate, $g$. Therefore the firm is valued as a growing (or shrinking) perpetuity, which, in financial economics, has been referred to as the Gordon constant growth model. A simple example demonstrates this. A firm generates cash flows of $40,000 which are expected to grow at 3 per cent per year indefinitely. The firm owes $400,000 to its bankers. How much is the shareholders' equity worth if the discount rate, $k$, is 8 per cent?

$$\text{Value} = \frac{C_F(1+g)}{k-g}$$

$$= \frac{$40,000(1+0.03)}{0.08-0.03}$$

$$= $824,000$$

After deducting $400,000 of debt from the estimated value of $824,000 we see that shareholders' equity is $424,000. If, on the other hand, the firm is worth less than the value of the debt, then the firm is technically insolvent. However, would shareholders be prepared to pay something for the company and, if they did, why? An answer to this question was offered by Black and Scholes in their 1973 paper. Black and Scholes suggested that owning levered equity was like owning a call option where shareholders had the right to buy back the firm’s assets from the debt holders by paying an exercise price - repaying the debt.
By borrowing, the shareholders have, in effect, sold the assets of the firm to the debt holders. When the debt matured the shareholders have the right, but not the obligation, to buy the assets back by paying back the amount borrowed. However, what provides the option value is the limited liability nature of the modern firm. If the value of the assets is less than the value of the debt the shareholders may let the debtors retain ownership of the assets - in other words let their option expire worthless. On the other hand, if the firm's assets are worth more than the value of the debt, it is in the shareholders' interest to repay the debt and retain ownership of the assets. Therefore, as the value of the firm's assets rise so does the value of the shareholders' equity. On the other hand, as the value of the debt rises, shareholders' equity falls. An increase in the time to repayment of the debt, or a rise in the interest rate, lowers the present value of the debt and therefore increases shareholders' equity. In a similar way that out of the money call options have some "time" value, insolvent companies may have some value based on the probability that the firm's assets will increase in value or the length of time that the firm's bankers will agree to extend the maturity date of the debt. Longstaff (1990) has demonstrated that there is an optimal extension period for risky debt that is in default.

In the following sections a number of applications of this theory are examined. In section 3.3.1 the equity valuation technique is applied to valuing the Rural Banking and Finance Corporation at the time of its sale in October 1989. In section 3.3.2 the application is extended to evaluating the 1988 debt discounting policy under which farmers applied to have debt written off. The policy reduced debt and therefore increased farmer equity at the stroke of a pen. However, what was the asymmetric nature of the policy? Conventional policy analysis ignores the fact that farmers could participate in future capital gains and that these had a positive value.

### 3.3.1 Valuing the Rural Banking and Finance Corporation

As an application of option pricing theory to valuing equity consider the Rural Banking and Finance Corporation, RBFC, which was sold to Fletcher Challenge Limited, FCL, for $550 million in 1989. In order to prepare the bank for sale, $1,071 million of debt was written off the monies owed to the Crown through a reduction in the bank's "Government Loan Account". Of this, $636.5 million was returned to shareholder reserves, while the remaining $434.5 million was an estimate of the present value of bad debts. Further conditions of the sale involved a carry forward of the bank's obligation to repay $454 million of Crown loans. In the years ended 30 June 1990 and 30 June 1991 the Government received $225 million and $229 million respectively as repayments from the bank. As a further condition of the sale the Government may also receive from FCL a further $100 million to $130 million bad debt "claw-back" depending on the difference between actual bad debts and the provisions for bad debts actually made at the time of the sale.

In order to apply the Black and Scholes approach described above we need estimates of five variables:

- the value of the RBFC's assets
- the value of the RBFC's debt
- the time to maturity of the debt
- the risk free interest rate at the time of the sale
- an estimate of the variability of the value of the RBFC's assets.
The Rural Bank annual reports contain estimates of the value of the bank's assets and borrowings. However, the published reports do not contain any estimate of the bank's asset value as at 31 October 1989 - the time of sale. By interpolating between the asset values reported as at 31 March 1989 and 30 June 1990 we have estimated that the assets may have been worth around $2,440 million at the end of October 1989. This figure is equivalent to the market value of the share in an ordinary share call option. The $1,973 million of debt is equivalent to the exercise price of the option. However, determining the correct maturity is difficult as little, or no, relevant information is contained in either the RBFC or FCL annual reports for that period. Recall, that the term of the guarantee is equivalent to the maturity of the debt. As details of the coupon, yield or exact maturity profile of the guaranteed debt have not been published the weighted time to maturity of the debt was estimated from the 1989 Rural Bank annual report to be 2.44 years as at 31 March 1989. The maturity structure was assumed to remain relatively constant between 31 March 1989 and the sale date 31 October later that year. However, some adjustment still needs to be made for the fact that the option pricing model assumes the debt is a "pure discount" bond while some of the guaranteed debt is probably conventional coupon paying debt. One way of accounting for this is to estimate the duration - or coupon adjusted maturity - of the debt. Duration views a coupon paying bond as a bundle of discount bonds. Viewed in this way a reasonable estimate of the guaranteed debt's duration is around 2 years. The yield on government securities, with the appropriate maturity, as at the time of the sale is the appropriate risk free rate. The prevailing rate on two year government stock as at 31 October 1989 was 13.32 per cent. One further variable required is the variability of the bank's asset values. From 1985 to 1991 the bank's asset values had an annualised standard deviation of 24 per cent. However, this may be an overstatement of the true risk, and volatility, due to the write down in asset values which occurred in 1988. Therefore estimates of the value of the Rural Bank debt guarantee for a range of volatilities and terms appear below.

