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Real options and the pricing of shares

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Real Options and the Pricing of Shares

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"Πάντων χρημάτων μέτρον άνθρωπος, των μην όντων ως έστιν,
των δε ουκ όντων ως ουκ έστιν"

Πρωταγόρας

CONTENTS

List of Tables

List of Figures

Notation

A	Advertising expenses
ABD	Number of months of presence of option to default or abandon before exercise
ABD_{xt}	Number of months of presence of option to default or abandon before expiry unexercised
AR	Abnormal return
AR'	Excess return
BVA	Book value of assets
BVE	Book value of equity
C_A	Price of an American call option
C_E	Price of a European call option
CAR	Cumulative abnormal return
CAR'	Cumulative excess return
CC	Capital contributions
CF	Cash flow
CO	Production cost
CP_F	Commodity futures price
CP_S	Commodity spot price
DCF	Discounted cash flow value
D	Dividends
E	Earnings
$EBRD$	Earnings before R&D expenditures
$EBRDA$	Earnings before advertising and R&D expenditures
$EMVA$	Excess market value of assets
$EMVE$	Excess market value of equity
EP	Earnings to price ratio, the inverse of P/E ratio, equal to EPS/SP
EPS	Earnings per share
EXP	Number of months of presence of option to expand before it became exercised
EXP_{xt}	Number of months of presence of option to expand before it expired unexercised
GRO	Number of months of presence of growth option before it became exercised
GRO_{xt}	Number of months of presence of growth option before it expired unexercised
HB	Highest bid value (winning bid value)
I	Investment

I_D	Investment financed by debt
I_E	Investment financed by equity
I_G	Investment in a developed project
I_{SC}	Sunk cost of a project
IV	Intrinsic value of property
K	Number of produced units
$MVAP$	Market value of assets in place
MVE	Market value of equity
MVF	Market value of the firm
N	Number of borrowed securities
NPV	Net present value
$NSCF$	Net dividends (dividends less capital contribution)
OD	Dummy variable equal to 1 if the option is eventually exercised, otherwise 0
OV	Option value
OVI	Value of the option to invest
$OVWI$	Value of the option to wait or invest
P_A	Price of an American put option
P_E	Price of a European put option
$PVGO$	Present value of growth opportunities
Q	Quantity of asset S_2 delivered if option is exercised
RD	Research and development expenses
RD_C	Capitalised research and development expenses
RE	Retained earnings
RI	Residual income, or abnormal earnings
S	Value of a project
S_1	Price of underlying asset 1
S_2	Price of underlying asset 2
SP	Share price
T	Time to expiration
UOP	Unit operating profit
UPC	Unit production cost
URR	Unit rental rate
USP	Unit selling price of output
V	Gross value of a project, equal to net present value plus the value of investment
V_C	Critical value of a project above which the first call option will be exercised
V_G	Going-concern value of a project before debt payments

V_L	Liquidation value of a project
V_p	Net present value of a project
V_S	Salvage value of a project
X	Strike price: X_{BS} (Black Scholes, 1973); X_M (Merton, 1973), X_B (Black, 1976)
X_D	Face value of debt outstanding
Ψ	Value of investment opportunity
a	The rate of production increase in the case of an option to expand
b	Cost of carry
BETA	Beta factor
d	Downside movement of a value
g_{CF}	Annual expected growth rate of cash flows after year n
g_d	Drift factor in a jump process (Pennings and Lint, 1997)
g_{ps}	Growth rate of output price/ commodity
p	Probability of upside movement of a value
p'	Risk adjusted probability of upside movement of a value
q	Dividend yield
R	Share price returns
r	Risk free rate of interest
r_b	Interest rate of borrowing
r_d	Discount rate
r_e	Cost of equity
r_k	Cost of capital
R_m	Capital market index returns
r_m	Expected market return
r_p	Expected return of a project
r_s	Expected return of a project's salvage value
u	Upside movement of a value
dz_{ps}	Random increment to the Wiener process Z_p
dz_p	Weiner process generating the unexpected changes in project value
$E[.]$	Expected value
v_t, v_{1t}, v_{2t}	Information other than abnormal earnings
$\mathbf{Z}_t$	Vector of other information variables
β	Beta coefficient of the project

γ_p	Project payout ratio
$\gamma, \gamma_1, \gamma_2$	Persistence parameter of information v_t, v_{1t}, v_{2t} respectively
δp	Risk premium
δs	Convenience yield
ε	Price sensitivity of the project's value, equal to (dV/dP)
θ	Output discount factor
π	Growth rate of average unit cost
ρ_{fs}	Correlation between project value and salvage value
ρ	Correlation between S_1 and S_2
σ_p	Volatility of the value of a project V_p
σ_{ps}	Volatility of unit output price growth
σ_1	Volatility of S_1
σ_2	Volatility of S_2
σ_{BM},	Cash flow volatility (Brealey and Myers, 1991)
σ_{BS}, σ_M	Share price volatility (Black Scholes, 1973; Merton, 1973)
σ_f	Annual volatility of the forward/futures contract
σ_G	Underlying asset volatility (Geske, 1979)
σ_s	Salvage value volatility
σ_x	Volatility of project's value in units of the salvage value
τ	Time to maturity of the simple option
τ^*	Time to maturity of the first call option
τ_A	Tax rate
ω	Cost discount factor
ω_{11}	Persistence parameter (abnormal earnings)
ω_{12}	Conservatism parameter
ω_{22}	Growth parameter (book value of equity)
Ξ	Jump amplitude in a jump process

CHAPTER ONE
INTRODUCTION

In many cases, option theory is believed to be superior to the naïve discounted cash flow approach to valuation because it captures the value of real options arising from managerial and strategic flexibility. Bearing this in mind, and in view of the fact that many firms listed on stock exchanges possess real options, this thesis investigates the extent to which company valuation is associated with the existence of real options.

In particular, the study evaluates the real options held by companies listed on the Athens Stock Exchange during the period from January 1990 to December 1999, using a dataset constructed specifically for this purpose. Initially, the thesis examines the events that reveal the existence of real options held by the companies and eventually their exercise. In addition the thesis examines whether the real options are value relevant in the context of the residual income valuation model. Overall, the findings are most promising as they show how market valuation practices and real option theory converge in the case of those real options which are growth options.

First, it is shown that the presence of growth options is associated with excessive returns during the period from the option announcement until the time of the exercise or expiration. Moreover, further evidence confirms that growth options are a significant explanatory variable in the context of residual income valuation. The study also provides evidence, albeit statistically weaker, concerning the relevance of other types of options (namely options to expand, options to default and abandonment options) to a company's value.

The first part of the thesis provides an overview of real options and their applications, including the theoretical framework of real option valuation and a review of related empirical findings. In this context, it should be noted that the need for the development of a new investment paradigm was discussed well before the existence of real options was fully understood. That is to say, early management researchers suggested that standard discounted cash flow criteria often undervalue investment opportunities, leading to the eventual loss of the competitive position, because they either ignore or do not properly value important strategic considerations. As a result, it is often said that investment tends to be skewed toward equipment and relatively short-term projects and away from structural investment and relatively long-term investments.

Proponents have argued that the problem arises from the misuse of discounted cash flow techniques in practice, especially from the improper treatment of inflation effects, excessive risk adjustments and failure to acknowledge how management can reduce project risk by diversification and other responses to future events. However, others argue that DCF practices fail whenever significant operating or strategic options are present. In effect, the adoption of the NPV rule is as if management makes at the outset an irrevocable commitment to an "operating strategy" (for example to take the project immediately and operate it continuously until the end of its pre-specified expected useful life) from which it cannot depart regardless of eventual cash flows. However, as new information arrives and uncertainty about market conditions and future cash flows is gradually resolved, management may alter its operating strategy so as to mitigate losses or to capitalise on favourable potential opportunities. This flexibility, it is argued, should be incorporated in the initial capital budgeting decision.

Although the use of simulation or decision tree analysis reduces some of the deficiencies of the standard discounting techniques, both methods fail to value investment opportunities whose claims are not symmetric. The asymmetry caused by managerial adaptability calls for the application of an "expanded NPV" rule that links the NPV of direct cash flows, and the option value of operating and strategic adaptability. The value of options from active management can be treated as a collection of real options embedded in capital investment opportunities, where the underlying asset is the gross value of expected operating cash flows. Many of these options occur naturally, while others may be planned and built-in at some extra cost, which is particularly relevant to companies with new technologies, product development ideas, and defensible positions in fast-growing markets or access to potential new markets. In these circumstances, the traditional DCF approach is clearly insufficient, and real option pricing becomes increasingly necessary.

In spite of the growing recognition of the need for a real options framework for valuation, the lack of understanding and the fuzziness of many options resulted in a considerable lag in option-pricing applications in corporate finance. In some cases, the identification and modelling of real options has proved to be a difficult task. Nevertheless, the option approach has certain advantages over DCF. Option valuation reduces information requirements, eliminates the need to determine risk-adjusted discount rates and helps to determine an optimal investment-timing decision. The growing literature on real options has revealed also that the volatility of prices becomes an important determinant of investment, and input price elasticity has less meaning at the micro-level than critical input price boundaries. Also, the incorporation of the flexibility value in pricing has important implications for the future resource plan design.

If investment opportunity is valuable in itself, the option is simple. However, the investment may be a prerequisite for subsequent investment opportunities. Also, if the project needs an immediate accept/reject decision, the option either expires or it is deferred. In this context, the major issue surrounding real option valuation is optimal capacity together with an understanding of optimal entry and exit conditions. Also the recognition that capital investment decisions can be irreversible gives the ability to delay investment added significance. For instance, although some early researchers underline the importance of protecting or enhancing the value of real options, only recent studies give special attention to the flexibility that will enhance the value of an option. This is called proactive flexibility, and in many cases firms can maximise the value of options by influencing the factors associated with such flexibility. However, despite the existence of proactive flexibility, the presence of competitive interaction in shared options may remove it and lead to earlier exercise. Indeed, it pays to exercise some real options earlier than necessary when the project's NPV is high and industry rivalry is intense.

Option pricing theory became popular among economists with the Black and Scholes paper in 1973 that shows that options can be priced by constructing a risk-free hedge, that is by dynamically managing a simple portfolio consisting of the underlying asset and cash. The Black Scholes model is based on the assumption that the price of the underlying asset is lognormally distributed. Others assume that the underlying asset follows a jump-diffusion process, and they require two additional parameters, namely the expected number of jumps per year and the percentage of the total volatility explained by the jumps, but still pricing an option on an underlying asset that is traded continuously. In many real option applications, however, the underlying "asset" is rarely traded in anything approximating a continuous market and its price is therefore not continuous either. For that reason the option-pricing framework has now developed to include non-tradability and non-observability. The analytical formulas derived in continuous-time options pricing provide certain advantages, but their usefulness is restricted by deficiencies that relate to their statistical assumptions. Many real option studies use binomial tree approaches to value real options, rather than continuous-time pricing. Certainly, if we assume a very large number of steps, a binomial tree is equivalent to the continuous-time Black-Scholes formula when pricing European options.

Early real option research developed a framework to allow for growth options, options to switch among various uses and various combinations of options. The valuation of an option to exchange one risky asset for another was the first serious attempt to value these complex types of option, while the valuation of an option to acquire another option provided the second main approach to real option pricing. The latter has been particularly useful in valuing timing options, growth options and options to default. The present study builds on this prior research and examines the valuation of (1) the option to defer or initiate investment, (2) the option to abandon, (3) the option to default, (4) the option to alter operating scale, (5) the option to switch use and (6) growth options, eventually focussing in the empirical research study on growth options and options to default, abandon or alter operating scale. By way of introduction, each of the six main types of real option is described briefly below.

When there is high uncertainty, and the potential benefits to wait and see if output prices justify the implementation of a project are high, then ***the option to defer or initiate*** investment is valuable. In particular, management has the option to invest only if output prices increase sufficiently, or to defer the investment if prices decline.

This is the case, for example, when legislative changes are to take place. The option to defer or initiate can be valued as an American call option on the present value of the project's cash flows.

In many projects, the required investment is incurred at numerous stages. The staging of capital investment as a series of cash outlays over time creates valuable ***options to default*** at any given stage, if conditions prove worse than initially expected. These options are particularly valuable in venture-capital finance, pharmaceuticals, computer, electronics and capital-intensive industries, including power station development, aircraft construction, mining or other large-scale construction projects.

If output prices prove to be lower than expected, due to a sustainable decline or due to other reasons, the management has the ***option to abandon*** the project permanently in exchange for the resale value of its capital equipment and other assets in second-hand markets. Similarly, the equity-holders have the ***option to default*** on debt payments, in exchange for the liquidation value of the firm minus the value of debt payments. The option to abandon is valuable in capital-intensive industries such as railways and airlines and in financial services, while the option to default is useful to value companies that are financially distressed. The option to abandon is valued as an American put option on current project value with the exercise price equal to the salvage value. Similarly, the option to default is valued as an American put option on the current enterprise value with the exercise price equal to the difference between the liquidation value and debt obligations.

Once a project is undertaken, managers may have the flexibility to alter it in various ways at different times during its life. The option to expand and the option to contract are two basic forms of the ***option to alter the operating scale*** of a project. The option to expand arises whenever the management finds it desirable to make additional follow-on investment if it turns out that its product is more successfully received in the market than originally expected. Conversely, if the product is not as well received in the market as initially expected, the management may find it desirable to forgo planned future expenditures by reducing the scale of operations (i.e. it has the option to contract) or by shutting down the project temporarily (i.e. it has the option to shut down and restart). In the case of the option to expand, the original investment opportunity can be thought of as the initial project plus a call option on a future opportunity to acquire additional capacity. However, the option to contract is analogous to a put option on part of the base-scale project, with exercise price equal to the potential cost savings. Similarly, the option to shut down and restart is analogous to a put option on the project's cash revenues, with exercise price equal to the variable costs of operating. The option to alter operating scale is particularly valuable in cyclical industries. Although the option to expand capacity may be planned and built in at some extra cost from the outset, both the option to contract and the option to shut down and restart operations occur naturally.

The ***option to switch use*** exists when a firm has valuable flexibility either to switch to a different product mix (product flexibility), or to switch to other input materials (process flexibility). This is the case when a project uses machines that have many alternative uses, which is more valuable than an otherwise identical project that uses specialised machines. The option to switch use, is, interalia, particularly valuable, in the form of product flexibility, in strategic acquisitions, and in the banking industry. The importance of the option becomes critical when the environment is highly volatile and the technology is flexible, thus permitting product or raw material changes at little cost. The option to switch can be viewed as an exchange-one-asset-for-another American option.

Growth options are opportunities that become available in the future but are not part of the initial project. Growth options, or strategic options, are evident whenever an early investment is a prerequisite or a link in a chain of interrelated projects, in industries or markets that provide the potential for successful product and/or market diversification. They are common in infrastructure-based or strategic industries, especially in high-tech ones as well as in industries with multiple product generation or applications (e.g. computers and pharmaceuticals). Moreover, growth options are particularly important for multinationals and entrants in new markets, including joint ventures. Growth options can be acquired via purchase of real assets, via learning-by-doing, via direct expenditure in research, advertising, training or some other activity, and can be viewed as options on options.

Finally, it should be noted that projects are often complex in that they may involve a collection of options whose values may interact, and project interdependencies may also affect the value of these multiple real options. To summarise, real option valuation may be applied in a variety of contexts, both in the specific circumstances outlined above and also in the more complex arrangements that give rise to multiple real options. Mine and land development, information technology, strategic analysis, acquisitions and multinational operations are only some of the areas developed. Indeed, as the introductory discussion of real options shows, any evaluation of real options held by firms requires a detailed understanding of the range of applications that might exist. Therefore, this thesis starts with a comprehensive examination of such applications and the implications for investment decision making.

Chapter Two of the thesis discusses in greater detail the types of real options that are likely to be encountered in practice. **Chapter Three** illustrates how real option theory might be used in capital budgeting. The examples show how the management's flexibility to proceed or not with an investment adds considerably to the company's value. The examples include the cases of a simple growth option, a compounded growth option, an abandonment option and an option to default. To simplify the examples, it is assumed that the value of the project follows a multiplicative binomial process over discrete period(s).

The *simple growth option* is an option to expand, which is illustrated by examining a petroleum refinery that considers developing a new unit similar to existing ones. In this case, the option is valuable because of high political uncertainty. If political party A wins the elections, petrol demand prospects are expected to be bright given party A's plans to lower an import tax for cars while if political party B wins the elections, petrol demand prospects are expected to fall since party B plans to increase the import tax for cars.

To illustrate how to apply real options theory in the case of a *compounded growth option*, we consider an example of a company that considers a phased expansion of its manufacturing facilities. First, the company will invest in developing the product (research and development expenses) and in promoting it (advertisement and other promotional expenses). Second, if demand proves satisfactory, the company will develop the planned production line, otherwise the company will cover the demand from existing lines. It is shown how, although Phase 1 of the project is negative in NPV terms, it gives the opportunity to proceed to the implementation of Phase 2 of the project, which may prove to be very profitable. In this case, the company has the flexibility not to develop a new production line, based on the information revealed during Phase 1 investment.

The *option to abandon* is illustrated by examining a food manufacturing company that has a bread production unit which is not profitable. As a result, the company considers the opportunity to sell the unit. To illustrate the *option to default*, a debt-financed textile company is examined, where the naïve DCF approach does not take account of management's financial flexibility to undertake riskier projects that raise the equity-holders' value. In fact, shareholders in such firms generally have the option to expropriate wealth from bondholders by pursuing riskier projects that increase the variance in the firm value and will lead to an increase in the value of equity. This option, and the financial flexibility involved, explains why financially distressed firms can have positive value on stock exchanges.

In **Chapter Four,** the theoretical developments in the area of real option analysis are presented. Initially, the chapter examines discrete-time valuation models. Although discrete-time models are conceptually easy to understand, they are of limited value in practice because they assume only two possible outcomes, something unusual in most real-life projects. In practice, there are many possible outcomes, and these can be better expressed by a mathematical function that assumes an appropriate distribution. In addition, whereas discrete-time models assume that the value of the asset is not continuous, continuous-time analytic models provide a solution to this limitation as well.

To value the *option to abandon* in continuous time, it is generally assumed that a company can increase incrementally its production and can shut down a project with no cost incurred, although more recent approaches examine the option to permanently abandon a project for its salvage value. In the case of the *option to default*, a continuous-time formula that is useful to apply is the option to exchange assets. While the formula gives the ability to value the option to default as a complex call option, some researchers use simple call option formulas or they value options to default as put options. The *option to expand* is valued as a simple call option by way of a transformation of the classic Black-Scholes model. Finally, in the case of the *growth option*, the value of the project consists of the value of a series of call options on the market value of the project.

The discussion in Chapter Four also considers the main difficulty in using valuation formulas in this way, which is the assumption that the variance of the rate of the return on the project is constant, while in practice this variance is not constant but depends on the value of the corporation. In fact, recent research assumes that the underlying asset price follows a jump process, instead of a continuous one. However, although jump formulas should provide more accurate estimation of growth options they are difficult to estimate because they require detailed analysis of strategic information that is not always disclosed, which is the case for the empirical analysis reported later in this thesis.

Chapter Five examines previous studies in real option valuation and related areas. Real options are shown to be a significant component of company value in some cases. Indeed, some 45% to 90% of the total value of companies examined in the USA is attributed to growth options (Kester, 1994; Ottoo, 2000). On average, however, 63% of the market value of emerging firms compared to 6% for mature firms is accounted for by the present value of growth opportunities (Ottoo, 2000).

Not surprisingly, growth options have attracted much interest among option researchers. For instance, early research provides evidence that option pricing theory is useful for valuing offshore petroleum leases as growth options. Oil managers report a higher level of agreement than others with the assumptions required by the real options framework and they show less over-valuation of options to expand and growth options than managers in other areas (Howell and Jagle, 1997). Theory approximates to management practices better in some sectors than others. As in the oil sector, there is evidence that IT investment options are in line with managerial practice to defer entry into the POS debit market (Benaroch and Kaufman, 1999). However, in the case of pharmaceuticals, practice is in line with growth option theory only in the early stages (Kellogg, Charnes and Demirer, 1999). There is also empirical evidence in land valuation that supports real option pricing in the case of an option to wait (Quigg, 1993), and the same model is useful to describe and predict the opening and closing decisions of North American gold mines (Moel and Tufano, 1999).

There is evidence to suggest that growth options occur in more than 60% of capital investments, and are taken into account in capital appraisal (Busby and Pitts, 1997). According to the Busby and Pitts survey among UK Finance Directors, options to defer occur in more than 40% of cases and abandonment, time to build and switch options in more than 20% of cases. Interestingly, many of the respondents had also developed procedures to value these different types of real option. Nevertheless, although the evidence is encouraging with regard to the significance of real options in practice, valuation methods differ significantly amongst researchers. In spite of the plethora of formulas developed to value real options, many empirical studies use Price/Earnings and Price/Book Value as proxies for growth options, either to measure their value or to measure their systematic risk. This thesis considers four aspects, not only the theoretical value of the real option estimated with an option pricing model, but also the DCF equivalent, the excess value created following the announcement of the real option and the value relevance of the real option in the context of the residual income valuation model.

Chapter Six presents the methodology that is used to identify and to value real options. In each of the cases examined (option to expand, growth option, option to default, abandonment option), identifying a real option requires the examination of project descriptions and the examination of project cash flow patterns. First, company capital increase prospectuses were reviewed together with annual reports. Second, information was gathered on press releases concerning company projects. Third, company management was contacted to verify and supplement the information gathered. After recognizing a real option, project characteristics were mapped onto the relevant variables. In the case of growth options, only those projects having two main stages (phases) have been considered, because the estimation bias in valuing further growth options (i.e. for projects that consist of more than two main stages) is likely to be very large. The last stage was to judge what spending was discretionary and what was not, based on the information already gathered (annual reports, capital increase prospectuses, press releases and discussion with managers). Then, using the approaches discussed in Chapter Five, real option values were estimated.

Then, the empirical results of the study are discussed in detail. Assuming the semi-strong form of market efficiency, the examination of all relevant notifications between 1990 and 1999 reveals the existence of 161 real options in companies listed on the Athens Stock Exchange. For this purpose, all publicly available plans and decisions about company-wide capital expenditure and about specific projects have been included in the sample. In addition, plans and decisions regarding acquisitions and tenders by groups and corporate subsidiaries were also included.

The results reject the hypothesis that real options are not recognised in the market place and they indicate that market participants are normally informed one day before the announcement. The value of companies that have real options increases for three days following real option announcements. The results also show that in the case of growth options, the announcement is associated with significant cumulative abnormal returns, which is consistent with previous studies. For instance, Kester (1984) reported significant growth option value when investigating the value of growth options as a proportion of the value of leading US companies, and Kellogg, Charnes and Demirer (1999) also reported results that support the hypothesis that growth options are associated with market value appreciation.

In the present study, 45% of the options exercised were growth options which compares with the higher figure of 60% among leading UK companies reported in the exploratory survey conducted by Busby and Pitts (1997). The deviation between the results reported in this thesis and those obtained by Busby and Pitts (1997) is probably due to the fact that their investigation was limited to leading companies while our study examines all companies listed on the exchange, irrespective of their market share and also irrespective of their capitalization.

To examine whether real options contribute during their lifetime to the company value in the share market, abnormal returns were computed as the difference between the stock return and the index performance over the examined periods (excess returns). The companies that exercised real options had large and statistically significant abnormal returns (19.19%) and outperformed the index during the examined period by 12.56% (excess returns) on average while companies that let options expire did not see any excess return on the stocks over the examined period. If expired options are deep-out-of-the-money options at the time of expiration, then these results are in accordance with what real option theory prescribes.

Surprisingly, the results also indicate that there is some anticipation in the share market about the possibility of exercising real options. Companies that possess options that later expired unexercised had on average low and statistically insignificant excess returns during the option announcement period. On the other hand, companies that finally exercised their real options had on average high excess returns during the option announcement period. In this study, in the case of exercised real options, 28% of excess returns are realised on average during the signalling period.

Furthermore, the analysis examines to what extent market values approximate theoretical option values. The results indicate that the real option model can explain a large proportion of abnormal returns on the Athens Stock Exchange. However, investors seem to overvalue *growth options* during their lifetime, an apparent irrational market behaviour that results in a 100% premium over the theoretical growth option value. The latter is similar to the findings of Howell and Jagle (1997) who found that, on average, UK managers overvalue growth options by 78% of the theoretical option value. In contrast, investors tend to value *options to expand* in the way that real option theory prescribes. Companies that possess an *option to default* are found to have negative and decreasing cumulative abnormal returns before the option initiation. Surprisingly, however, the study does not support the hypothesis that the presence of an *option to expand* increases company value, possibly because analysts have already accounted for expanding options well before their announcement. Overall, the results support real option theory and the findings reported here for Greece are in line with the findings of Paddock, Siegel and Smith (1988) and Pennings and Lint (1997) who examined DCF values and theoretical option values.

Chapter Seven presents the methodology and the empirical results in the context of residual income valuation. Taking the Ohlson (1995) residual income model into account and following the methodology developed in Green, Stark and Thomas (1996) and Akbar and Stark (2001), the results provide support for the predictive ability of the residual income model and are generally in line with other findings from UK and USA researchers. Growth options contribute significantly to the predictive ability of the residual income model, and therefore there is strong support for the hypothesis that growth options are value relevant. On the other hand, the results do not provide any support for the hypothesis that options to invest and options to abandon or default are value relevant.

The overall study makes a new contribution to our understanding of the link between real option theory and market valuation. The findings indicate that growth options contribute strongly to company value if they are exercised. Indeed, the results imply that the longer the duration of growth options, the higher the appreciation of company market value. These results are interesting from both the theoretical and the practical point of view. If abnormal returns in the early stages of an option indicate the possibility of exercising the option, then market participants will make extraordinary gains by choosing shares that have excess returns during the option announcement period. These results may indicate that market participants can predict if a real option is in-the-money or deep-out-of-the-money.

CHAPTER TWO
REAL OPTIONS

Even though finance theory has made major advances in understanding how capital markets work and how risky real assets are valued, it has had relatively little impact on strategic planning.

Due to the deficiencies of applying the DCF methodology, the sole application of standard NPV criteria eventually leads to underinvestment. DCF techniques fail to evaluate investments that include strategic or operating opportunities. Similarly, DCF fails to evaluate investments that are a link in a long chain of subsequent investments. In particular, Discounted Cash Flow misuse comes from the improper treatment of inflation effects, excessive risk adjustments and failure to acknowledge how the management can reduce project risk by diversification and other responses to future events.

Some decision scientists have tried to solve the problem by proposing instead the use of other methods, especially the use of simulation and the application of decision tree analysis. However, these methods experience considerable difficulties with the problem of determining the appropriate discount rate. The fundamental problem lies in the valuation of investment opportunities whose claims are not symmetric. In the case of growth or compound investment opportunities, uncertainty is not resolved continuously at a constant rate over time. Also, managerial flexibility creates several interacting real options in most investment projects that may add value due to their inherent asymmetry. The resulting asymmetry caused by managerial adaptability calls for the application of an "expanded NPV" rule that reflects both the traditional (static or passive) NPV of direct cash flows, and the option value of operating and strategic adaptability.

The adoption of an "expanded NPV" criterion has certain implications;

- the value of managerial flexibility can now be quantified through option pricing;
- price volatility becomes an important determinant; and
- investment decisions take on a long-run strategic view.

In this area, early research focused on the classification of real options, the driving forces behind real option value and the effects of real option valuation on management practices. More recent research has focused on real option applications, developing a theoretical framework that facilitates the wider use of option pricing theory. The present Chapter considers these issues in greater detail.

2.1 Valuation Techniques

Well before the development of real options, management researchers were discussing strategic interactions and managerial flexibility issues. In some cases, they provided insight into the growth and value drivers that are implied by investment practices, and which question pure DCF techniques (e.g. Porter, 1980, Porter, 1985). Moreover, other researchers have suggested that the standard discounted cash flow criteria often undervalue investment opportunities, leading to eventual loss of competitive position, because they either ignore or do not value important strategic considerations properly (e.g. Hayes and Abernathy, 1980, Hayes and Garvin, 1982). The composition of investments has been skewed toward equipment and relatively short-term projects and away from structures and relatively long-lived investments. Overall, discounting methods are biased against investments in new capital stock. (Hayes, Garvin , 1982). Moreover, Capital Asset Pricing Model discount rates distort appraisals even if the financial market is perfect and the stipulations of the CAPM are met, due to the existence of investment opportunities that originate in barriers to entry, impediments to information flow, governmental regulatory constraints or other limits resulting in certain market imperfections (Myers, 1987).

Although finance theory has made major advances in understanding how capital markets work and how risky real assets and financial assets are valued, yet it has had scant impact on strategic planning.

Discounted Cash Flow

There are three common DCF misuses. First, accelerating inflation makes projects less attractive. Second, premiums are tacked on for risks that can easily be diversified. Rates are raised to offset optimistic biases of managers but if the bias does not increase geometrically with the forecast period, long lived projects are penalised if the start-up period risk –premium is also applied after the start-up period, and short-lived projects are artificially favoured. Third, the DCF approach does not fully grasp and describe the firm's strategic choices. Time-series links between projects (in other words the project's impact on the firm's future investment opportunities) may not be estimated properly (Hodder and Riggs, 1985, Myers, 1987). Also DCF procedures fail to acknowledge how management can reduce project risk by diversification and other responses to future events (Hodder and Riggs, 1985).

Some researchers tried to eliminate the deficiencies of DCF approaches by proposing more sophisticated DCF-related formulas. Although a spanning approach to estimate divisional cost of capital (Krueger, Linke, 1994) can partly eliminate the problem of excessive risk adjustments, there are other deficiencies among different types of DCF models discussed by Chambers, Harris, Pringe (1982) that are partially solved by applying other adjustments. Especially in the case of high leveraged companies, Arzac (1996) concludes that their valuation is difficult because their future leverage ratios are uncertain.

Adjusted Present Value is a DCF approach that stems on Modiglianni and Miller (1958) and Myers (1974) and that does not have the deficiencies of early DCF approaches. An illustration of APV is provided by Luehrman (1997b). Nevertheless, even APV remains a DCF methodology and is poorly suited to valuing projects that are essentially options (Luehrman, 1997b).

Uncertainty about market conditions and management flexibility is usually ignored by DCF. In many industries, companies stay in business and absorb large operating losses for long periods, even though a conventional NPV analysis would indicate that it makes sense to close down a factory or go out of business. In the mid-1980s, many U.S. farmers saw prices drop drastically, as did producers of copper, aluminium and other metals but most of them did not disinvest, although a naïve NPV approach would suggest doing so (Dixit and Pindyck, 1995). Delaying investment decisions is also due to the cost of information gathering, somewhat ignored by DCF. Using a Bayesian framework, Cukierman (1980) examines the issue and shows that the firm which has to pick an investment project out of many that are available will find it profitable to delay an investment decision in cases of increasing project uncertainty, in order to collect more information. The paper concludes that increased uncertainty will result in decreasing investment.

If information cost asymmetries are seen as opportunities, the traditional discounted cash flow method has inherent limitations when it comes to valuing investments with significant operating or strategic options (Myers, 1987). To illustrate, the commercialisation of patents and technologies through construction of new plants and expenditures for marketing can allow companies to take advantage of profit opportunities. Less obviously, companies that shut down money-losing operations are also investing: the payments they make to extract themselves from contractual agreements, such as severance pay for employees, are the initial expenditure. The payoff is the reduction of future losses (Dixit, Pindyck, 1995). Similarly, R&D or Marketing expenditures, and spending to create a new or stronger brand, all create opportunities for companies with new technologies, product development ideas, defensible positions in fast-growing markets or access to potential new markets.

In general, the management may be able to defer, expand, contract, abandon, or alter a project at different stages during its useful operating life. That flexibility, not captured by DCF, in many cases limits the downside risk while improving the upside potential (Luehrman, 1997a). Also, strategically important investments that are a link in a long chain of subsequent investment decisions are difficult to evaluate using DCF, because future events often make it desirable to modify an initial project by expanding or introducing a new production technology at a later date (Kester, 1984).

Although much of the uncertainty in introducing a new product or production technology is usually resolved early in the project life, companies may use the same discount rate for the project life (Hodder, 1986). However, in practice if demand is not satisfactory the project is abandoned or restructured to limit losses. In such situations, DCF evaluation can be seriously biased against desirable projects. DCF also misevaluates companies that are in a loss carryforward position. If the loss carryforward position is sufficiently long, projects with a negative NPV (under the assumption the tax rate is positive in each year of the project) may ultimately have a positive NPV if the effects of the loss carryforward are considered (Hurley, Johnson, 1997).

The asymmetry inherent in the value of these opportunities leads to the necessity to use other valuation techniques.

Alternative Valuation Techniques

Some decision scientists have tried to solve the problem laying in the application of the wrong valuation techniques by proposing the use of other methods, especially the use of simulation (e.g. Hertz, 1964) and the application of decision tree analysis (e.g. Magee, 1964).

When there are several uncertain variables at each stage (many chance variables), uncertainty can be handled readily by using simulation methods. Simulation methods are also useful where the relationship between the chance variable and the cash flow following some decision alternative is a complex one. Under simulation methods the uncertainties are clearly portrayed, so the management can discriminate among expected return based on weighted probabilities of all possible returns, variability of return and risks (Magee, 1964).

Similarly, decision tree analysis (DTA) can overcome some drawbacks of DCF techniques especially in analysing complex sequential investment decisions (Ritchken, Rabinowitz, 1988). Unfortunately, Decision Tree Analysis may oversimplify reality in the case of using discrete chance levels. Finally, the limiting factor in drawing up a complex decision-tree analysis is the capacity of the analysts to imagine alternatives and to think out the implications of the various possible choices (Magee (1964)). Moreover, more recent researchers agree that the main drawback of DTA is to determine appropriate discount rates to be used in working back through the decision tree (Ritchken, Rabinowitz, 1988, Trigeorgis,1988). According to Trigeorgis (1988), simulation also basically stumbles on the problem of determining the appropriate discount rate. The fundamental problem for both methods lies in the valuation of investment opportunities whose claims are not symmetric. Managerial flexibility creates several interacting real options in most investment projects that may add value due to their inherent asymmetry. In the case of growth or compound investment opportunities uncertainty is not resolved continuously at a constant rate over time, so using a constant risk-adjusted discount rate is incorrect (Trigeorgis ,1988). Also the existence of probabilities and a wide range of scenarios makes estimation too complicated[1] (Ritchen, Rabinowitz, 1988). The inability of simulation

[1] Further discussion over the deficiencies of Simulation and DTA is provided by Teisberg (1995) and Haug (1998).

and decision tree analysis to value correctly investment opportunities whose claims are not symmetric, made necessary the development of a new method to value these contingent assets[2].

2.2 Expanded NPV and Real Options

Generally speaking, the resulting asymmetry caused by managerial adaptability calls for the application of an "expanded NPV" rule that reflects both the traditional (static or passive) NPV of direct cash flows, and the option value of operating and strategic adaptability.