### Table 3.5

**Simplified Black and Scholes Valuation of the Rural Banking and Finance Corporation as at 31 October 1989. ($ million)**

<table>
<thead>
<tr>
<th>Volatility</th>
<th>Term of Debt</th>
<th>1.5 years</th>
<th>2.0 years</th>
<th>2.5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 per cent</td>
<td></td>
<td>833.54</td>
<td>938.45</td>
<td>1,035.83</td>
</tr>
<tr>
<td>25 per cent</td>
<td></td>
<td>849.29</td>
<td>955.63</td>
<td>1,053.57</td>
</tr>
<tr>
<td>30 per cent</td>
<td></td>
<td>871.71</td>
<td>980.46</td>
<td>1,079.53</td>
</tr>
</tbody>
</table>

**Note:** The value of the equity has been evaluated as a european call option with an exercise price of $1,973 million and underlying price of $2,440 million. The risk free rate is 13.32 per cent and term and volatility are as shown above.

Given our estimates of the variables we estimate that the RBFC had a value of around $956 million in 1989, compared with the negotiated sale price of around $680 million - which
includes any additional payments. As mentioned above, one of the biggest determinants of the value of shareholder equity when using the option pricing approach is the underlying riskiness, or volatility, of the asset value. For example, if, instead of being around 25 per cent, the true volatility was actually 20 per cent then the equity would be worth about $938 million - given a two year term. Likewise, if the actual volatility was 30 per cent then the value of the equity would be around $980 million. The term also affects the value of the equity. Given a volatility estimate of 25 per cent the equity value ranges between $849 million and $1,054 million for terms from 1.5 to 2.5 years. Therefore, as one would expect, the riskiness of the underlying asset and the length of time before the repayment of the debt are major determinants of the equity value.

3.3.2 The Rural Bank Debt Discounting Policy

During the late 1970s and early 1980s farmland prices rose dramatically due, largely, to relatively high inflationary expectations, output price subsidies and risk reduction policies. However, from 1984 to 1988 the value of arable farmland fell by about one third. Over the same period dairying and fattening land prices also fell significantly. The fall in land values coincided with the removal of most government support measures designed to reduce farmers' business and/or financial risk. At the same time agricultural commodity prices fell and many areas of the country were struck by drought. By 1988 a significant number of farmers, many of whom were Rural Bank mortgagors, were technically insolvent. However, the real problem for many farmers was debt servicing. Many of the high debt farmers were paying interest rates which had doubled since they had incurred the debt.

The Rural Bank debt discounting scheme, as the name implies, discounted existing low interest rate debt at a yield of 17.5 per cent. Although the present value of the debt remained the same the face value of the debt would have been cut by over 35 per cent in the case of a 20 year loan. The mechanics of the scheme were quite simple. The old loan was repaid by a new loan with a lower face value and the difference written off by the Rural Bank and other lenders. Johnson et al (1989) report that of the 8,099 applicants for discounting, 4,706 were successful in having some portion of their debt written off. In total $234.7 million was forgiven - an average debt reduction of $49,879 per successful applicant. The debt discounting scheme also applied to other lenders who were expected to bear some of the costs of reducing farmers' debt.

Ironically, although the scheme increased successful applicants' solvency, the discounting did not address farmers' debt servicing problems which were the lenders' major concern. Therefore, farmers still had to make ad hoc arrangements with lenders to resolve what was often the original problem. Although the discounting made no difference to the present value of the mortgage, successful applicants could easily realise an increase in equity roughly equal to the cut in the face value of their debt if they sold their properties, or refinanced their debt, shortly after their debt was discounted. As well, land values, which react to farmers' expectations of product prices and likely capital gains, rose considerably after most of the discounting was completed. For example, dairy farm prices rose over 50 per cent between 1988 and 1990 and in some parts of the South Island cropping and pastoral farm prices rose by around the same. Rising land prices resulted in many farmers benefiting from both a market led capital gain on their assets and a cut in their debt due to the debt discounting policy. Therefore, farmers' equity positions would probably have improved anyway given time.
Recent applications of option pricing theory to valuing financial contracts e.g., Merton (1977), Leung (1989), Shilton and Webb (1989) and Schwartz and Van Order (1989) use the Black and Scholes option pricing model to value debt, or the guarantees conferred on some classes of debt by central agencies. However, this case study concentrates on valuing the change in value of a farmer's equity due to the lender forgiving a portion of the debt. Farmers' equity can be valued prior to the debt's maturity using the Black and Scholes call option pricing model. The option pricing approach to valuing equity takes the shareholders' "accounting" equity and adds to it the value of any potential for increases in the asset value.

A farmer's equity, $S$, can be likened to a call option on the farm's assets, $V$, with an exercise price of, $B$, the value of the farm's debt. Effectively, when the farmer borrows money he "sells" the farm to the lender for the value of the debt. The farmer can "buy" back the farm assets by paying the lender back the debt. This arrangement has all the characteristics of a call option. The value of the debt is the exercise price, the maturity of the debt is the time to expiry and the value of the farm assets is equivalent to the value of the underlying asset. Therefore the value of the call option is the value of the farmer's equity position. The pay off to the farmer in this case is max[ 0, $V - B$]. That is, if the debt is more than the value of the farm assets the farmer will have zero equity and the lender will loose the value of the debt. However, if the value of the farm assets is greater than the value of the debt, the farmer has positive equity and the loan will be repaid in full.