In other words,

Expanded (strategic) NPV

=

Static (Passive) NPV of expected cash flows

+

Value of options from active management

The above-mentioned equation, developed by Trigeorgis (1993a), stems from concepts developed in early studies that examine the firm as a composition of two distinct asset types. First, consisting of real assets that have their market value independent from the firm's investment strategy and second, consisting of real options, which are opportunities to purchase real assets on possibly favourable terms (Myers, 1977).

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2 Nevertheless, both the decision tree analysis and simulation techniques are useful in conjunction with option pricing theory (see, Boyle (1977) and Cox, Ross and Rubinstein (1979) for discussion). Contingent Claims Analysis (CCA) is able to value operating flexibility (option to defer, option to shutdown, abandonment option, option to expand, option to contract facilities) or strategic options (growth options). Ritchken and Rabinowitz (1988) provide examples of binomial pricing of growth options and options to switch. A heuristic approach, named option-adjusted NPV, that combines NPV and CCA analysis in the context of real options (in the case of the option to delay projects) is provided by Ross(1995).

The existence of valuable real options presumes some sort of market imperfection. More recent researchers distinguish firm specific and industry specific real options (Kester, 1984) and they link the framework developed by early strategic management researchers with real option literature. They propose that the company must examine the type of options (firm- specific or industry-specific) and the intensity of rivalry. When the intensity of rivalry is low and the real option is firm specific, the option-related potential benefits are high (Kester, 1984). The value of these options normally vanishes or declines if the firm does not exercise it because either the option is firm-specific, or it is traded in thin and imperfect secondary markets (Myers, 1977).

Despite the wide recognition of real options in the marketplace, researchers often formulate conceptually different statistical models to evaluate these options. Early researchers (e.g. Myers, 1977, Kester, 1984) assumed that real option value is implied by excessive P/E ratios. Others examine similarities between financial options and real options, in the area of commodities to form their models. The comparison of the variables for pricing models of share call options and undeveloped petroleum reserves was examined by Siegel, Smith and Paddock (1987). At the same time, other finance researchers show how the time-decision rule can be derived and applied to project valuation, in a real option framework (Majd and Pindyck, 1987). Their paper links and integrates previous research, over the effect of uncertainty on investments, with real options modelling. The interaction among options has not been examined properly given the complexity of these issues. Trigeorgis (1993b) examines projects with collections of real options and quantifies interactions among these options. Nevertheless, only more recent researchers provide a framework to apply option-pricing theory for general company valuation purposes[3] (Luehrman, 1998).

The lag in option-pricing applications in corporate finance is attributed (Myers, 1996) to the lack of understanding and the fuzziness of many options. Unless real options can be talked about, calculations of real option values will not be trusted. Moreover in some cases, the identification and modelling of real options is a difficult task.

Nevertheless, early researchers define three main advantages of the option approach over DCF approaches. First, the OV (option valuation) approach reduces

[3] Dixit and Pindyck (1994), Trigeorgis (1996a) and Lander and Pinches (1998) provide extended discussion and literature review.

information requirements by eliminating the need to estimate some future values (including developed reserve values). Second, the OV approach eliminates the need to determine risk-adjusted discount rates. Third, the OV approach helps to determine an optimal investment-timing decision. (Paddock, Siegel, Smith, 1988). The last two advantages exist also for other types of investments. More generally, an options approach to capital budgeting has the potential to conceptualise and even quantify the value of options from active management (Trigeorgis, 1993a). This value is manifested as a collection of real options (call or put ones) embedded in capital investment opportunities, having as an underlying asset the gross project value of expected operating cash flows. Many of these options occur naturally, while others may be planned and built-in at some extra cost. Options pricing can be used in Research and Development projects that are essentially a series of sequential investments, generating information at each stage which can be used to determine whether to proceed or not. Option perspective is also useful because managers could take action to help boost a project's NPV if it falls behind forecast, in a similar way to investors selling financial assets to increase their performance (Peskett, 1999).

The presence of competitive interaction in shared options may justify earlier investments. For example early pre-emptive investment may at times be the only available response to prevent such undesirable value losses (Kester, 1984).

The adoption of option pricing leads eventually to an increase in investments, since it may be justified to accept projects with negative NPV (Trigeorgis, 1988). Also, option pricing makes the volatility of prices become an important determinant of investment, both in terms of type of investment (e.g. rigid versus flexible technologies) and in terms of the quantity of investment (Kulatilaka, 1993). Volatility becomes important because the value of managerial flexibility is higher in more uncertain environments and may be higher during periods of high real interest rates and for investment opportunities of longer duration (Trigeorgis, 1988).

In addition, critical input price boundaries have more meaning at the micro-level than input price elasticity. Besides it may be optimal for a firm to utilise a short-run inefficient technology, creating a hysteresis (Kulatilaka, 1993). Finally, option pricing gives investment decisions a long-run strategic view. (Kulatilaka, 1993, Trigeorgis, 1996a).

2.3 Types of Real Option

Although there are various classification approaches, we distinguish seven main types of options: the option to defer or initiate investment, the "time to build" option, the option to abandon, the option to default, the option to expand, the option to contract, the option to switch use and growth options.

When there is high uncertainty, potential benefits to wait and see if output prices justify the implementation of a project are high, so the option to defer or initiate investment is valuable. Thus, the management has the option to invest only if output prices increase sufficiently, or to defer the investment if prices decline. This is the case, for example, when legislative changes are to take place. The option to defer or initiate investments is also evident in real estate development, farming, resource extraction industries and paper products.

In many projects, the required investment is incurred at numerous stages. The staging of capital investment as a series of cash outlays over time creates valuable options to default at any given stage, if conditions prove worse than initially expected, called timed-to-build options. These options are particularly valuable in venture-capital finance, pharmaceuticals, computer, electronics and capital-intensive industries, including power station development, aircraft construction, mining or other large-scale construction projects.

If output prices prove to be lower than expected, due to a sustainable decline or due to other reasons, the management has the option to abandon the project permanently in exchange for the resale value of its capital equipment and other assets in second-hand markets. Similarly, the equity-holders have the option to default on debt payments, in exchange for the liquidation value of the firm minus the value of debt payments. The option to abandon is valuable in capital-intensive industries such as railways and airlines and in financial services. In addition, the option to abandon is evident whenever an asset is not for specific use (so it is easy to resell).

The option to default is useful to evaluate companies that are financially distressed.

Once a project is undertaken, the managers may have the flexibility to alter it in various ways at different times during its life. The option to expand and the option to contract are two basic forms of the option to alter the operating scale of a project.

The option to expand arises whenever the management finds it desirable to make additional follow-on investment if it turns out that its product is more successfully received in the market than originally expected. Conversely, if the product is not as well received in the market as initially expected, the management may find desirable to forgo planned future expenditures by reducing the scale of operations (i.e. it has the option to contract) or by shutting down the project temporarily (i.e. it has the option to shut down and restart). Although the option to expand capacity may be planned and built in some extra cost from the outset, both the option to contract and the option to shut down and restart operations occur naturally. Detailed discussion is provided by Trigeorgis (1995). The option to alter operating scale is particularly valuable in natural-resource industries, fashion apparel, consumer goods, commercial real estate, in facilities planning, and construction in cyclical industries (Trigeorgis,1993a, Trigeorgis, 1995).

The option to switch use exists when a firm has valuable flexibility either to switch to different product mix (product flexibility), or to switch to other input materials (process flexibility). This is the case when a project uses machines that have many alternative uses. That project is more valuable than an otherwise identical project that uses specialised machines. The option to switch use is particularly valuable, in the form of product flexibility, in strategic acquisitions, car manufacturing, electronics, pharmaceuticals and the banking industry. The option is also evident, in the form of process flexibility, in farming, chemicals and power stations. The importance of the option to switch the use becomes critical when the environment is highly volatile and the technology is flexible, thus permitting product or raw material changes at little cost. These options are also evident among multinationals. For example a multinational tire company built extra capacity in several plants worldwide, and schedules extra shifts at the plant currently having the lower unit cost. Further discussion over the importance of flexibility options is provided by Kulatilaka (1995) and Smith and Triantis (1995).

Growth or strategic options are opportunities that are made available in the future by undertaking a project but are not part of the initial project (Willner, 1995). Growth options exist whenever an early investment is a prerequisite or a link in a chain of interrelated projects (Trigeorgis, 1993a). Growth options are particularly evident in industries or markets that provide the potential for successful product and/or market diversification. They are common in infrastructure-based or strategic industries, especially in high-tech ones as well as in industries with multiple product generations or applications (e.g. computers and pharmaceuticals). Moreover, growth options are particularly important for multinationals and entrants in new markets, including joint ventures. Growth options can be acquired via purchase of real assets, via learning-by-doing, via direct expenditure in research, advertising, training or some other activity (Myers, 1977). Research and Development investments are considered as growth options (Myers, 1977, Kester, 1984) and Brealey and Myers (1991). Valuable growth options may result from patents and technical knowledge, managerial expertise and market position for specific firms (Pindyck, 1988). Growth options are also evident in strategic acquisitions. A discussion of the importance of long-run (strategic) criteria in acquisitions, which includes provides several examples of growth options is provided by Smith and Triantis (1995)[4].

Delaying or accelerating investment projects

The information advantage of sequential development makes the naïve application of the NPV rule inappropriate in many cases, because it implies that the optimal ordering of sequential projects does not always begin with the highest value project.

As many researchers argue, the rate at which some investments proceed is usually flexible and can be adjusted with the arrival of new information. This is the case in many important industries, including aircraft and mining. The production of a new line of aircraft requires engineering, prototype production, testing and final tooling stages that together can take up to ten years to complete. Similarly, the construction of a new underground mine, or the development of a large petrochemical

[4] They are classified by distinguishing between projects whose future benefits are realised primarily through cash flows (simple growth options) and those whose future benefits include opportunities for further discretionary investments (compound growth options) (Kester, 1984). The latter include R&D projects, major expansions into new markets and acquisitions. Compound growth options lead to new investment opportunities while affecting the value of the existing growth options. Two other types of growth options are distinguished by Kester (1984): proprietary and shared ones. The proprietary options result from patents or the company's unique knowledge of a market, while the shared growth options are collective opportunities of the industry, like the chance to enter a market unprotected by high barriers. Proprietary growth options provide highly valuable exclusive rights of exercise. Shared growth options are less valuable "collective" options because competitive moves can erode or even pre-empt profits. Shared growth options are valuable only for companies that have a sufficiently strong competitive position (Kester, 1984). Other researchers provide additional classification schemes.

plant, usually require at least five years, with clear constraints on the pattern of expenditures (Majd and Pindyck, 1987).

The issue of the optimal investment and the examination of the stages of time to build options prevailed among the researchers of these options.

Optimum exercise policy by combining maximum construction rates and the option to delay projects with sequential investment outlays is examined in an early study (Majd and Pindyck, 1987). The effects of time to build are greatest when uncertainty is high, when the opportunity cost of delay is greatest, and when the maximum rate of construction is lowest.

Other researchers defined some stages for time to build options. Paddock, Siegel and Smith (1988) examine the option to defer leases by breaking up the process into three stages: the exploration stage, (option to spend the expected exploration costs and receive the value of expected reserves), the development stage (option to pay the development costs and install productive capacity) and finally the extraction stage (option to extract the hydrocarbons).

However, the impact of the existence of the parallel projects for the value of the sequential opportunities was examined only in a recent study by Childs, Ott and Triantis (1998). Since investment in one project can provide valuable information for correlated projects, Childs, Ott and Triantis (1998) concluded that highly correlated project values favour sequential development. However, as the variance of the project revenues increases, this effect is partially offset by the benefits of the development in parallel. The parallel development is superior for projects that have low development costs, require long periods of development, are likely to generate high cash flows when implemented, and are highly irreversible. Their results are consistent with development strategies observed in practice, mentioning the development of the commercial aircraft at McDonell Douglas.

The time to build option can be viewed as an option on the value of subsequent stages and can be valued as an option on option.

The value of the option to delay projects, assuming the market value of the completed investment follows a Wiener process, was examined in an early study (Majd and Pindyck ,1987). However, whenever an exchange of assets creates the potential for further exchange, the valuation of sequential opportunities becomes necessary. The valuation formulas developed by Margrabe (1978) and Geske (1979) were generalised by Carr (1988) to value American sequential exchange options. The possible outcomes of the project interrelations during the staged investments are also addressed by Trigeorgis (1993a). The binomial tree valuation formulas and closed-form solutions that assume normally distributed values were developed by Childs, Ott and Triantis (1998) to examine both the cases of sequential and parallel development of two projects.

Although in many cases investment decisions are irreversible, the decision to defer these investments is reversible. This asymmetry, leads to the rule to invest only if the benefits exceed the costs by a certain positive amount. The proper calculation involves comparing the value of investing today with the value of investing at all possible times in the future. Assuming that investment-timing decisions are made by risk-averse investors who hold well-diversified portfolios, McDonald and Siegel (1986) derive explicit formulas for the value of the option to invest in an irreversible project. These formulas also enable the researchers to compute the optimal investment-timing rule, as well as the value lost by a firm that takes on a project at a suboptimal time. These findings are integrated in the context of a clean surplus equation by Pope and Stark (1997).

Nevertheless, valuing real options in special cases (when the underlying asset trades in a commodity market) may require a deeper understanding of equilibrium in the market for the underlying asset than valuing options on financial assets. Recent researchers have attempted to provide a model that incorporates these features. Paddock, Siegel and Smith (1988) develop the option to defer valuing leases for offshore oil and they demonstrate how to integrate an explicit model of equilibrium in the market for the underlying real asset (oil reserves).

Nevertheless, even in cases the project itself has certain cash outflows, the uncertainty in interest rates gives a project an option-like feature. With uncertain interest rates an investment should not be undertaken until its projected rate of return is substantial in excess of its break-even rate (Ingersoll and Ross, 1992).

Early researchers who used the simulation showed that the higher the degree of irreversibility, the lower the value of the timing options. The value lost by adopting a project with zero net present value sub-optimally can easily range from 10 to 20 per cent or more of a project's value (McDonald and Siegel, 1986).

In another study (Bjersund, Ekern, 1995), simulated models show that the timing option alone doubles the break-even output price in commodity markets.

The empirical results are in line with the theory. The comparison of oil price valuations based upon the discounted cash flow approach and the option valuation approach with actual industry bids for the period 1974-1980, provides evidence that supports the option valuation approach (see Paddock, Siegel and Smith ,1988)

In the case of large-scale infrastructure projects, the value of the option to delay comes out not only from interest rate risk, but also from environmental risk, regulatory risk and force-majeure risk (catastrophic unanticipated events, such as earthquakes, which may occur to damage the project (Adam ,1996).

The option to defer or initiate can be valued as an American call option on the present value of the project's cash flows.

A binomial tree approach to valuing the option to defer or invest in land is presented by Titman (1985). If the value of the vacant land exceeds the profit from building at the specified date, the landowner will choose to have the land remain vacant, otherwise s/he will construct the building.

On the contrary McDonald and Siegel (1986) assumed that both expected cash flows and investment payments are lognormally distributed to develop a model to value the option to defer or invest in a project. They also examine the case of the expected cash flows following a jump process. The later analysis assumes the investment to be lumpy, but ignores the possibility the investment may be partially reversed or scrapped after the project is adopted.

A model that allows us to explore the effect of the decision to wait in light of the beneficial impact of a potential future interest rate decline was developed by Ingersoll and Ross (1992). A simplified model to account for the value of interest rate options inherent in the right to delay a project was developed by Ross (1995)

A two-mode, three-period problem to apply dynamic programming is considered for the valuation of the waiting to invest option which are treated as special cases of a general flexibility option by Kulatilaka and Marcus (1988).

Unlike previous studies that introduce uncertainty by means of the stochastic value of a completed project which is either producing or ready for production (McDonald and Siegel, 1986 and Paddock, Siegel and Smith, 1988), the study made by Bjersund and Ekern (1995) traces the elementary source of uncertainty down to the risky spot output price, which is assumed to follow a geometric Brownian motion.

The option to abandon and the option to default

A first discussion over the value of the option to abandon is provided by Myers (1977). He notes that the existence of secondary markets for an asset will, in general, increase the present value of the firm, providing that the appropriate restrictive covenants can be written. Thus, the option to abandon is valuable. However, complete formulas to value these options were not developed before the late 1980's.

The option to permanently abandon a project for its salvage value, seen as an American put option is analysed by Myers and Majd (1990). The abandonment option is thought of as an option on a dividend-paying stock, and the exercise price of the put is the salvage value of the project while the cash flows from the project are equivalent to the dividend payments on the stock. The real option perspective is linked with the clean surplus equation to derive the integrated company profitability measures by Stark (2000).

The option to default during construction and the recognition of its similarity to the equity-holders' option to default on debt payments deriving from limited liability has been analysed and valued by Trigeorgis (1993a).

The examination and valuation of potential interactions between operating and financial default flexibilities are also examined by Trigeorgis (1993a).

The examination of the economic rationale behind the value of the option to default has been a prevailing issue in most of the studies in the area. There are three main conclusions from the researchers of the option to default.

First, the option to default formula is appropriate whenever a financially troubled firm has to be valued. (Trigeorgis, 1993a and Damodaran, 1996)

Second, the value of the option stems from the stockholders' incentive to take riskier projects than bondholders do and to pay more out in dividends than bondholders would like them to (Damodaran, 1996).

Third, corporate mergers will induce a drop in the value of the option to default, so stockholders can reclaim some of the lost wealth by issuing a new debt. The real option decline is due to the decline of the variance in earnings and cash flows of the combined firm because the merging firms have earning streams that are not perfectly correlated. (Damodaran, 1996).

An analytical framework to show how the conflicting incentives of debt-holders and equity-holders will affect the outcome of a default option was developed by Vila and Schary (1995).

The option to abandon is valued as an American put option on current project value with an exercise price that amounts to the salvage value. Similarly, the option to default is valued as an American put option on current enterprise value with the exercise price equal to the difference between liquidation value and debt obligations.

As explicitly explained by Carr (1995), the abandonment option is a mirror problem to the timing option problem and can be similarly valued with a suitable interpretation of variables.

The option to abandon a project is first valued by reinterpreting variables in the option to defer investment. In the model developed by McDonald and Siegel (1986) the investment cost is the value of the project in place.

The option to permanently abandon a project as an American put option is analysed by Myers and Majd (1990). Their valuation model has many similarities to Magrabe's (1978) but also differs from Margrabe's model, because the latter assumes no payouts from the assets.

A dynamic programming approach for the valuation of the abandonment option is provided by Kulatilaka and Marcus (1988), while a binomial risk-adjusted approach is provided by Trigeorgis (1993a). Special approaches to value the venture capitalists' option to abandon are provided by Trigeorgis (1993a).

Although the valuation of the option to abandon can be interpreted to value an option to default, a more integrated valuation formula of the bankruptcy options is developed by Carr (1988) who values these options as sequential exchange opportunities.

The option to expand and the option to contract

Whereas some researchers assume that there is an option to temporarily shut down production whenever variable costs exceed operating revenues (McDonald and Siegel , 1985), for others it is not optimal to shut down. For example, it is not optimal to shut a mine unless the value of the shut mine exceeds the value of the operating mine by the amount of the shutting costs (see Brennan and Schwartz, 1985).

There are three main findings of the research in the area.

First, referring to natural resource projects, it is not optimal to open a mine until the spot price reaches the point where the value of the mine in operation exceeds its value shut by just the amount of the opening costs. In addition, it is not optimal to shut down the mine unless the price drops to the point where the value of the shut mine exceeds the value of the operating mine by the amount of the shutting costs (Brennan and Schwartz, 1985b).

Second, the value of the scaling options is high in volatile markets. In particular, the option to contract and to expand may be valuable in the case of a new product introduction in uncertain markets, in markets with volatile and unpredictable demand (Trigeorgis, 1995). The implications of volatility are stressed in the early studies. Firms should hold less capacity than they would if investments were reversible or future demands were known. (Pindyck, 1988).

Third, the value of the options to contract or to shut down becomes important whenever the cost mix can be somehow modified. The option to contract is important in cases where the management finds it preferable to build a plant with lower initial construction costs and higher maintenance costs in order to have the flexibility to contract operations by cutting down on maintenance if the market conditions turn out unfavourable. The option to temporarily shut down may be important when deciding among mutually exclusive projects or alternative production technologies having different proportions of variable costs.

In the case of the option to expand, the original investment opportunity can be thought of as the initial scale project plus a call option on a future opportunity to acquire an additional part of the initial project. In opposition, the option to contract is analogous to a put option on part of the base-scale project, with exercise price equal to the potential cost savings. Similarly, the option to shut down and restart is analogous to a put option on the project's cash revenues, with exercise price equal to the variable costs of operating.

The option to shut down investments was examined under different assumptions. Initially it was examined by assuming that risk-neutrality and costs follow a continuous time stochastic process (McDonald and Siegel (1985), later integrated by Dixit, Pindyck (1994)), and later under the assumption that demand is lognormally distributed and the assumption that there is an asset (or dynamic portfolio of assets) whose price is perfectly correlated with demand shifts (Pindyck , 1988[5]) to value the option to temporarily shut down investment. These models had to face simultaneously the problems of assessing the expected future output price and of assigning a discount rate appropriate to the risk of revenues, bypassed by using a convenience yield approach (Brennan and Schwartz, 1985a). An economically corrected version of Decision Tree Analysis is used to value both the option to expand, the option to contract (Trigeorgis and Mason, 1987 and Trigeorgis, 1993a) and the option to shut down (Trigeorgis, 1993a) while a dynamic programming approach is used to value the shutdown option by Kulatilaka and Marcus (1988).

The option to expand and the option to contract frequently are expressed in the form of switching options. There are two main issues examined in studies that examine switching options. First, they discuss implications of increasing value of the option to switch production. Second, they examine the conditions under which the value of option to switch increases. The main implication is that the value of the short-lived projects increases proportionally to the value of the option to switch production. Future price uncertainty creates a valuable switching option that benefits short-lived projects (Baldwin and Ruback, 1986). Whilst both long-lived and short-lived assets have a valuable switching option, the option is more valuable for the short-lived assets because the opportunity to switch occurs sooner. Also, the higher the variability of future costs of these assets, the higher the value of the options.

The value of option to switch increases from the existence of low competition, low correlation between input and output prices and flexible company design.

The examination of the exchange option when product flexibility and process flexibility take place lead to the conclusion that the difference between the true project NPV (computed by option pricing theory) and the NPV computed by naïve DCF methods is greater the more innovative the project, and the stronger the barriers to entry (Kensinger, 1987),

The more volatile the relationship between the prices of the input and output commodities the higher the value of the exchange option (Kensinger, 1987). Even in

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[5] The latter approach (Pindyck, 1988) ignores interalia competition, the lumpiness of investment, adjustment costs, delivery lags, depreciation and different functional forms for demand and cost that may limit the quantitative importance of these options.

acquisitions, the greater the uncertainty surrounding the demand for a firm's products and the lower the correlation among these product demands, the more valuable will be the combined benefits of flexibility and diversification. (Smith and Triantis, 1995)

The more flexible the production systems under consideration for purchase, the higher the value of exchange option (Kensinger, 1987). Similarly since there are variables that affect the input supplier but are excluded from bargaining there will be a potential for beneficial or detrimental flexibility from incomplete contracting (Kulatilaka and Marks, 1988). Moreover, firms with significant flexibility in organisation, marketing, manufacturing and financing may reap additional benefits from strategic acquisitions. An acquisition program that focuses on strategic, rather than financial diversification will not only decrease the variance of the firm's future cash flows but also it may significantly increase firm value by enhancing the value of the firm's flexibility options (i.e. the option to switch use)(Smith and Triantis, 1995). An illustration of the flexibility options for multinational companies is found in Baldwin (1987)

The options to switch can be viewed as exchange-one-asset-for-another American options. The financial exchange-one-asset-for-another European option was introduced by Margrabe (1978). Both the binomial method and Margrabe(1978) formula are used by Kensinger (1987) to illustrate the usefulness of the exchange option in the case of a soybean converter. The formula for pricing the exchange options on the exchange options is introduced by Carr (1988). The binomial tree approach to value American exchange options is developed by Rubinstein (1991). However, a later study has shown that pricing an American exchange option can be simplified to the problem of pricing a standard American call option (Bjerksund and Stensland, 1993). A lattice-based model to value flexibility options is presented by Kamrad and Ernst (1995) and using the Bellman equation of dynamic programming Kulatilaka (1993) formulates the option to switch.

Growth options

Early investment management researchers drew no distinction between the cost of capital for assets in place versus future investment, these included Miller and Modigliani (1961) who proved that growth opportunities have value if investors expect the rate of return earned on future investments to exceed the firm's cost of capital. Real assets are examined as options whose ultimate value depends on the future discretionary investment by the firm, as described in Myers (1977). He examines a firm as a collection of tangible (units of productive capacity) and intangible assets, the second being options to purchase additional tangible assets in future periods. The sum of these options is, according to Myers, what Miller and Modigliani (1961) meant by the present value of growth. These options are called "growth options" and their existence implies, interalia, two things. First, neo-classical valuation models are mis-specified and second, the measure of the equilibrium capitalisation rate as a hurdle rate for capital budgeting is inappropriate, as it will be an overestimate of the correct rate for firms having valuable growth opportunities.

The growth options can be distinguished as proprietary and shared ones. The shared growth options are less valuable and less attractive than the proprietary ones because counter investments by competitors can erode or even pre-empt profits (Kester, 1984).

The implications of the growth options for the capacity choice, utilisation, firm value and long-run marginal cost are examined by Pindyck (1988). He finds that in markets with volatile and unpredictable demand, firms should hold less capacity than they would if investments were reversible or future demand was known. He also finds that much of the market value of these firms is due to the *possibility* (as opposed to the expectation) of increased demands in the future. His findings are consistent with previous researchers' conclusions.

The start-up venture option value is examined by Willner (1995).

The use of sensitivity analysis to assess the impact of the growth option on gross project value is made by Willner (1995) and Trigeorgis (1996b).

The former paper provides numerical examples illustrating how calculated value varies with changes in the expected cash-flow value, relative to the economic scale manufacturing facility (ESMF), with the other parameters held constant. Even when the expected cash-flow value is 33% below the cost of ESMF, there is still a positive value to the start-up venture, while when at-the-money (i.e., zero-NPV), the start-up venture is worth approximately 38% the cost of ESMF. The latter study (Trigeorgis, 1996b) has similar conclusions.

Providing an extensive discussion of growth options in strategic acquisitions, Smith and Triantis (1995) conclude that many of the strategic synergies in an acquisition are not immediately realised but rather should be seen as growth options.

The empirical evidence from US companies indicates that growth options account from 4% up to 88% of their total equity value (Kester, 1984, Ottoo, 2000). The value of these options depends on four main factors, namely the length of time the project can be deferred, the projects' risk, the level of interest rates, and exclusiveness. The longer a project can be deferred the more valuable a growth option will be. Other research (Paddock, Siegel and Smith, 1988) provides some evidence that option pricing theory is useful to value offshore petroleum leases as growth options.

Other studies provide empirical evidence that supports the real option theory in the case of the growth options in a case study base (Panayi and Trigeorgis, 1998, Benaroch and Kauffman, 1999, and Kellogg, Charnes and Demirer, 1999). In Panayi and Trigeorgis (1998), the growth options are examined in relation to a telecommunications company and in relation to an international bank expansion. IT growth options in the banking industry are examined by Benaroch and Kauffman (1999) and an Internet company is examined by Kellogg, Charnes and Demirer (1999). These papers provide insight into the methodological issues.

Growth options can be viewed as options on options. The binomial method to value the growth options is used by Brealey and Myers (1991). A similar approach (an economically corrected version of Decision Tree Analysis) for the growth options, is developed by Trigeorgis and Mason (1987) and Panayi, Trigeorgis(1998).

A jump model for valuing the growth options for start-up ventures is developed by Willner (1995). His model is useful to value a simplified growth opportunity or it can be extended to compound growth options. A methodology to value the growth options in the case of a bank that expands its network is provided by Panayi and Trigeorgis (1998). A heuristic approach, based on P/E multiples, to estimate the value of growth options is developed by Kester (1984) while an approach based on P/BV multiples, is applied by Ottoo (2000).

Multiple interacting options

The combined value of the options to shut down (and restart) a mine, and to abandon it for salvage value are examined by Brennan and Schwartz (1985). A log-transformed version of binomial numerical analysis is used by Trigeorgis (1990) and Trigeorgis (1993) to evaluate real option interactions. The examination of interactions among growth options, options to expand, options to abandon for salvage, and options to defer are examined by Trigeorgis (1990), while the interactions of the option to defer, the abandonment option, the option to contract, the option to expand and switch options are examined by Trigeorgis (1993a). Dynamic programming is used to investigate potential interactions among the wait-to-invest option, the shutdown option and the option to expand on their optimal exercise schedules (Kulatilaka, 1995). The interacting option to defer payment of the concession fee to the Government and the option of the Government to take ownership of a construction project in Australia are examined simultaneously by Rose (1998).

The combined value of the options to shut down (and restart) a mine, and to abandon it for salvage value is found to induce an hysteresis effect, making it long-term optimal to remain in the same operating state, though short-term considerations may seem not to suggest so (Brennan and Schwartz, 1985).

Sensitivity analyses over the interaction of multiple options show that their separate values may not be additive (Trigeorgis, 1990). Moreover, valuing each operating option (option to defer, the abandonment option, the option to contract, the option to expand and switch options) individually and summing these separate option values can substantially overstate the value of the project (Trigeorgis, 1993a). Also, Kulatilaka (1995a) who conducts numerical simulations, finds that when two options are present simultaneously the project value is greater than the cases when each option is included in isolation and smaller than the sum of the values of these options. This general failure of value additivity carries through when further options are included. In the same study, the presence of the option to temporarily shut-down has the effect of reducing the value of the wait-to-invest option and interprets these options as substitute for hedging strategies. However, the addition of the expansion option tends to increase the value of the shutdown option and vice versa. She describes the shutdown and the expansion option as complements to each other.

Interacting options in leasing are examined in Trigeorgis (1996b) and the conclusions are in line with these of Kulatilaka (1995a).

The more detailed classification of the option interactions depending on the type of options (call or put) that interact is examined in another study (Trigeorgis, 1993a). The study finds that the value of a prior option would be altered if followed by a subsequent option because it would effectively be written on a higher underlying asset. The research concludes interalia that the incremental value of an additional option is in most cases less than its value in isolation. It also provides evidence that the greater the number of options, the smaller their incremental contribution. The paper shows that, in some cases, option interactions can be large and negative.

Specifically, the main conclusions of the paper are the following

- if the first option is a put, its value would be lower and
- if a call, higher relative to its value as a separate option.
- The effective underlying asset for the latter option may be lower depending on prior exercise of an earlier put option than if the prior option were not exercised. This may lead to a double negative effect if the prior option is a put.
- However, if the prior option is a call, the interaction can be positive with the incremental value of both the prior and the latter option being greater than their separate values.
- If the two options are of an opposite type so that they are optimally exercisable under opposite circumstances, then the conditional probability of exercising the latter option given prior exercise of the former would be smaller than the marginal probability of exercising the latter option alone. The degree of interaction would then also be small and the options approximately additive.
- If the two options are of the same type, then the conditional probability of exercise would be higher, and so would be the magnitude of interaction (the deviation from option value additivity). If the prior option is a put, the sign of the interaction will be negative. If, instead, the prior option is a call, the sign will be positive.

Table 2.1 illustrates the types of the interacting real options included in the examined papers.

Table 2.1 Interactions among real options

Types of real option examined	Shut-down/ Contract	Invest	Abandon	Growth	Expand	Defer	Switch	Other types
Brennan and Schwartz (1985)	√	√	√					
Trigeorgis (1990)			√	√	√	√		
Trigeorgis (1993)	√		√		√	√	√	
Kulatilaka (1995)	√	√			√			
Trigeorgis (1996)			√		√	√		
Rose (1998)						√		√

A numerical method, based on a log-transformed variation of binomial option pricing, for valuing complex investments with multiple interacting options is presented by Trigeorgis (1991) and followed by Trigeorgis (1993a), Trigeorgis (1993b) and Trigeorgis (1996a). On the contrary, Kulatilaka (1995a) uses dynamic programming, while the Monte Carlo simulation is used by Rose (1998) to value interacting real options in a toll road infrastructure project in Australia. The comparison of several numerical methods in terms of accuracy, consistency, stability and efficiency can be found also in Trigeorgis (1991).

2.4 Some Fundamental Issues

The link of the value of real options with strategic or financial flexibility triggered the interest of real option researchers to investigate fundamental factors that alter or mitigate the value of real options. Recent research increasingly gave attention to interdependencies among real options and these fundamental factors.

Competitive interaction and early real option exercise

Early studies (Kester, 1984, Trigeorgis, 1988) indicate that it pays to exercise real options earlier than necessary when the project NPV is high, the level of risk and interest rates are low, industry rivalry is intense, and competitors have access to the same options. Later studies find that deciding when to exercise real options depends also on the technical uncertainty, input cost uncertainty[6] and external uncertainty[7]. An early exercise of shared real options frequently includes the bearing of high infrastructure costs or the appropriation of "rents"[8] by owners of needed co-specialised assets and other aggravations (McGrath, 1997). The early exercise of these options may lock out late entrants who can also be subject to "time compression" diseconomies relative to early movers.

The link between uncertainty and investments may also explain optimal investment decisions.

Optimal entry decisions, hysteresis and irreversibility

Sensitivity analysis shows that firms should hold less capacity in markets with volatile and unpredictable demand, than they would if investment were reversible or future demand were known. The policy implication is that ignoring opportunity costs of investing would lead to overinvestment (Myers, 1977 and Pindyck, 1988).

Early studies show that in many cases projects should be undertaken only when their present value is at least double their direct cost (see Brennan and Schwartz, 1985b, McDonald and Siegel, 1986 and Majd and Pindyck, 1987). Another study that focuses on the marginal investment decision, as a simple solution to the optimal capacity problem, shows that a firm's capacity choice is optimal when the present value of the expected cash flow from a marginal unit of capacity just equals the summation of purchase and installation cost plus the opportunity cost of exercising the option to buy the unit (Pindyck, 1988). Dixit (1989) also examines

[6] "Technical uncertainty" relates to the likely costs and probabilities of accomplishing technical success. "Input cost" uncertainty relates to factors exogenous to the firm. Technical uncertainty and input cost uncertainty are examined in Dixit and Pindyck (1994).
[7] It is evident when sources of uncertainty are largely "external" to the firm but can be influenced by a strategic action. (McGrath, 1997)
[8] "Rents", represent profits that do not immediately induce a competitive response.

optimal entry and exit conditions. If p is the output price, k is the sunk investment cost, w is avoidable operating cost per unit of time, and r is the rate of interest, the company will make the investment if $p>w+rk$. Since investment is made, the firm will abandon the project if $p<w$. Thus the full cost serves as the entry trigger p_H and the variable cost as the exit trigger p_L.