We know from the Black and Scholes pricing model that the value of farmers' equity should rise if:

- the value of farm assets, $V$, rises,
- short term interest rates rise,
- the time to maturity of the debt rises, and,
- farm asset values become more variable.

Intuitively, when interest rates rise the present value of the debt falls. Likewise if the farm asset values become more volatile we know the probability of insolvent becoming solvent, before the debt matures, will increase. We also know that the value of farmers equity is negatively related to the value of the debt, $B$. Therefore any reduction in debt will unambiguously increase the farmer's equity.

Say that a farmer borrows $400,000 which is due for repayment in two years. At the end of two years the farm will be sold and the farmer will receive anything over and above the face value of the debt. Therefore at maturity the farmer’s equity will be the difference between the value of the farm assets and the value of the debt. Initially the value of farm assets are say $600,000. Now let’s say that the value of farm assets falls dramatically to $350,000 implying that the farmer is now technically insolvent. That is, the value of farm assets ($V$) is less than the face value of the farm’s debt ($B$). The creditors have lost the security margin for their loan and therefore have two choices open to them:

- force a mortgagee sale, or
- participate in the debt discounting scheme.

By forcing a mortgagee sale the creditors would realise the losses on their loans. However, the creditors would probably also make the losses larger by holding a distressed sale and by
incurring extra legal costs. The farmer’s liability for the remaining debt will depend on whether a limited or unlimited liability ownership structure is used. We have assumed the farm is owned by a limited liability company without personal guarantees. If the mortgagee sale takes place the farmer is forced to realise a capital loss. In effect, the farmer is forced to exercise an out-of-the-money option. That is, the value of the debt or the exercise price of the farmer’s option, is more than the value of the farm assets, or market price of the underlying asset. In this case the conventional measure of equity, is zero. Furthermore, the potential to benefit from future capital gains is also zero. Therefore, the time value of the farmer’s equity option is zero as the farmer has no choice over the outcome. If the discounting application is unsuccessful the farm will be sold at the creditor’s discretion and the farmer will, effectively, be forced to exercise an out-of-the-money option.

On the other hand the creditors could agree to take part in the debt discounting scheme. In return for writing off a part of the principal the creditors would at least continue to receive interest, albeit on a reduced principal. If the farmer’s discounting application is successful he receives an injection of equity equal to the amount of debt written off by the creditors. This capital injection is reflected in the increase in the intrinsic value of the option. However, the farmer may now also benefit from future increases in land prices. This ability to benefit from future capital gains is reflected in the time value of the equity option. Therefore the debt discounting scheme was worth more to farmers than simply the increase in equity. The farmers potential to benefit from future capital gains also increased.

<table>
<thead>
<tr>
<th>Value of Farm Assets (V)</th>
<th>Intrinsic Value max(0, V - B)</th>
<th>Black-Scholes Estimate of Equity (I)</th>
<th>Time Value (III - II) (IV)</th>
<th>Adjusted Black Scholes Estimates of Equity (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250,000</td>
<td>0</td>
<td>3,364</td>
<td>3,364</td>
<td>0</td>
</tr>
<tr>
<td>300,000</td>
<td>0</td>
<td>24,115</td>
<td>24,115</td>
<td>0</td>
</tr>
<tr>
<td>350,000</td>
<td>0</td>
<td>65,033</td>
<td>65,033</td>
<td>65,033</td>
</tr>
<tr>
<td>400,000</td>
<td>50,000</td>
<td>113,591</td>
<td>63,591</td>
<td>63,591</td>
</tr>
<tr>
<td>450,000</td>
<td>100,000</td>
<td>163,454</td>
<td>63,454</td>
<td>63,454</td>
</tr>
<tr>
<td>500,000</td>
<td>150,000</td>
<td>213,445</td>
<td>63,445</td>
<td>63,445</td>
</tr>
</tbody>
</table>

Note: The short term interest rate is assumed to be 10 per cent, the time to expiry is two years, and the annualised standard deviation of the farm assets is 10 per cent.

Obviously, from the farmer’s point of view, the debt discounting scheme is the far better approach. The farm remains in operation, the debt is reduced by a significant amount and the farmer is restored to a positive equity position. Therefore, the farmer will also be in a position to benefit from future capital gains due to any improvement in the general level of land prices. In option pricing terminology the exercise price - the value of the debt - has
been reduced. This has the effect of making an out-of-the-money option into an in-the-money one. In Table 3.6 the farmer is assumed to have successfully applied for the debt discounting scheme and had $50,000 of debt written off. Therefore the exercise price of the option has been reduced from $400,000 to $350,000 which will increase the farmer’s equity and also increase the potential to benefit from future capital gains.

In our simple example the farmer is initially insolvent by $50,000. After discounting, the farmer’s equity position is $50,000 better off. However, option pricing theory suggests that this measure understates the true value of the scheme. In fact the true value of the debt discounting scheme to individual farmers is closer to $115,033. That is, the $50,000 written off plus the potential for future capital gains - valued at $65,033 in our example. Therefore this study captures the value of the potential for future capital gains given that the farmer is successful in applying for debt discounting. In effect, the adjusted Black and Scholes estimate is simply the usual Black and Scholes estimate truncated when the value of the farm assets is less than the value of debt. From Table 3.6 we can see the value of this potential for future capital gains when the value of the debt and the farm assets equals $350,000 is $65,033.

From the discussion above we know that the major determinant of the value of this potential is the volatility of the underlying asset. The example serves to demonstrate that the conventional accounting measure of equity understates the value of the Rural Bank debt discounting scheme to the successful applicants.

3.4 Further Reading

The following texts and articles provide a good introductory discussion of option pricing applications to general capital budgeting problems:

Brealey, R.A. and C. Myers, Principles of Corporate Finance, 4e, McGraw Hill.

Kensinger, John W., 1987, Adding the value of active management into the capital budgeting equation, Midland Corporate Finance Journal, Vol 5, 1, Spring, 31-42.


Trigeorgis, Lenos and Scott P. Mason, 1987, Valuing Managerial Flexibility, Midland Corporate Finance Journal, Vol 5, 1, Spring, 14-21

For applications of option pricing theory to practical capital budgeting problems see the following recent articles.


SECTION FOUR

VALUING GUARANTEES AND CONTINGENT LIABILITIES

4.1 How Can Option Pricing Theory Help?

A second major type of policy evaluation problem often encountered by policy makers is how to evaluate the costs and benefits of government guarantees or underwriting agreements. Examples of these contingent liabilities are the SOE loans guaranteed by Government, proposed export receipt guarantees, the supplementary minimum price (SMP) scheme of the late 1970s and the New Zealand Wool Board minimum price scheme. The cost of the guarantee is more than simply the fiscal cost of paying exporters for any losses incurred due to importer defaults or wool growers due to lower prices. It is not unusual for governments, and other agencies administering guarantee schemes, to value them solely on the basis of fiscal cost. That is, the total cheques written to the people, or organisations, that benefit from the guarantee. For example, in the case of the New Zealand Wool Board minimum price scheme, the wool growers are the beneficiaries, while for SOE loans the organisations and individuals who buy SOE debt are the main beneficiaries.

However, the usual approach to valuing guarantee schemes is flawed as it implies that if exporters, lenders or wool growers receive nothing then the guarantee is worth nothing. In other words, the usual evaluation methods assume that the reduction in risk is granted free of charge. However, this is like saying a car insurance policy was worth nothing in January because the owner did not make a claim over the following year. As pointed out in recent studies the real value of a guarantee should incorporate the value of assistance potentially available to the exporters at the time the scheme is announced. Insurance premiums are assessed relative to the risk the policy is covering - i.e. the probability of a claim being made during the life of the policy. Likewise a guarantee must be worth more than just the value of assistance paid out - the value of the guarantee must also reflect the value of the reduction in risk. That is, the total benefit of the guarantee should be assessed as the value of any cash payments plus the value of the right to sell a commodity at a minimum price or receive the full proceeds of a loan made to a potential bad debtor.

4.2 Minimum Price Schemes

Over the past 15 years there have been several schemes designed to reduce New Zealand primary producers’ downside revenue risk. In the late 1970s and early 1980s there was the supplementary minimum price, or SMP, scheme which underwrote farmer income and -some would argue - farmland prices over that period. With the abolition of subsidies and reduced state sector involvement in the primary sector in the mid 1980s, price smoothing schemes - such as those operated by the New Zealand, and Australian, Wool Boards' were to become far more important in underwriting meat and wool farm incomes. The following example evaluates the New Zealand Wool Board's scheme.
4.2.1 The New Zealand Wool Board Minimum Price Scheme

From the 1974-75 season until February 1991 the New Zealand Wool Board administered the Minimum Price Fund from which it supplemented payments to wool growers through the Minimum Price Scheme. Amid considerable controversy the Board suspended the Minimum Price Scheme on 12 February 1991 in the face of a sudden fall in world wool prices and the decision by the Australian Wool Corporation (AWC) to discontinue its own price support activities. The Minimum Price Scheme set minimum prices for all wool types at the start of each season. If a grower's wool sold for less than the published minimum price the Wool Board paid the grower the difference. The Board's move meant New Zealand wool growers lost a significant product price support "insurance policy". As expected, wool prices have been far more volatile since the Board's decision to discontinue market intervention at auction. The Minimum Price Scheme operated in concert with the Wool Board's Market Support or price smoothing scheme. The two schemes were complementary as by increasing the price level at which the Board bid, and perhaps bought the offered wool, the level of supplementation required to be paid from the Minimum Price Fund was reduced. Likewise, reduced intervention resulted in increased supplementation.

Programmes such as the Minimum Price and Market Support schemes reduced wool growers' downside revenue risk by guaranteeing a minimum price for their wool. Growers had the right to sell their wool to the Wool Board at some fixed minimum price for the season. Therefore the Board's decision to axe the scheme was like an insurance company without enough money to cover current policy holder claims. An insurance company would probably get into a similar position by not charging high enough premiums to cover its risk. Therefore how high should the "premiums" have been to adequately cover the Wool Board's risk? In other words how high should the Wool Board levy have been set to ensure that the Minimum Price Fund had sufficient funds to cover supplementary payments to growers?

Governments and other agencies administering price support schemes sometimes regard the value of a contingent liability as being equal to the amount guaranteed. However, this is like saying a house insurance premium should be the same as the value of the house being insured. On the other hand guarantees are also often valued on the basis of fiscal cost. That is, the total value of cheques written to growers. This implies that if the market price never falls below the minimum price then the scheme is worth nothing to farmers because nothing was paid out. This is clearly not the case as it is like saying an insurance policy was worth nothing at the beginning of the year because no claims was made during the period. Insurance premiums are based on the probability of a claim being made in the future. Therefore, the value of the minimum price scheme must be higher than just the cash value of the assistance paid out by the Wool Board.