Other economists have tried to define important features that are explained by the value of the real options. An important economic feature that is linked with the value of the scaling options is "Hysteresis", defined as the failure of an effect to reverse when its underlying cause is reversed. Due to hysteresis, foreign firms that entered the US market when the dollar appreciated did not exit when the dollar fell back to its original levels (Dixit, 1989). Similarly, in the mid-1980's, many US farmers saw prices drop drastically, as did producers of copper, aluminium and other metal, and they did not disinvest. (Dixit and Pindyck, 1995).

Recent research attributes hysteresis to irreversibility. Irreversible investment expenditures exist when the firm cannot disinvest, so the expenditures are sunk costs. This happens because capital is industry-specific or firm-specific so it cannot be used in a different industry or by a different firm. A steel plant and most marketing and advertising expenses are sunk costs. Irreversibility can also arise because of government regulations, institutional arrangements or differences in corporate culture. For example, capital controls may make it impossible for foreign investors to sell their assets and reallocate their funds. Similarly, investments in new workers may be partly irreversible (sunk costs) because of the high costs of hiring, training and firing. The recognition that capital investment decisions can be irreversible gives the ability to delay investment added significance[9].

[9] When irreversible choice among mutually exclusive projects under output price uncertainty is examined, the choice among projects depends on how the output changes with scale. If the elasticity of output with respect to capital expenditure is greater than one, it is found not optimal to invest in any but the largest available project. If the elasticity is less than one but increasing then the optimal choice is an extreme: either the smallest or the largest available project. Greater uncertainty of the price process makes it optimal to wait for a larger project. (Dixit, 1993). Irreversibility also helps us explain why commodity metal prices are so volatile. Corporate inertia in building and closing down facilities feeds back into prices. Supposing copper demand rises due to higher DNP growth, producers (knowing that the price might fall later) typically wait rather than respond immediately with new production increases. Thus the reaction of producers to price volatility in turn sustains the magnitude of price volatility (Dixit and Pindyck, 1995).

Recent findings from the area of environmental investments are also in line with previous research. Companies under emission restrictions designed to encourage environmental investments may optimally choose to cut back production instead of engaging in heavy environmental investments. The reason is that firms consider both the closing and the timing options available and require very high returns on environmental investment before exercising the option to invest. (Cortazar, Schwartz and Salinas, 1998). Similarly, expected profits and the associated opportunity cost of waiting increases with higher uncertainty for landowners that want to build, due to irreversibility. (Bar-Ilan and Strange, 1996).

Optimal entry and exit decisions are meaningful when investors have a model for the distribution of market prices in mind.

Real options and equilibrium prices

Some economists during the 1980's tried to link the valuation of real options with a deeper understanding of equilibrium in the market for the related commodities (assets). Paddock, Siegel and Smith (1988) demonstrate how to integrate an explicit model of equilibrium in the market for the underlying real asset (petroleum reserves) with option pricing theory to derive the value of a real option[10]. Defining that Exploration, Development and Extraction are the three stages for the holder of an offshore petroleum lease, they represent the Exploration stage as the option to spend the expected exploration costs, E, and to receive the expected value of undeveloped reserves.

Recent studies try to investigate implications of the real options to management practices and the way management practices can increase the real option value.

[10] They extend the model explored by Geske (1979) and using equilibrium model of McDonald and Siegel (1984) to value compound options.

Proactive flexibility

Although early research underlines the importance of protecting or enhancing the value of the real options (e.g. Kester, 1984), only recent studies give special attention to proactive flexibility, the flexibility to take action in ways that will enhance the value of the option. Indeed, management can use its skills to improve an option's value before exercising it, effectively making it worth more than the price paid to acquire or create it by pulling the levers that control its value.

An illustration is the case of a manager in a pharmaceutical company who has the flexibility to influence a real-option lever by increasing the resources put into marketing. He might be able to increase the option's duration (time to expiry) by selling a product or negotiating a licensing agreement. These actions would, of course, also affect the value of the options held by other players (Leslie and Michaels, 1997).

To raise options value, the management decreases cash outflows or increases cash inflow uncertainty. To reduce cash outflows, the management leverages economies of scale/scope. A company unable to do these things alone can do so in partnerships. As a thriving lobbying industry suggests, it may behove firms to maximise the value of their options by influencing key legal boundary conditions rather than by investing in technology per se[11]. These pre-investments create a context in which the technology can flourish, which has the effect of increasing the value of the underlying technology asset and the value of the option (McGrath, 1998).

The considerable discussion over the strategic implications of applying and enhancing the value of real options, raised the interest for real options applications.

2.5 Real Option Applications

Real option valuation has been applied in a variety of contexts. Some of these contexts such as land development, acquisitions and natural resource investments are in the core of companies' value, while others help us to evaluate part of the companies' operation in a new, better way. Overall, these applications help us to identify whether real option theory meets valuation practices.

Natural resource investments

The high volatility of natural resource prices and the long duration of associated assets eventually results in higher real option values that triggered the interest of early researchers.

Treating a natural resource extraction project or mine as an option on the underlying commodity overcomes the deficiencies[12] of the other valuation approaches.

The use of convenience yield[13], to define the option formulae to shut down or abandon a mine is developed by Brennan and Schwartz (1985) and applied by Moel and Tufano (1999). Other researchers examine the analogy between undeveloped oil reserves and stock call options that justifies use of the option pricing models and discuss ways of estimating the parameters that are necessary for continuous time models (Siegel, Smith and Paddock, 1987). The valuation of forestry resources under stochastic timber prices and tree inventories is examined by Morck, Schwartz and Stangeland (1989). On the contrary, the assumption of fixed input prices is used to arrive at option valuation estimates of selected offshore petroleum leases by Paddock, Siegel and Smith(1988). Actual cases in the petroleum industry, namely, a timing option in an offshore project, a case of a growth option and an abandonment decision of a refinery production unit is also examined by Kemna (1993).

There is plenty of empirical evidence or simulation results that show the importance of real options in the area of natural resources.

Empirical evidence that option values are better than actual discounted cash flow based bids, in valuing oil leases is provided by Siegel, Smith and Paddock

[11] On the other hand, the need frequently emerges to invest in participation in "community technological organisations" which help shape the standards and specifications for an emerging technology, as well as in the technology itself (McGrath, 1997).

[12] Especially the deficiencies of both the classical discounted cash flow model and scenario or simulation approach in evaluating natural resource investments are discussed in Brennan and Schwartz (1985a) They note that especially the scenario approach requires that the appropriate policy for each scenario be determined in advance and the determination of an appropriate discount rate. DCF and simulation require also forecasting output prices for many years into the future, a particularly acute problem for natural resource industries where annual price fluctuations of 25 percent or even 50 percent are not uncommon.

(1987) and Paddock, Siegel and Smith (1988). In these papers, the option valuation approach is compared with both the valuations based upon the discounted cash flow approach and the actual industry bids. Another study (Moel and Tufano, 1999) provides the evidence that the real options model is useful to describe and predict gold mines' opening and shutting decisions. The study examined opening and closing decisions of 285 North American gold mines in the period 1988-1997. Alike real option theory, the probability of a mine being open increases with gold price and increasing volatility is positively related to the probability that an open mine will remain open. Also, as variable cost of operation increase, a mine is less likely to be open, while as maintenance costs increase mines are more likely to stay open. An analysis of actual cases in the petroleum industry (Kemna, 1993) also leads to promising results. The timing option in an offshore project, the case of a growth option and an abandonment decision of a refinery production unit are examined for different volatility and pay-out rate assumptions. For a base case of 20 per cent commodity price volatility and 5 per cent Pay-Out Rate, net investment opportunity value, based on the timing option, amounts to about eighth per cent of the investment outlay. The results, based on the compound option value, also indicate that a pioneer investment can be justified when commodity price volatility is 20 percent or higher.

The reversion effects of the commodity projects for the value of real options in natural resource investments are examined in a recent study. Laughton and Jacoby (1995) find that reversion tends to increase the value of any claim to cash flows that increase with long-term prices and to decrease the value of claims to cash flows that decrease with prices. Lower uncertainty also tends to depress directly the value of long-term options of any type.

Land development

Studies in land valuation examine the time to build options. The value of land as an option on a building is examined in Titman (1985)[14], while analytical solutions for the value of the option to wait to invest as it applies to land development are presented in another study (Quigg, 1995). The latter study constructs the rules that

[13] The convenience yield comes out from futures and spot prices of a commodity.
[14] He presents a pricing model illustrated by an example in which the developer has a choice between different-sized structures and examines some comparative statistics.

determine the optimal exercise strategies and shows that the time to build option adds value to the land over and above the value of expected rents based on what is known at the decision date. This option value provides a rationale for the existence of a vacant land. The examination of the empirical predictions of a real option-pricing model that accounts for the option to wait to invest is made by Quigg (1993). The study uses data on 2700 land transactions in the US, distinguishes land values by year and type (Business, Commercial, Industrial, Low density residential and High Density residential) and evaluates the theoretical land values given by the option-based model relative to the intrinsic values and to market prices. The paper finds that the option premiums range from 1% to 30%, with a mean of 6% and in support of the theory, these premiums are consistently positive. The research also performs several regressions to ascertain the comparative fit and explanatory power of the option-pricing model. The results support the use of option pricing theory for valuation purposes.

Flexible production

Research in the area of manufacturing confirms that flexible projects may allow for the downside protection against unfavourable events whilst introducing growth opportunities on the upside. A simple model of flexibility, based on dynamic programming that can be used to obtain the option value to switch between different modes of operation is presented by Kulatilaka (1993). She applies her model to evaluate the incremental cost saving of a dual-fuel boiler over the better of two single-fuel boilers. She finds that the value of flexibility exceeds the incremental investment cost of purchasing a dual-fuel boiler. On the contrary, a lattice-based contingent claims valuation model to value manufacturing firms, projects and agreements where input prices and output yields fluctuate randomly over time is developed by Kamrad and Ernst (1995).

The option value of R&D investments in optical tape recording is estimated by Pennings and Lint (1997). They use information over discussion on standardisation, strategic alliances, patent positions and technological breakthrough to compute growth option values. The expansion value of a Telecom through the growth option modelling is estimated by Panayi and Trigeorgis (1998). The case of a bank's entry into the POS debit market and the estimation of the optimal deferral time is examined by Benaroch and Kauffman (1999). The real option valuation of an internet company is examined by Schwartz and Moon (2000)[15].

Strategic Management

An early study (Roberts and Weitzman, 1981) shows that in sequential decision-making, it may be useful to undertake investments with negative NPV when early investment can provide information about future project benefits, especially when uncertainty is high. In the opposition, when a firm has market power and faces irreversible decisions, optimal sequential decisions may require a positive premium over NPV to compensate for the loss in value of future opportunities that results from undertaking an investment (Baldwin, 1982).

The options to choose capacity under the product price uncertainty when investments are irreversible are examined by Pindyck (1988) and Dixit (1989). It may not be optimal to reverse an investment decision when sunk or switching costs are present even when prices appear attractive in the short-term (Dixit, 1989). The examination of multinational firms under volatile exchange rates is done by Bell (1995) who combines Dixit's (1989) and Pindyck's (1988) methodology.

The value of the bargaining flexibility in the firm's negotiations with input suppliers is quantified by Kulatilaka and Marks (1988).

The more current studies give special attention to the flexibility to take action in ways that will enhance the value of the option (Kulatilaka and Marks, 1988, Leslie and Michaels, 1997 and McGrath, 1997), or to factors that may decrease the company's flexibility (Trigeorgis, 1996a). The value of the bargaining flexibility in the firm's negotiations with input suppliers is quantified by Kulatilaka and Marks (1988), strategies that increase the value of the firm-specific real options are

[15] In manufacturing, frequently the "perfect competition" assumption is violated in practice, leading to asset markets that are monopolistic or oligopolistic. In valuation terms, this is better addressed by allowing downward sloping demand curves for the underlying assets. These factors are incorporated in the option valuation model presented by Triantis and Hodder (1990). Their model also allows for possibly increasing marginal production costs and includes a capacity constraint and multiple products on the production system.

examined by Leslie and Michaels (1997), and methods to increase the value of collective real options are discussed by McGrath (1997), as well as Leslie and Michaels (1997). The effect of the early strategic investments and competitors' reaction in company's position and flexibility is discussed by Trigeorgis (1996a).

The usefulness of the real options in strategic acquisitions is discussed by Smith and Triantis (1995) who conclude that the long-term acquisition programs can significantly change an acquirer's competitive position through the development of the growth options. The researchers give the examples of the growth options in strategic acquisitions in the computer, airline and publishing industry and they examine possible interactions between the purchasing and the acquired company's growth options. The option pricing models to value start-up ventures are presented by Trigeorgis (1993a) and Willner (1995)[16].

Other applications

Also McConnell and Schallheim (1983) examined real options in leasing contracts, but unlike Copeland and Weston (1982) they analyse lease as a call option. They use Geske (1979) method for valuing the compound options. A unified framework for pricing a wide variety of leasing contracts is developed by Grenadier (1995) who examines the forward leasing case and he addresses options to renew or cancel the lease.

The use of the options pricing theory to value shipping contracts is examined by Bjerksund and Ekern (1995). Interacting real options in a toll road infrastructure project in Australia by Rose (1998). They found that the option to defer accounts for more than half of the market value of the examined company.

Another study finds similarities between the real options literature and share buyback announcements (Ikenberry and Vermaelen, 1996), recognising that managers have the option to wait for more information to arrive before actually deciding to repurchase shares. The study provides evidence from NYSE firms consistent with viewing repurchase programs as exchange options.

[16] The conceptual approaches to value Real Options are provided by Dixit and Pindyck (1994), Trigeorgis (1995), Damodaran (1996) and Copeland and Antikarov (2001). A conceptual approach to value Growth opportunities is also provided by Ottoo (2000). The real option valuation issues are discussed by Brealey and Myers (1991) and Damodaran (2001).

Real options are evidenced among exporting companies. The location, timing, technology and growth option for multinational corporations are described by Baldwin (1986). The effects of volatile exchange rates on the entry, exit and capacity decisions of an exporting monopolist, in a real options perspective is examined by Bell (1995)[17]. He finds that the effects of the volatility generally depend on whether the project is fixed- or variable-scale. For the fixed-scale projects, the volatility raises the minimum exchange rate that supports entry into the foreign market whilst lowers the exchange rate that triggers exit. He concludes that the hysteresis is more significant under the expectations of the volatile exchange rates than under the expectations of certainty. For the variable-scale projects, the volatility also raises the minimum scale of entry but it also raises the minimum exchange rate supporting entry.

Company valuation

More recent researchers give an insight look on applying Option Pricing Models for equity valuation purposes. Their suggestions also facilitate the use of the "real options" in firm valuation.

Fifteen selected American companies in five industries, namely in the electronics, the computers and peripherals, the chemicals, the tires and rubber as well as the food processing sector are examined by Kester (1984). He develops a methodology to estimate the aggregate value of real options of US companies. He assumes discount rates that vary between 15% up to 25% to capitalise the value of the firms' anticipated earnings. The difference between the market value of the equity and the estimated capitalised value is the real options value. He estimates that the value of the growth options of the examined companies is, in most cases, more than half their market equity value. Moreover, he finds that growth options account for 60-80% for firms in more volatile industries (electronics and computers). Similar findings are provided by Ottoo (2000), who examined US companies in the Internet, Biotechnology, Computers, Pharmaceutical, Automotive and Rubber & Tire sector. Another study (Pindyck, 1988) shows that the Growth options represent more than

[17] He extends the model of optimal capacity choice developed by Pindyck (1988) to incorporate exit options and an analysis of hysteresis when the source of uncertainty is exchange rates, rather than the product price

half of the firm value if demand volatility exceeds 20%. Moreover, his model indicates that for many firms, the fraction of market value attributable to the value of capital in place should be one-half or less. Furthermore, this fraction should be smaller the greater is the volatility of market demand. Other researchers show how the option-pricing model can be useful in understanding and analysing troubled firms, natural resource firms and high-technology stocks (Damodaran, 1996). Also, there is some evidence that the real option valuation fits relatively well with market valuation practices in Pharmaceuticals, when projects are in early phase of development (Kellogg, Charnes and Demirer, 1999).

There are also two studies (Howell and Jagle, 1997 and Busby and Pitts, 1997) that provide some evidence that in many cases managers in UK companies use procedures to value real options, although their models in many cases differ from real option models.

2.6 Conclusions

We examined the way real option valuation has been applied in a variety of contexts. Some of these contexts such as land development, acquisitions and natural resource investments are in the core of companies' value, while others help us to evaluate part of the companies' operation in a new, better way. Given that project valuation is closely related with the equity valuation, we will try to investigate whether the real options methodology can be applied for company valuation purposes. Our investigation is facilitated by recent research. Numerous researchers suggest specific ways to recognise most types of the real options for valuation purposes and to estimate the formulated variance. They also provide the empirical methods to estimate the value of the corporate growth options. Moreover, the recent papers show how the option-pricing model can be useful in understanding and analysing troubled firms, natural resource firms and high-technology stocks and suggest pricing formulas to include nontradability and nonobservability.

However, as Myers (1977) recognises, although the real options are superior to naïve DCF approach, in many cases it is difficult to identify and quantify these options. In our research, we will examine four types of real options that are relatively easy to quantify, so as to investigate the use of real options for valuation purposes. In particular we will examine the option to abandon for salvage value, the growth option, the option to default during construction and the option to alter operating scale.