Bardsley and Cashin (1990) point out that the real value of a price guarantee should include the value of the assistance potentially available to the recipient at the time the details of the scheme are announced. That is, the total value of the scheme should equal the value of any cash payments plus the value of the right to sell the wool at a fixed price, if the market price falls below the minimum price in the future. A simple way to value the minimum price scheme is to treat it as a put option on growers' wool. When each season's minimum price was announced, the New Zealand Wool Board was giving wool growers the right, but not the obligation, to sell their wool at the set minimum price. The growers did not have to sell the wool at that minimum price - and during the 1980s there were few cases when they did. Nevertheless the promise was there.
This right to sell can be valued using the put option formula derived by Black and Scholes (1973). If, at the start of a season, the prevailing market price was substantially higher than the minimum price, and there was little chance of the market price falling below that announced minimum price before the wool was sold, then the put option would be worth little. If however, there was a reasonable chance that the market price would fall below the minimum price during the season, the ability to sell the wool at the minimum price would have a positive value to the grower.

Seed and Anderson (1991a) used the Black and Scholes put option pricing model to value the minimum price scheme. The scheme was valued each August as the minimum prices for the coming season were announced at that time. In Table 4.1, the value of the scheme is compared to both the amount of levy income paid into the Minimum Price Fund by wool growers and the actual amount of supplement paid to the growers in each year.

<table>
<thead>
<tr>
<th>Season</th>
<th>Market Price c/kg</th>
<th>Minimum Price c/kg</th>
<th>Annual Minimum Price Fund Levy $m</th>
<th>Total Supplement Paid from the Minimum Price Fund $m</th>
<th>Implied Value of the Minimum Price Scheme $m</th>
<th>Implied Value of the Minimum Price Scheme c/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982/83</td>
<td>327.08</td>
<td>339</td>
<td>10.060</td>
<td>32.093</td>
<td>78.585</td>
<td>42</td>
</tr>
<tr>
<td>1983/84</td>
<td>392.97</td>
<td>336</td>
<td>19.669</td>
<td>0.343</td>
<td>61.922</td>
<td>32</td>
</tr>
<tr>
<td>1984/85</td>
<td>479.42</td>
<td>423</td>
<td>12.390</td>
<td>0.099</td>
<td>109.155</td>
<td>56</td>
</tr>
<tr>
<td>1985/86</td>
<td>479.45</td>
<td>443</td>
<td>5.581</td>
<td>18.490</td>
<td>181.994</td>
<td>92</td>
</tr>
<tr>
<td>1986/87</td>
<td>496.18</td>
<td>443</td>
<td>6.264</td>
<td>0.048</td>
<td>132.151</td>
<td>70</td>
</tr>
<tr>
<td>1987/88</td>
<td>645.36</td>
<td>476</td>
<td>7.126</td>
<td>0</td>
<td>134.207</td>
<td>78</td>
</tr>
<tr>
<td>1988/89</td>
<td>634.35</td>
<td>500</td>
<td>0</td>
<td>0</td>
<td>124.032</td>
<td>68</td>
</tr>
<tr>
<td>1989/90</td>
<td>651.95</td>
<td>525</td>
<td>0</td>
<td>2.700</td>
<td>106.040</td>
<td>64</td>
</tr>
<tr>
<td>1990/91</td>
<td>481.70</td>
<td>485</td>
<td>0</td>
<td>107.100</td>
<td>103.999</td>
<td>66</td>
</tr>
</tbody>
</table>

Table 4.1 summarises in the last column on the right the implied value to wool growers of the Minimum Price Scheme. The right hand column shows the total dollar value of the scheme and the value per kilogram of wool sold. For example, in the 1987/88 season the option pricing approach suggests that the guarantee provided by the Minimum Price Scheme was worth a total of $134.207 million to wool growers. The option pricing approach also suggests that if wool growers had been able to obtain price insurance - through some form of put option - they would have had to pay 78 cents per kilo to receive the same degree of price protection. In other words, wool growers paid nothing for price insurance worth 78 cents per kilogram or $134.207 million in total. These results point to the scheme being far more valuable to wool growers than the total amount of funds paid into the Minimum Price Scheme in each of the 9 years. For example, none of the 6% levy charged to wool growers was diverted to the Minimum Price Fund during the 1989/90 season even though the implied
value of the Minimum Price Scheme in that year was approximately $106 million. In fact between 1986 and 1988 growers would have had to pay average levies of between 92 and 70 cents per kilogram in order to make sure the scheme was sustainable.

Interestingly, if growers had paid the levies suggested by the put option pricing model, the Minimum Price Fund would not have had to be abandoned. In fact, by August 1990 the fund would have had a balance of about $1.9 billion. Even if growers had paid only half the estimated "fair" levy the fund would still have had around $1.0 billion to see it through the current price trough. It is also interesting that the calculated put option values are much higher than the amount of supplementation paid to growers in all but the last year of the study, 1990/91. A plausible explanation for this is that the market indicator price was consistently increasing throughout the first 8 years of the study, before the dramatic price decrease occurred in that last season.

As the results show the implied annual value of the Minimum Price Scheme between 1982/83 and 1990/91 is far higher than the traditional, ex post measure of actual supplement payments. However, more importantly, the put option values are consistently much higher than the amount of levy paid to the Minimum Price Fund by the wool growers. This points to the actual grower levies being too low. Therefore probably the only reason the scheme continued as long as it did was that the market wool price trended mainly upward from 1982 to 1990. This allowed the Wool Board to "sell" put options to the growers which did not usually need to be exercised. The big lesson from the New Zealand Wool Board's experience here is that if a price smoothing scheme is to be sustainable in the future, the levies charged to growers need be priced to fully reflect the risk carried by the producer board.

4.3 Export Receipt Guarantees

Recent defaults on payment agreements by major trading partners have highlighted the vulnerability of producer boards, and other exporters, to trade credit risk. For example, during 1990 the then Soviet Union (USSR) suspended all payments to suppliers of wool and dairy products because it ran out of hard currency. During the same year South Korean wool mills reneged on several forward purchase agreements for wool in the face of falling world wool prices. The recent dissolution of the Soviet Union is likely to make exporting to the new republics of the old USSR even more risky. Some countries, for example Australia, provide export receipt guarantees where taxpayers underwrite the risks of the private sector exporter. Proponents of the policy argue that guarantees encourage export activity by reducing the expected costs of default. That is, if exporters do not have to worry about importers' creditworthiness then the exporters will probably try to increase sales to those markets. For example, the Australian Government underwrites a considerable portion of Australian wool exports to nations which have poor payment records.

There is no such thing as a "free lunch" and export guarantees have real costs which, in most cases, are borne by taxpayers. As with other forms of guarantee the cost of export guarantees is usually more than simply the difference between the amount guaranteed and what was finally received. However, it is not unusual for governments and other agencies administering guarantee schemes to cost the schemes as simply the total value of cheques written to producers. Costing the policy in this way implies that if exporters receive nothing then the guarantee is worth nothing. Insurance premiums are assessed relative to the risk the
policy is covering - i.e. the probability of a claim being made during the life of the policy. Similarly the value of a guarantee must reflect the protection it offers to exporters. Therefore the export guarantee will probably be worth more than just the value of assistance paid out.

Therefore the costs of the export guarantee policy comprise two parts: the value of any monies actually paid, plus; the contingent liability of the Government for the specific guarantee. In a reasonably efficient market the claim on the government should be roughly equal to the benefits of the guarantee to the exporters. Conceptually, the export guarantee is very similar to a loan guarantee. Therefore the export guarantee may be evaluated as a put option. In effect, the guarantor (the government), provides an additional payment to the exporter of \( \max[0, Z - U] \), where \( Z \) is the amount of the contracted export receipt and \( U \) is the present value of what is expected to be received in settlement, i.e. the present value of whatever is expected to be paid by the importer. Usually, \( U = Z \), as the exporters are seeking government guarantees for export receipts where the importer has not yet defaulted. However, there may be a positive probability of the importer defaulting at some point in the future. Therefore \( U \) may be less than \( Z \), due to payment delays and increased financing costs or just simply failure to pay at all.

If the importer defaults or delays payment the exporter can "sell" the export contract to the government for \( Z \) - the amount originally negotiated between the importer and the exporter. Therefore the value of the export guarantee may be estimated with the face value of the export contract being equivalent to the exercise price, and the actual export receipts being equivalent to the market value of the underlying security. The volatility measure, which reflects the risk of default by the importing nation is an estimate of the standard deviation of export profits or losses from exporting to the importing nation. Intuitively, export guarantees to nations where the actual repayments, \( U \), are more volatile are worth more to the exporter. In general, the longer the period over which the scheme operates, the more the scheme is worth. Therefore a scheme which operates for one year would be worth less to exporters - all other things being equal - than a two year scheme.

4.3.1 A Hypothetical Export Guarantee

Assume that the Government agrees to guarantee NZ$100 million of various exporters' contracts with a relatively risky nation. At the time the guarantee is granted the exporters expect to receive either the full NZ$100 million, NZ$80 million or only NZ$60 million. The value of the export guarantee may be calculated in each case or outcome in a straightforward application of the put option pricing model derived by Black and Scholes. Estimates of the value of the guarantee are given below in Table 4.2.

The value of the guarantee has been calculated for a range of estimates of volatilities of actual export receipts, from annualised standard deviations of 10 per cent to 50 per cent. As the exporter can exercise the guarantee at any time prior to the guarantee's expiry, the methodology used is similar to that required to value an American put option - which due to the right of early exercise will always be more than the value of a similar European put option. Therefore the estimates reported in Table 4.2 are really lower boundaries of the value of the guarantee.
Table 4.2

Implied MINIMUM Values of an Export Guarantee Scheme to Scheme Participants

<table>
<thead>
<tr>
<th>Volatility</th>
<th>U = NZ$60 mn</th>
<th>U = NZ$80 mn</th>
<th>U = NZ$100 mn</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>40.0 mn</td>
<td>20.0 mn</td>
<td>1.053 mn</td>
</tr>
<tr>
<td>20%</td>
<td>40.0 mn</td>
<td>20.0 mn</td>
<td>4.243 mn</td>
</tr>
<tr>
<td>30%</td>
<td>40.0 mn</td>
<td>20.0 mn</td>
<td>7.816 mn</td>
</tr>
<tr>
<td>40%</td>
<td>40.0 mn</td>
<td>20.338 mn</td>
<td>11.469 mn</td>
</tr>
<tr>
<td>50%</td>
<td>40.0 mn</td>
<td>23.517 mn</td>
<td>15.127 mn</td>
</tr>
</tbody>
</table>

Note: the guarantee has been evaluated as a European put option with an exercise price of 100, risk-free rate of 8.5 per cent, 1 year to expiry, annualised standard deviations from 10 to 50 per cent and values of actual receipts of 60, 80 and 100.