CHAPTER THREE

REAL OPTIONS IN CAPITAL BUDGETING

This chapter examines how the real options might be incorporated in capital budgeting, based on a number of in-depth case studies of real option applications in practice. Although seven major types of real option are discussed in the literature, as shown in Chapter 2, only four of these are commonly found among the firms sampled for the thesis. Therefore, the following examination of real option applications concerns an expansion option (*or simple growth option*), a growth option (*or compounded growth option*), an abandonment option and an option to default. To simplify the examples, we assume in each case that the value of the project follows a multiplicative binomial process[1] over discrete period(s).

3.1 The Option to Expand

Let us suppose that *Hellenic Petroleum S.A.,* a Greek petroleum refinery, has already developed two petroleum refinery units that operate profitably. *Hellenic Petroleum's* managers are considering the case of developing **one more** petroleum refinery unit. Political uncertainty, about the outcome of the forthcoming elections that will take place in 1 month, leads to increasing domestic demand uncertainty.

Let us assume that the management has concluded that there are two possible outcomes:

$S^{+}=u*S$ with probability p

or

$S^{-}=d*S$ with probability 1-p

where

[1] The binomial process is used here as it can be linked with DCF calculation in a way that is straightforward. Although continuous-time modelling expresses the value of real options in a more complete way (because the number of possible outcomes is not small in most real-life projects and the value of the project is usually continuous), it is not suitable for illustrative purposes. Nevertheless, Chapter Four provides a methodology to link discrete-time models with continuous-time formulas.

S^+ is the value of the project in the case where political party A wins the elections (optimistic scenario)

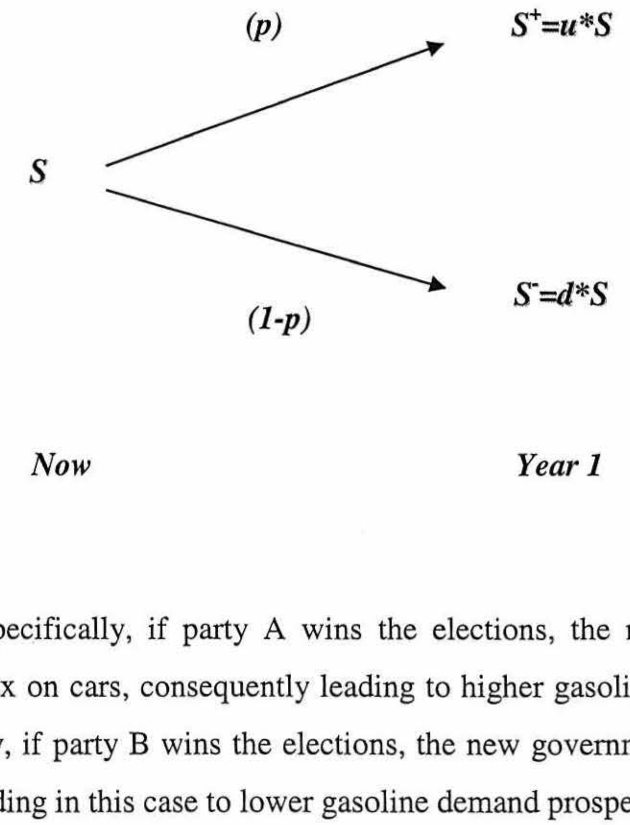
S^- is the value of the project in the case where political party B wins the elections (pessimistic scenario).

u represents upside movement

d represents downside movement

Expressed in mathematical terms, if the current project value is S, the value of the project at the end of the period will be either $u*S$ or $d*S$, as represented in Figure 3.1 below:

Figure 3.1 : Possible outcomes assuming passive management practices

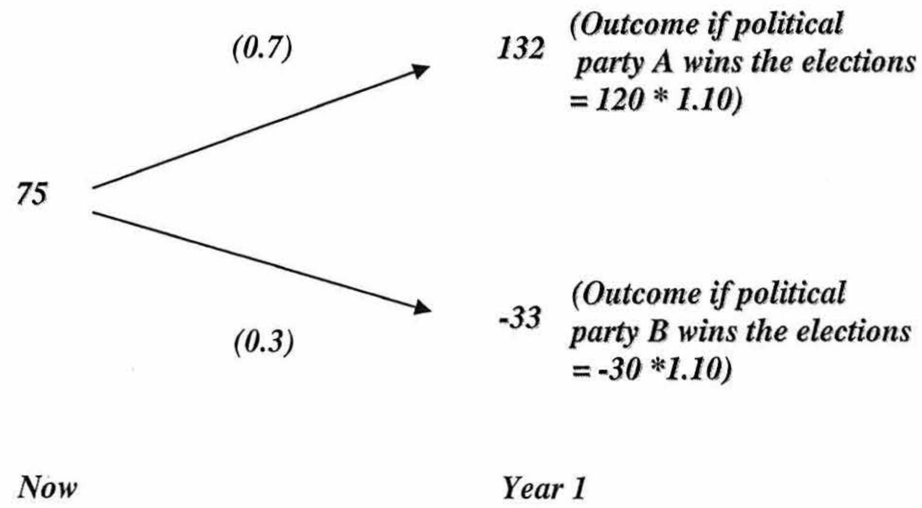


More specifically, if party A wins the elections, the new government will lower import tax on cars, consequently leading to higher gasoline demand prospects. On the contrary, if party B wins the elections, the new government will raise import tax on cars, leading in this case to lower gasoline demand prospects.

Now consider the following estimates. The probability p that party A will win the elections is 70% while the probability $(1-p)$ that party B will win the elections is 30%. If party A wins the election, the present value of a new petroleum refinery unit will amount to Euro 120m. However, if party B wins the election the value of a new petroleum refinery unit will be equal to a deficit of Euro -30m. Finally, the discount rate is assumed to be 10%.

The management has the flexibility to delay the investment decision for a month, so as to invest only if the election outcome is favourable. However, assuming that the company's management does not take advantage of the flexibility to delay its investment decision but decides to invest immediately to develop the new petroleum refinery unit, then the possible payoffs may be expressed as follows:

Figure 3.2: The value of the investment, assuming passive management practices



Using a static NPV approach, the value of the investment will be

$$Static\ NPV = p*S^{+}+(1-p)*S^{-}$$

$$= 70\%*(132/1.1)+30\%*(-33/1.1)$$

$$= 70\%(120)+30\%(-30)=84-9 = Euro\ 75m$$

Although this naïve interpretation of the Net Present Value rule assumes that the management cannot respond to new information in future periods, in practice the management of *Hellenic Petroleum S.A.* has the option (the right, not the obligation) to proceed to the additional investment, if conditions are favourable. Rational management practice implies that, if the outcome of the elections is favourable, then the management will proceed with the investment, otherwise it will not exercise its option and it will let it expire.

In other words, rational option exercise policy implies that the project has two possible values

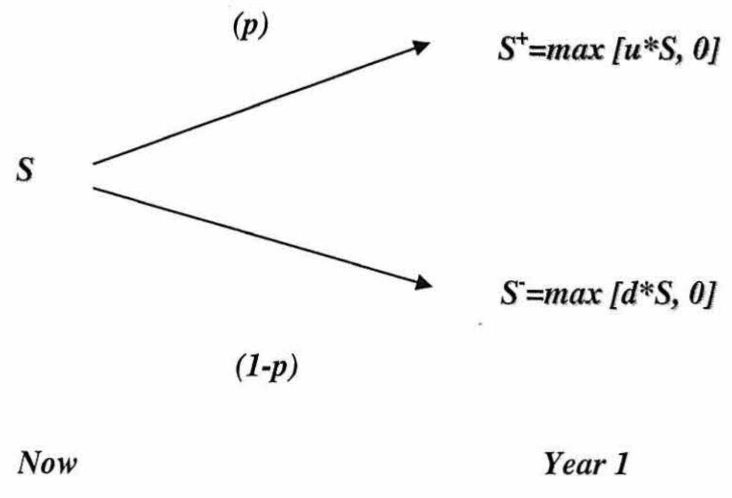
$S^+ = \max [u*S, 0]$ with probability p

or

$S^- = \max [d*S, 0]$ with probability 1-p

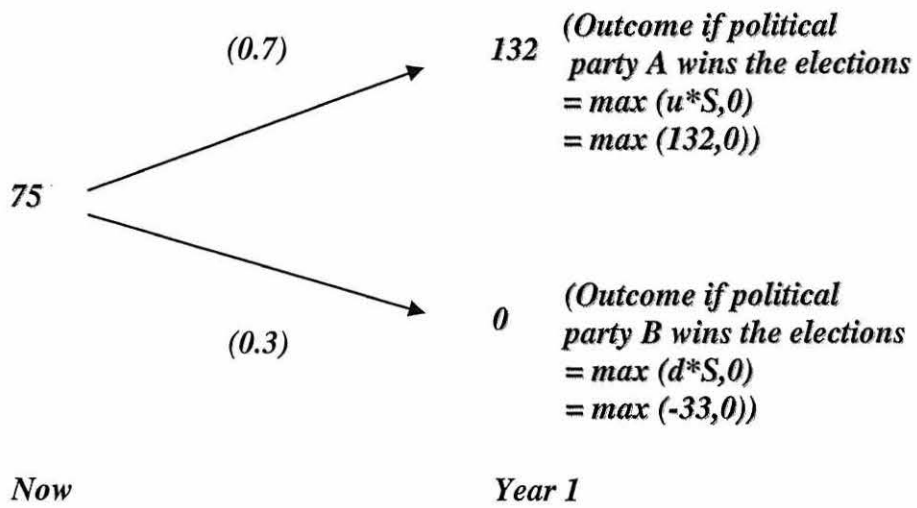
The payoffs may now be expressed as follows:

Figure 3.3: Possible outcomes based on real option theory



In the case of *Hellenic Petroleum*, the following figure (Figure 3.4) shows the possible outcomes under real option theory :

Figure 3.4: The value of the investment under real option theory



In this case, the value of the investment will be

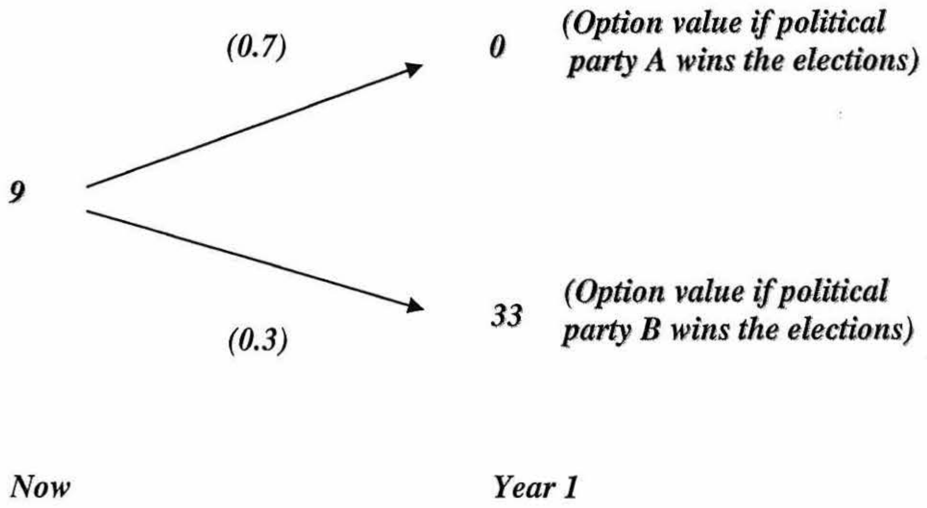
$$
\begin{aligned}
&S = \textit{Static NPV} + \textit{Value of Option to expand} = \\
&= p * S^{+} + (1-p) * S^{-} = p * (max[u * S,0]) + (1-p) * (max[d * S,0]) = \\
&= 70\%(120) + 30\%(0) = 84 - 0 = \textit{Euro 84 mn}
\end{aligned}
$$

Thus, the management's flexibility to proceed or not with the investment has added considerable value to the company's investment opportunity and the value of the project's option to expand can be expressed as

$$
\begin{aligned}
&\textit{Value of Option to expand} \\
&= (\textit{Static NPV} + \textit{Value of Option to expand}) - (\textit{Static NPV}) \\
&= \textit{Euro 84m} - \textit{Euro 75m} = \textit{Euro 9m}
\end{aligned}
$$

The value of the option to expand is also illustrated in Figure 3.5.

Figure 3.5: The value of the option to expand



In mathematical terms, the outcomes in Year 1, expressed in Figure 3.5, can be expressed as

$$\Psi^{+} = max[u*S,0] - u*S = max(132,0) - 132 = 132 - 132 = 0$$

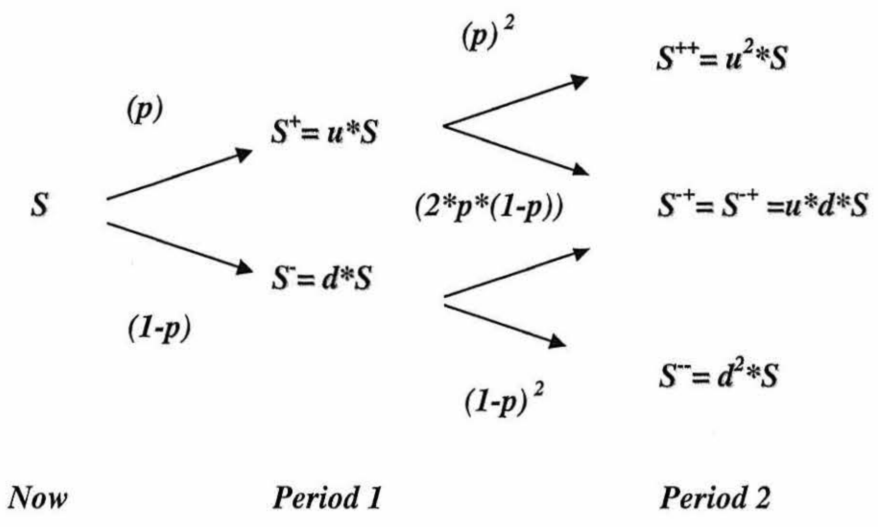
$$\Psi^{-} = max[d*S,0] - d*S = max(-33,0) - (-33) = 0 - (-33) = 33$$

3.2 The Growth Option

To illustrate how to apply real option theory in the case of a growth option, consider an example of a hypothetical, but representative, capital investment. Managers at *Chipima S.A.*, a Greek bagel producing company, are proposing a phased expansion of their manufacturing facilities. They plan to develop a new bagel production unit, the third one, to produce a type of bagel that will serve the German market. The product serves a niche market and it is highly differentiated (wrapping, taste, and size) from other products in the bagel sector.

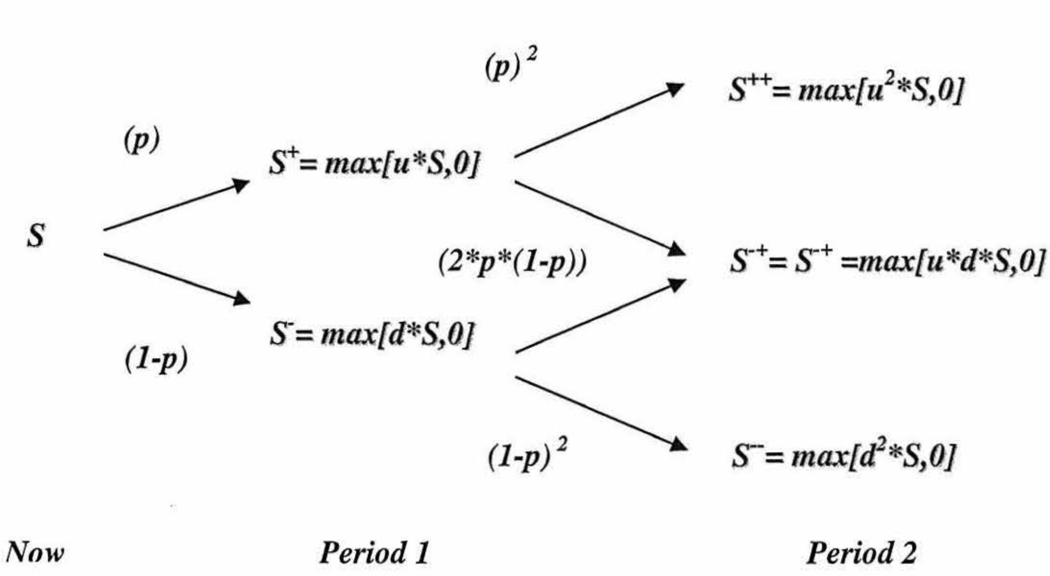
Expressed in mathematical terms, if the current project value is S, the value of the project at the end of the first period *(Phase 1)* will be either $u*S$ or $d*S$, and at the end of the second period *(Phase 2)* will be either u^2*S, $u*d*S$ or d^2*S, as represented in Figure 3.6 below

Figure 3.6 : Two phase investment: Possible outcomes assuming passive management practices



Now we can consider a growth option, with two periods (Phase 1 and Phase 2) before its expiration date. In keeping with the binomial process the project can take on three possible values after two periods, as follows:

Figure 3.7: Project value under real option theory



In our example the expansion of *Chipima* consists of two phases. As shown, the growth option can take on three possible values after two periods, namely Ψ^{++}, Ψ^{+-} or Ψ^{--}

where

Ψ^{++} is the value of the option if the value of the project follows the optimistic scenario

$\Psi^{+-} = \Psi^{-+}$ is the value of the option if the value of the project follows the normal scenario

Ψ^{--} is the value of the option if the value of the project follows the pessimistic scenario

At the end of the first period, there will be one period left (Phase 2) and the option can take on two possible values. Following Cox, Ross and Rubinstein (1979), it can be shown that the possible values of the option at the end of Phase 1 will be respectively

$$\Psi^{+} = \frac{[\,p\Psi^{++} + (1-p)\Psi^{+-}\,]}{1+r}$$

or

$$\Psi^{-} = \frac{[\,p\Psi^{-+} + (1-p)\Psi^{--}\,]}{1+r}$$

where

r is the risk-adjusted discount rate.