From Table 4.2 we can see that even when the exporter expects to receive the full NZ$100 million from the importer the guarantee is still worth NZ$1.053 million, given an assumed standard deviation of actual receipts of 10 per cent. As we would expect, as the volatility of export receipts rises - say to 30 per cent - the value of the guarantee also rises to NZ$7.816 million. Where the exporter actually knows that he will only get NZ$60 million from the importer, the guarantee is worth a minimum of NZ$32.627 million - as calculated by the Black and Scholes formula - equation (1.0). Of course, in this case the exporter has the right to exercise the guarantee and receive the full NZ$100 million. This implies the guarantee has a value of NZ$40 million. i.e. NZ$100 million less the actual receipts of NZ$60 million.

4.4 Valuing Loan Guarantees

Loan guarantees are common arrangements in financial markets. For example, banks may require the directors of small limited liability companies to guarantee any borrowing. At the other end of the commercial scale the New Zealand Government may guarantee borrowing by state owned enterprises or other government agencies. Housing Corporation and Rural Bank debt issued prior to privatisation is explicitly guaranteed by the Crown. In the past the Government has also guaranteed area health board debt and trustee savings bank deposits. In fact as at 30 June 1991 the financial statements of the New Zealand Government showed a total of around $6,664 million of loans were guaranteed by the Crown.

Loan guarantees have been likened by Merton (1977) to put options on ordinary shares. Take a simple example where a firm borrows $500,000 from its bank. As security for the loan the firm grants the lender a mortgage or debenture over its assets which are currently worth $600,000. When the loan matures the firm will be wound up, the loan repaid and the equity distributed to the share holders. If the assets, V, are worth less than the face value of the loan, B, the borrower will not be able to repay the full loan, and the bank will end up with the firm’s assets. However, what would happen if a third party guaranteed the firm’s risky loan? That is, someone else gave the bank the right to "sell" the defaulting loan to them for what was owing? In other words, if the value of the firm’s assets fell below the value of the loan, someone else - the guarantor - will make up the difference. The guarantee
is a cost for the guarantor but gives a benefit to the both the borrower and lender. These benefits or payoffs are summarised in Table 4.3.

Table 4.3
Loan Guarantee Payoffs

<table>
<thead>
<tr>
<th>State</th>
<th>Guarantor</th>
<th>Lenders</th>
<th>Borrowers</th>
</tr>
</thead>
<tbody>
<tr>
<td>If V &gt; B</td>
<td>nil</td>
<td>B</td>
<td>V - B</td>
</tr>
<tr>
<td>If V &lt; B</td>
<td>-min[0, V - B]</td>
<td>B</td>
<td>max[0, B - V]</td>
</tr>
</tbody>
</table>

The guarantee actually creates an additional cash inflow to the borrower equal to max[0, B - V]. That is, nothing or the value of debt minus the asset values, which ever is the greater. This pay off is identical to a put option pay off and can therefore be valued as one. By guaranteeing the debt the guarantor has issued a put option on the firm’s assets to the bank. This has the same effect as giving the bank the right to sell the assets back to the guarantor for the value of the debt when it matures. However, in the case of the guarantee, the face value of the debt replaces the exercise price and the value of the firm’s assets replaces the underlying asset price. The volatility measure is the standard deviation of the value of the firm’s assets and the term of the debt is equivalent to the term to expiry of the option.

Intuitively, the longer the term of the loan guarantee the more it is worth to the borrower. Guaranteeing a loan for 5 years is worth more than guaranteeing a loan for 1 month. Likewise, when the underlying variability of the firm’s assets is high the loan guarantee is worth more. For example, the fee for guaranteeing the deposits of a consumer finance company which has a portfolio of high risk loans should be higher than the fee to guarantee deposits in an institution with a less risky portfolio. Merton (1977) used this approach to price deposit insurance for United States banks and calculated appropriate premiums for various capital adequacy ratios and levels of asset risk. As you would expect, the government should demand higher fees for guaranteeing deposits at banks with lower capital adequacy ratios and loan portfolios which have higher volatility. Similar approaches have been taken to valuing the implicit or perceived government guarantee of the Federal National Mortgage Association (FNMA) of the United States. The primary function of the FNMA is to buy mortgages. Although the FNMA does not have an explicit guarantee from the US government, investors in the debt and equity markets perceive the government to do so (see Schwartz and Van Order (1988)).

4.4.1 Fletcher Challenge Limited’s Guarantee of Rural Banking and Finance Corporation Debt

As discussed in section 3.3.1 above, the Rural Bank was sold to Fletcher Challenge Limited, FCL, on 31 October 1989. However, a more interesting feature of the sale, from the point of view of this section, was a counter-indemnity granted by FCL to the Government to cover Government guarantees on existing Rural Bank debt at the time of the sale. The debt issued prior to 31 October 1989 is guaranteed in the first instance by the Crown. However, as part of the deal FCL, in effect, indemnified the Government for any loss it would incur as part of that guarantee. Therefore if the Rural Bank were to default on repayment of any of the
$1,973 million of Rural Bank loan facilities, bonds, stock and debentures outstanding at 31 October 1989, the Government, in the first instance would repay the lenders. It would then be up to the Government to enforce the counter-indemnity agreement it has with FCL. According to Treasury sources this agreement appears to have been largely misinterpreted as a Government guarantee of the Rural Bank debt. For example the Opposition at the time of the sale, made much of DFC creditors not being offered similar guarantees. However, the FCL guarantee would have been similar to the National Provident Fund and Salomon Brothers offering DFC debt holders a guarantee. The DFC creditors were not offered such an arrangement.