From this, Cox, Ross and Rubinstein give the present value of the option as

$$\Psi = \frac{[p^2\Psi^{++} + 2p(1-p)\Psi^{+-} + (1-p)^2\Psi^{--}]}{(1+r)^2} =$$

$$= \frac{[p^2 max[0,\ u^2S - I] + 2p(1-p)max[0,\ d*u*S - I] + (1-p)^2\ max[0,\ d^2S - I]]}{(1+r)^2}$$

where

I is the value of investment

Next, let us assume that the company will spend Euro 1,000m to develop the product and to promote it (Euro 200m in Research and Development expenses and Euro 800m in Advertisement and other promotional expenses in the German market). If demand proves satisfactory, *Chipima* will develop the planned bagel unit (Phase 2), otherwise the company will cover the demand from existing production lines. There are two scenarios, one optimistic where demand is strong and the other pessimistic where demand is weak. Without the second phase, under the optimistic scenario a revenue stream of Euro 500m is projected to start in Year 1 and to grow at 10% p.a. The present value of the project is Euro -240m (see Table 3.1), as shown below.

Table 3.1: Phase 1 - product development

Year	0	1	2	3	4	5
Operating projections						
Revenues		500	550	605	666	732
-Cost of goods sold		250	275	303	333	366
=Gross Profit		250	275	303	333	366
-R&D expenses	200	20	23	26	30	35
-Advert.&Prom.expenses	800	70	77	85	93	102
-Admin & other expenses		30	33	36	40	44
=Operating Profit	-1000	130	142	155	169	185
Free Cash Flow calculation						
EBIT(1-applied tax rate)	-700	91	99	109	118	129
+Depreciation		4	4	4	5	5
-Fixed capital investments		50	51	52	53	54
-Increase in Net Working Capital		75	8	8	9	10
=Free Cash Flow	-700	-30	45	53	61	70
Asset Terminal Value calculation						
Assets' Terminal value						70
Terminal value/(risk premium - growth factor)						700
Discounted Cash Flow calculation						
discount factor 2(risk free int'rate+ risk premium)	1	0.87	0.76	0.658	0.572	0.497
=Present Value of projected cash flows	-700	-26	34	35	35	383
Total Present Value of projected cash flows	-240					

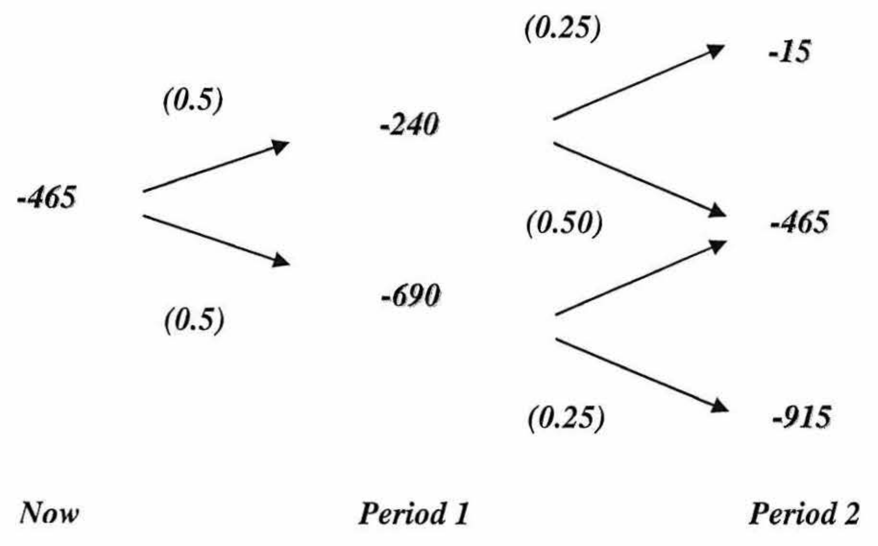
Under the pessimistic scenario, the revenue stream starts at Euro 200m, and the corresponding present value is Euro -690m (see Table 3.2).

Table 3.2: Phase 1 when demand is weak

Year	0	1	2	3	4	5
Operating projections						
Revenues		200	220	242	266	293
-Cost of goods sold		100	110	121	133	146
=Gross Profit		100	110	121	133	146
-R&D expenses	200	20	23	26	30	35
-Advert.& Prom.expenses	800	25	28	30	33	37
-Admin & other expenses		28	31	34	37	41
=Operating Profit	-1000	27	29	30	32	34
Free Cash Flow calculation						
EBIT(1-applied tax rate)	-700	19	20	21	22	24
+Depreciation		4	4	6	7	7
-Fixed capital investments		20	20	21	21	22
-Increase in Net Working Capital		30	3	3	4	4
=Free Cash Flow	-700	-27	1	4	4	5
Asset Terminal Value calculation						
Assets' Terminal value						5
Terminal value/(risk premium - growth factor)						52
Discounted Cash Flow calculation						
discount factor 2(risk free int.rate+ risk premium)	1	0.87	0.76	0.658	0.572	0.497
=Present Value of projected cash flows	-700	-24	1	2	3	28
Total Present Value of projected cash flows	-690					

During the first phase, the path the project may follow and the corresponding probabilities are set out in Figure 3.8.

Figure 3.8: Possible outcomes of Phase 1 (development of a product)



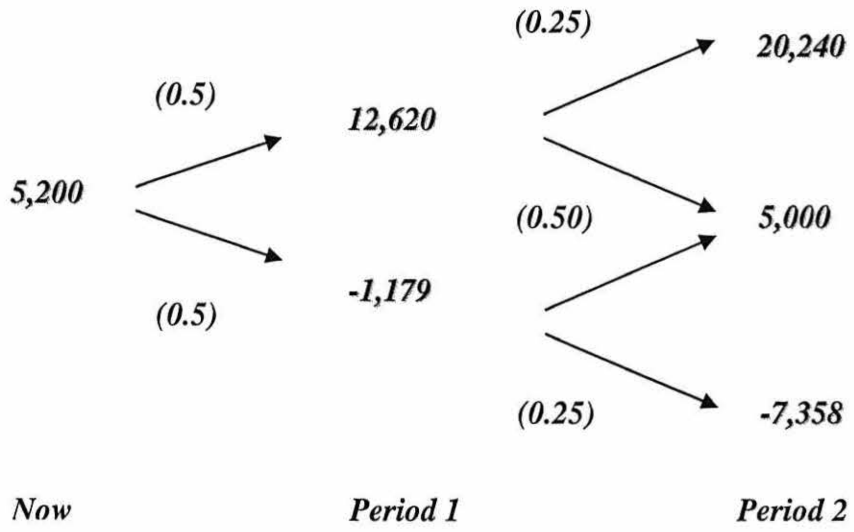
The market research on the German market indicates that if Phase 1 is successful, the expected product sales in the German market will reach Euro 5,000m by year 3. Allowing also for growth at 10%, the NPV of Phase 2 can be estimated at 12,620m (see Table 3.3).

Table 3.3: Phase 2- the option to produce and promote a product

Year	0	1	2	3	4	5
Operating projections						
Revenues				5,000	5,500	6,050
-Cost of goods sold				2,500	2,750	3,025
=Gross Profit				2,500	2,750	3,025
-R&D expenses				0	0	0
-Advert. &Prom. Expenses				0	0	0
-Admin'& other expenses				0	0	0
=Operating Profit				2,500	2,750	3,025
Free Cash Flow calculation						
EBIT(1-applied tax rate)				1,750	1,925	2,118
+Depreciation				505	530	557
-Fixed capital investments				5,000	100	102
-Increase in Net Working Capital				750	75	83
=Free Cash Flow				-3,495	2,280	2,490
Asset Terminal Value calculation						
Assets' Terminal value						2,490
Terminal value/(risk premium - growth factor)						24,900
Discounted Cash Flow calculation						
Discount factor 2 (risk free int. rate+ risk premium)	1	0.87	0.76	0.658	0.572	0.497
=Present Value of projected cash flows	0	0	0	-2,298	1,300	13,618
Total Present Value of projected cash flows	12,620					

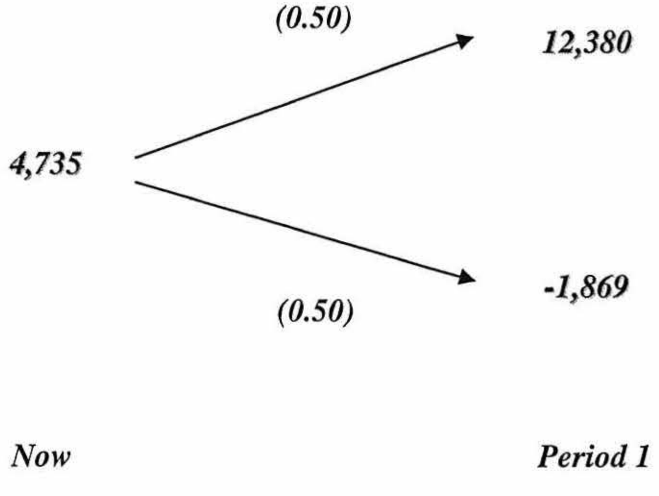
Illustrating all possible scenarios, the Phase 2 investment can take on two possible values after one period and three possible values after two periods. That is, with 50% probabilities of upside and downside movements, the present values of the project at the end of Period 1 are either 12,620 or -1,179, and they are either 20,240, 5,000 or -7,358 at the end of Period 2, under the scenarios described in the tables above. The present value of these possible outcomes is 5,200, as shown below in Figure 3.9.

Figure 3.9: Possible outcomes of Phase 2 investment (production and promotion of a product) assuming passive management practices



The summation of the value of both Phase 1 and Phase 2 investments that were separately illustrated in Figure 3.8 and Figure 3.9 is as follows:

Figure 3.10: Possible outcomes of Phase 1 & Phase 2 assuming passive management practices



Note that, if the company develops the unit even though demand is weak, it will suffer additional losses, leading to a value at the end of Period 1 of -1,869. This is expressed in a more detailed way in Table 3.4, below.

Table 3.4: DCF calculation under passive management (no real options)

Year	0	1	2	3	4	5
Operating projections						
Revenues		200	220	242	266	293
-Cost of goods sold		100	110	169	186	205
=Gross Profit		100	110	73	80	88
-R&D expenses	200	20	23	26	30	35
-Advert.&Prom.expenses	800	70	77	85	93	102
-Admin & other expenses		30	33	36	40	44
=Operating Profit	-1000	-20	-23	-75	-84	-94
Free Cash Flow calculation						
EBIT(1-applied tax rate)	-700	-14	-16	-52	-59	-65
+Depreciation		4	4	510	535	562
-Fixed capital investments		50	51	5,052	153	156
-Increase in Net Working Capital		75	3	3	4	4
=Free Cash Flow	-700	-135	-66	-4,598	320	336
Asset Terminal Value calculation						
Assets' Terminal value						336
Terminal value/(risk premium - growth factor)						3,363
Discounted Cash Flow calculation						
discount factor 2(risk free int'rate+ risk premium)	1	0.87	0.76	0.658	0.572	0.497
=Present Value of projected cash flows	-700	-117	-50	-3,023	183	1,839
Total Present Value of projected cash flows	-1,869					

To summarise, the outcome of Phase 1 gives us the information that is needed to estimate the outcome of Phase 2 with certainty. To express this in mathematical terms, where the probability ***p*** of successful introduction of Phase 1 on the German market is 50% whilst the probability ***(1-p)*** of unsuccessful introduction is 50%, then the certainty equivalent value of the investment will be

Static NPV

= p [NPV (successful phase 1) +NPV (successful phase 2)]

+(1-p) [NPV (unsuccessful phase 1) +NPV (unsuccessful phase 2)]

= 50%(-240+12,620) + 50%(-690-1,179)

= 50%(12,380) + 50%(-1,869)

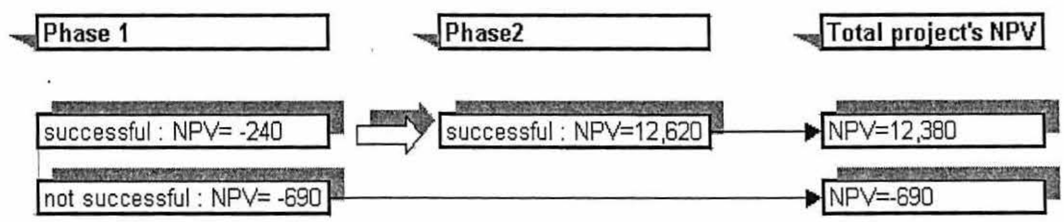
= Euro 4,735m

The above shows that the combined implementation of Phase 1 and Phase 2 investments is profitable (Euro 4,735m), given the assumption that the management will proceed to these investments irrespective of the information revealed after the implementation of Phase 1 investment. This contrasts with the initial naïve NPV analysis, which implied that Phase 1 should be rejected because the Net Present Value was negative (Euro -240m). However, as shown below, the real option approach will lead to a third solution.

Rational investment policy implies that the market information revealed during Period 1 gives *Chipima's* management the flexibility to proceed (or not) to Phase 2 investment under the light of information that becomes available during Period 1. If conditions in Period 1 are favourable, the management will exercise the right to develop an additional bagel chip production line, to increase[2] company value by Euro 12,384m because Phase 2 investment will add Euro 12,620m value. On the contrary, if demand proves to be weak (the pessimistic scenario), and in the light of information revealed after the implementation of Phase 1 investment, the company will not develop the new production line in Phase 2. It will lose Euro 690m, as shown in Table 3.2, instead of losing the Euro 1,869m shown in Table 3.4.

The contribution of Phase 1 and Phase 2 investment to company value under these two scenarios is illustrated in the following Figure:

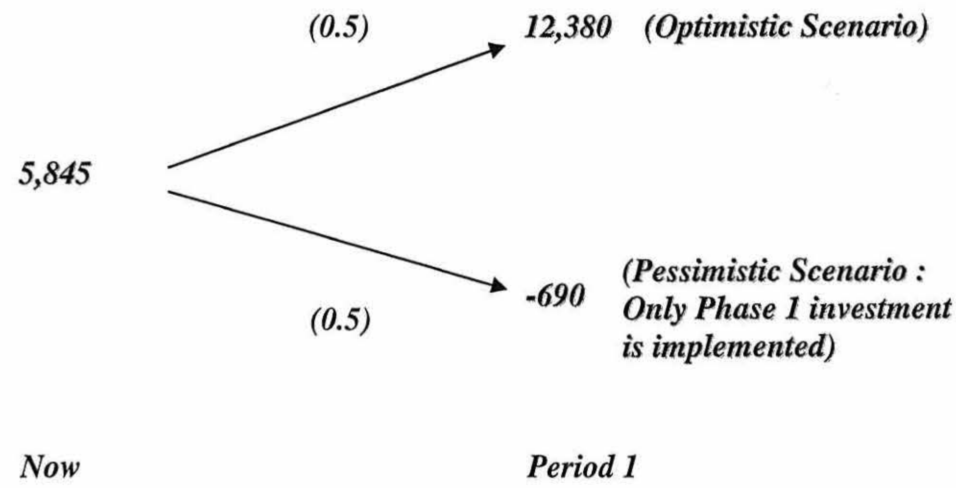
Figure 3.11 : Investment value from Phase 1 to Phase 2



As a result, the project path will lead to the following two outcomes:

[2] We use the methodology applied by Mills (1994), Damodaran (1996), Damodaran (2001) and Copeland and Antikarov (2001) to obtain NPV.

Figure 3.12: Investment value under real option theory



Expressed in mathematical terms, the value of the investment will be

Expanded NPV = Static NPV + Growth option value

= p (NPV(successful phase 1) + NPV(successful phase 2))

+ (1-p) (NPV(unsuccessful phase 1))

= 50%(-240+12,620) + 50%(-690) = 50%(12,380)+50%(-690)

= Euro 5,845m

Therefore, the management's flexibility to proceed or not to Phase 2 investment (i.e., its growth option) has added considerable value to the company. By deduction, the value of the project's growth option will be

Growth option value =Expanded NPV- Static NPV

= Euro 5,845m – Euro 4,735m

= Euro 1,110m

3.3 The Option to Abandon

During the life of a project, management may find it desirable to abandon a project temporarily whenever operating costs exceed operating revenues. Moreover, the management may abandon a project permanently for its salvage value to direct proceeds to more profitable activities, or to mitigate losses.

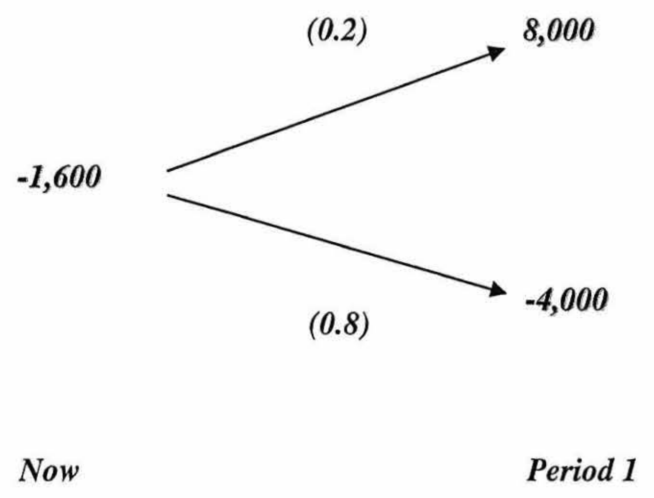
The option to abandon a project is valued as an American put option on current project value. The exercise price of the option to abandon is the project's salvage value.