Nevertheless, how much was the FCL guarantee worth - both to the creditors and the Rural Bank - at the time of the sale settlement on 31 October 1989? As discussed, above a loan guarantee may be valued in the same way as a put option, with the major determinants of the option’s value being the riskiness, or variability, of value of the borrower’s assets and the length of time the guarantee applies for. In section 3.3.1 we estimated the value of the RBFC’s assets to be around $2,440 million. This figure is equivalent to the market value of the share in an ordinary share put option. The $1,973 million of debt guaranteed by the Government is equivalent to the exercise price of the option. The risk free rate and the term to expiry are as before.

Using the same estimates of volatility as those used in section 3.3.1 the most likely estimate of the value of the guarantee is $27.209 million (say $27 million) given the observed volatilities and estimated term of the guarantee. As mentioned above, one of the biggest determinants of the value of the guarantee is the underlying riskiness, or volatility, of what is being valued. For example if, instead of being around 25 per cent the true volatility was actually 15 per cent then the guarantee would be worth only about $1.682 million - given a two year term. Likewise, if the actual volatility was 30 per cent then the value of the guarantee would be around $52.039 million. The term also affects the value of the guarantee but to a lesser degree. Given a volatility estimate of 25 per cent the guarantee’s value ranges between $24.855 million and $27.757 million for terms from 1.5 to 2.5 years. Therefore, as one would expect, the riskiness of the liability being guaranteed is the major determinant of the guarantee’s value.

Using the same estimates of volatility as those used in section 3.3.1 the most likely estimate of the value of the guarantee is $27.209 million (say $27 million) given the observed volatilities and estimated term of the guarantee. As mentioned above, one of the biggest determinants of the value of the guarantee is the underlying riskiness, or volatility, of what is being valued. For example if, instead of being around 25 per cent the true volatility was actually 15 per cent then the guarantee would be worth only about $1.682 million - given a two year term. Likewise, if the actual volatility was 30 per cent then the value of the guarantee would be around $52.039 million. The term also affects the value of the guarantee but to a lesser degree. Given a volatility estimate of 25 per cent the guarantee’s value ranges between $24.855 million and $27.757 million for terms from 1.5 to 2.5 years. Therefore, as one would expect, the riskiness of the liability being guaranteed is the major determinant of the guarantee’s value.

### Table 4.4
The Value of the Fletcher Challenge Counter Indemnity (Guarantee) of $1.973 Million of Rural Bank Debt as at 31 October 1989. ($ million)

<table>
<thead>
<tr>
<th>Volatility</th>
<th>1.5 years</th>
<th>2.0 years</th>
<th>2.5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 per cent</td>
<td>9.218</td>
<td>10.030</td>
<td>10.015</td>
</tr>
<tr>
<td>25 per cent</td>
<td>24.855</td>
<td>27.209</td>
<td>27.757</td>
</tr>
<tr>
<td>30 per cent</td>
<td>47.393</td>
<td>52.039</td>
<td>53.721</td>
</tr>
</tbody>
</table>

Note: The value of the guarantee has been evaluated as a European put option with an exercise price of $1,973 and underlying price of $2,440. The risk free rate is 13.32 per cent and term and volatility are as shown above.
4.5 Further Reading

The following articles apply option pricing theory to evaluating contingent liability valuation problems:


REFERENCES


RESEARCH REPORT


196 Employment and Unemployment in Rural Southland, J. R. Fairweather, November 1988

197 Demand for Wool by Grade A. C. Zwart, T. P. Grundy, November 1988


199 An Economic Evaluation of Coppice Fuelwood Production for Canterbury, J. R. Fairweather, A. A. MacIntyre, April 1989

200 An Economic Evaluation of Biological Control of Rose-Grain Aphid in New Zealand, T. P. Grundy, May 1989

201 An Economic Evaluation of Biological Control of Sweet Brier, T. P. Grundy, November 1989

202 An Economic Evaluation of Biological Control of Hieracium, T. P. Grundy, November 1989


204 The Q Method and Subjective Perceptives of Food in the 1990s. J. R. Fairweather 1990


208 Generations In Farm Families: Transfer of the Family Farm in New Zealand. N. C. Keating, H. M. Little, 1991


211 Administered Protection in the United States During the 1980's: Exchange Rates and Institutions, D. A. Stalling, 1991

212 The New Zealand Consumer Market For Cut Flowers in the 90's, C. G. Lamb, D. J. Farr, P. J. McCartin, 1992


DISCUSSION PAPERS

118 Desirable Attributes of Computerised Financial Systems for Property Managers, P. Nuthall, P. Oliver, April 1988

119 Papers Presented at the Twelfth Annual Conference of the NZ Branch of the Australian Agricultural Economics Society, Volumes 1 and 2, April 1988

120 Challenges in Computer Systems for Farmers, P. Nuthall, June 1988

121 Papers Presented at the Thirteenth Annual Conference of the N.Z. Branch of the Australian Agricultural Economics Society, Volumes 1 and 2, November 1988


123 Do our Experts Hold the Key to Improved Farm Management? P. L. Nuthall, May 1989

124 Some Recent Changes in Rural Society in New Zealand, J. R. Fairweather, July 1989

125 Papers Presented at the Fourteenth Annual Conference of the N.Z. Branch of the Australian Agricultural Economics Society, Volumes 1 and 2, October 1989


127 Marketing of Agricultural and Horticultural Products — selected examples, K. B. Nicholson, 1990


129 Proceedings of the Rural Economy and Society Section of the Sociological Association of Aotearoa (NZ), April 1991

130 Evolutionary Bargaining Games J. K. D. Wright, May 1991