To illustrate, let's assume *Chipima* has not only profitable bagel chips production lines, as described above, but also a unit producing bread rolls for hamburgers. Since the bread production unit is not profitable, *Chipima* examines the possibility of selling it. In other words, *Chipima* has a certain option: to retain the bread production unit in operation or to abandon the unit for its salvage value.

Luckily, the bread production unit could be useful to *Goomy Catering S.A.*, a subsidiary of a fast-food chain that plans to develop a similar production line to support its customers, including its 50 privately owned fast-food restaurants. The bread production line is built on a piece of land that is in a commercial area, and the proceeds from the sale of the unit are expected to be Euro 6,000m. Moreover, if the sale takes place, *Chipima* is expected to have Euro 2,000m extraordinary gains.

Before examining the value of the option to abandon, the value of the project may be calculated according using the decision tree approach. The market value of a profitably operating unit is 8,000, but *Chipima* has only a 20% probability of achieving this optimistic outcome, whilst there is 80% probability of the pessimistic scenario of unprofitable operations valued at -4,000. Naïve interpretation of the NPV rule (i.e. assumption of passive management practices) implies that the value of the project is Euro -1,600m, as shown below in Figure 3.13.

Figure 3.13 : The unprofitable production line: Possible outcome assuming passive management practices



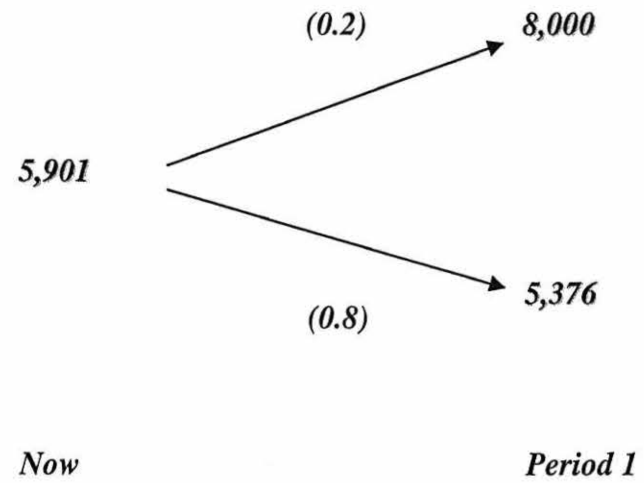
Next, in order to examine the option to abandon for salvage value, we assume for simplicity that if *Chipima* retains the bread production unit the NPV will be Euro 2,000m. As shown below, if *Chipima* exercises the abandonment option by selling it to *Goomy*, there will be a positive effect on Net Working Capital of +4,000m, and the NPV of the sale is therefore Euro 5,376m, as demonstrated below in Table 3.5.

Table 3.5 : The liquidation value of the production unit.

Free Cash Flow calculation	
Non Operating Profit	2,000
Non Operating profit (1- 20% tax rate on non-operating profits)	1,600
Change in Net Working Capital	4,000
=Free Cash Flow	5,600
Discounted Cash Flow calculation	
discount factor (risk free int.rate*months/12)	0.96
=Present Value of projected cash flows	5,376
Total Present Value of projected cash flows	5,376

The management's flexibility to exercise the option to abandon raises the value of the production unit, and the projected outcomes will be as follows:

Figure 3.14 : Possible outcome of Chipima's bread production line according to Real Option Theory



Therefore, the value of the abandonment option will be

Abandonment option value
= Expanded NPV - Static NPV
= Euro 5,901m - (- Euro 1,600m)
= Euro 7,501m

3.4 The Option to Default

So far we have dealt with real options assuming an all-equity firm. If we allow for debt financing, then the value of the project to equity-holders can improve by the additional amount of financial flexibility. In particular, shareholders have the option to expropriate wealth from bondholders by pursuing riskier projects that increase the variance in the firm value, leading to an increase in the value of equity.

According to Vila and Schary (1995), from the shareholders' view, equity is seen as a call option on the value of the firm's assets, as equity-holders have the option to acquire the firm value by paying back the debt. In the example below, the option to default is valued as an option on the current value of the firm, with exercise price equal to the difference between liquidation value and debt obligations.

To illustrate how to apply the option to default, we examine *Disdress S.A.*, a Greek textile company which has outstanding debt of Euro 1,200m. The asset value of the company is Euro 875m, which is lower than the face value of its outstanding debt[3], as shown below in Table 3.6.

Table 3.6 : Asset value calculation of a company in distress

Year	0	1	2	3	4	5
Operating projections						
Revenues		1,000	1,100	1,210	1,331	1,461
.-Cost of goods sold		700	770	847	932	1,025
.=Gross Profit		300	330	363	399	439
.-R&D expenses		20	23	26	30	35
.-Advert.&Prom.expenses		70	77	85	93	102
.-Admin.& other expenses		30	33	36	40	44
.=Operating Profit		180	197	216	236	258
Free Cash Flow calculation						
EBIT(1-applied tax rate)		126	138	151	165	180
.+Depreciation		4	4	10	10	11
.-Fixed capital investments		50	51	52	53	54
.-Increase in Net Working Capital		14	15	17	18	20
.=Free Cash Flow		66	76	92	104	117
Asset Terminal Value calculation						
Assets' Terminal value						117
Terminal value/(risk premium - growth factor)						1,170
Discounted Cash Flow calculation						
Discount factor 2(risk free int.rate+ risk premium)	1	0.87	0.76	0.658	0.572	0.497
.=Present Value of projected cash flows	0	58	58	60	59	640
Total Present Value of projected cash flows	875					

Given the above, the naïve application of the NPV rule implies that the equity value is negative:

Market Value (Equity)

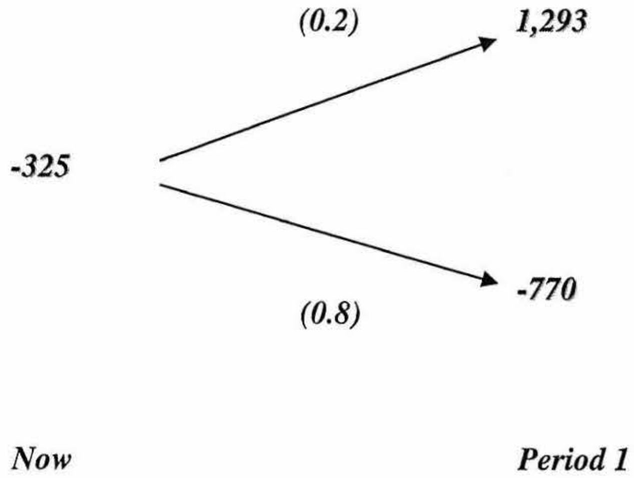
= Market Value (Assets)- Market Value (Debt)

= Euro 875m - Euro 1,200m = - Euro 325m

[3] We assume, for simplicity, the market value equals the face value of outstanding debt

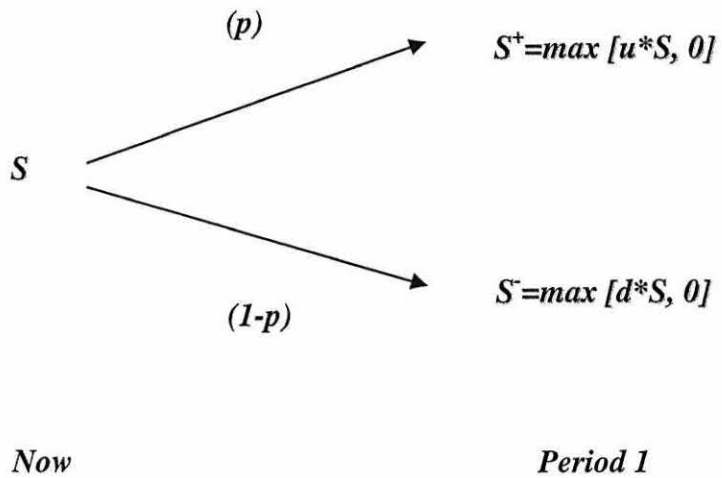
Applying the decision tree approach, Figure 3.15 shows the value of equity, based on naïve NPV assumptions, if there is 80% probability of a pessimistic outcome and 20% probability of an optimistic outcome.

Figure 3.15: Equity value assuming passive management practices



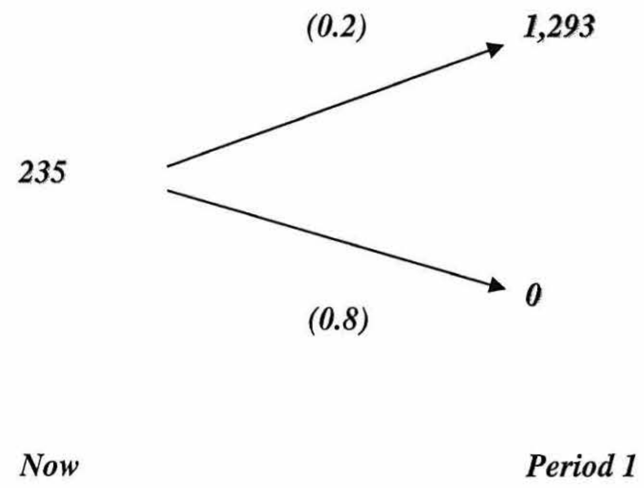
In practice, however, the liability of shareholders is limited. In the case of default, the company's value cannot become negative from the shareholders' point of view. Applying real option theory, the possible outcomes are defined as:

Figure 3.16: Possible outcomes under real option theory



That is, in our example, the company's value can be expressed as follows.

Figure 3.17: Equity value under real option theory



Consequently, the value of the option to default can be written in mathematical terms as

Option to Default
= Expanded NPV – Static NPV
= Euro 235m - (- Euro 325m)
= Euro 560m

3.5 Summary

It has been shown above that the naïve DCF approach does not take account of management's flexibility arising from potential project growth, the possibility to abandon projects, and the opportunity to take on riskier projects that raise equity-holders' value. In the latter case, such flexibility explains why financially distressed firms have a positive value on stock exchanges.

In the examples given above, by way of a practical introduction to this thesis, the use of real options in capital budgeting has been illustrated by a number of case studies. The following chapter goes on to describe the major theoretical developments in the area.

CHAPTER FOUR
REAL OPTION THEORY

Whilst the previous chapter illustrated the use of real options in capital budgeting, this chapter presents the theoretical developments in real option pricing.

In practice, valuation of financial options provided a theoretical background for the development of real option valuation. Thus, lately, real option formulas are frequently the development of mathematical formulas for financial options. In many cases the theories developed are based on different assumptions regarding the distribution function of the underlying asset and the critical factors to determine real option value. Some researchers, especially in early studies, examine the value of real option in the light of the incremental investment decision. Others developed heuristic approaches.

4.1 Mathematical foundations in option pricing

The breakthrough in option pricing theory came with the Black and Scholes paper in 1973 which shows that options could be priced by constructing a risk-free hedge by dynamically managing a simple portfolio consisting of the underlying asset and cash. The formula that evaluated European stock options on a share that does not pay dividends was extended by Merton (1973) to allow for an option on shares that distribute a known dividend yield and by Black (1976) to price European options when the underlying security is a forward or futures contract.

The mentioned formulas were based on the assumption that the underlying asset is lognormally distributed (i.e. it follows a geometric Brownian motion-Wiener process[1]). The Wiener process can easily be generalised into more complex processes.

[1] The Wiener process-also called a Brownian motion-is a continuous time process with three important properties. First, it is a Markov process, so its probability distribution for all future values of the process depends only on its current value. Second, the process has independent increments. This means that the probability distribution for the change in the process over any time interval is independent of any other time interval. Third, changes in the process over any finite interval of time are normally distributed, with a variance that increases linearly with the time interval. The Markov property, assumed by the Brownian motion, implies that the weak form of market efficiency holds.

The simplest generalisation is the Brownian motion with drift. When the drift and variance coefficients are functions of the current state and time, the continuous-time stochastic process is called an Ito process. In case the price is somehow related to long-run marginal costs, as in the case of raw commodities, the price should be modelled as a mean-reverting process. Also often it is realistic to model an economic variable as a process that makes infrequent but discrete jumps. A Poisson (jump) process is a process subject to jumps of fixed or random size, for which the arrival times follow a Poisson distribution. Nevertheless, the valuation of options on assets that are assumed to follow stochastic processes other than Brownian motion has received less attention by practitioners because the additional accuracy offered by several of these models is outweighed by the complexity of estimating the additional parameters required. A model that assumes that the underlying asset follows a jump-diffusion process was developed three years after the development of the Black-Scholes formula by Merton (1976). However, the model requires two additional parameters to be estimated, namely the expected number of jumps per year and the percentage of the total volatility explained by the jumps.

Later on, attention was paid to the development of the formulas that value American options. The valuation of an American call option on a stock paying a single dividend with given time to dividend payout was developed by Roll (1977), Geske (1979) and Whaley (1981). A compound option approximation approach to value analytically an American put option on stock paying cash dividends was developed by Geske and Johnson (1984). The quadratic approximation method was used later to value American call and put options on an underlying asset with given cost of carry (Barone-Adesi and Whaley ,1987). When the cost of carry rate exceeds the risk-free rate, the American call value is found to be equal to the European call value. An analytical method, based on an exercise strategy corresponding to a flat boundary, to price American options on stocks, futures and currencies is used by Bjerksund and Stensland (1993). The model presented by Bjerksund and Stensland (1993) is claimed by Haug (1998) to be somewhat more accurate for long-term options than the model developed by Barone-Adesi and Whaley (1987). All the mentioned models are one-factor models. However, there is some concern that the one-factor models tend to misprice options on commodity prices in the long-run, while the three-factor models do not (see Hilliard and Reis ,1998).

The three-factor models for pricing options on commodity prices were deployed by Miltersen and Schwartz (1997) and Hilliard and Reis (1998). The model assumes stochastic futures prices, term structure of convenience yields and interest rates[2].

Furthermore, in many real-option applications the underlying "asset" is rarely traded in anything approximating a continuous market and its price therefore is not continuous either. For that reason, Merton (1998) suggested an extended Black-Scholes option-pricing framework to include non-tradability and non-observability.

These studies valuate simple options[3]. However, in practice more complex options are evident. Other papers fill that valuation gap by developing the framework to analyse the options to switch among various uses, growth options and combinations. The valuation of an option to exchange one risky asset for another[4] has been the first serious attempt to value these types of options (Margrabe, 1978). The valuation of an option to acquire another option, important to value both timing options and growth options, was developed by Geske (1979). More recent researchers focused their interest to value options on the maximum of other assets, or to value exchange options. The pricing formulas of the European options on the maximum or the minimum of two risky assets was introduced by Stultz (1982), while options on the maximum of several risky assets were analysed by Johnson (1987). The valuation of the option to acquire another option to exchange the underlying asset for another alternative asset by Carr (1988) has been useful to value timing options and options to default. Kulatilaka (1988) and Kulatilaka (1993) provide an equivalent formulation for the real option to switch among operating modes. Although analytical formulas provide certain advantages, their usefulness is restricted by the deficiencies that relate to their statistical assumptions (see Trigeorgis (1995) for discussion). Multinomial models, decision tree analysis and Monte Carlo simulation provide useful alternatives.

[2] The formulas assume lognormally distributed commodity prices, and normal distributed (Gaussian) continuously compounded forward interest rates, and future convenience yields.

[3] A simple type of option in the area of real options is the option to expand

[4] It is useful to value abandonment options and options to default

Multinomial models

The simplest types of multinomial models are the binomial ones. The binomial method was introduced by Cox, Ross and Rubinstein (1979) and Rendleman and Bartter (1979), who show how to construct a recombining tree that uses the geometric Brownian motion in discrete stages. If we assume a very large number of steps a binomial tree is equivalent to the continuous-time Black-Scholes formula when pricing European options. Trinomial trees in option pricing are introduced relatively early by Boyle (1986). The trinomial trees can be used to price both European and American options on a single asset. The lattice binomial approach developed by Cox, Ross and Rubinstein (1979) can be extended to handle two state variables (see Boyle, 1988). When there is a series of exercise prices, nonproportional dividends and interactions among a variety of options imbedded in a single underlying asset, then a log-transformed variation of the binomial option pricing method is useful and efficient (Trigeorgis, 1991). A three-dimensional binomial model that can be used to price most types of options that depend on two assets, both European and American is constructed by Rubinstein (1994b)[5].

Monte Carlo simulation

The Monte Carlo simulation in option pricing was introduced by Boyle (1977). The numerical method developed can be used to value most types of European options. The Monte Carlo simulation can be used also to price American options (Barraquand and Martineau, 1995). The main drawback of the Monte Carlo simulation is that it is computer-intensive.

The replication of an option from an equivalent portfolio of traded securities has facilitated the valuation of options in practice. The risk-neutral valuation presented by Cox and Ross (1976) enables the replacement of actual probabilities by risk neutral ones and therefore established present value discounting at the risk free rate of expected future payoffs. Another piece of research showed that standard option

[5] Recent research pays attention also to the development of implied tree models. The implied tree models use information from liquid traded options with different strikes and maturities to build an arbitrage-free model that contains all the information given by market prices (see Rubinstein, 1994a and Dupire, 1994).

pricing formulas can be derived by risk aversion and proved that continuous trading or risk neutrality are not necessary to enable a risk free hedge (Rubinstein ,1976).

If the underlying asset is traded in futures markets, though, this return shortfall or rate of foregone earnings can be easily derived from the futures prices of contracts with different maturities (Brennan and Schwartz, 1985).

To estimate that particular rate of foregone earnings when the underlying asset is a commodity, McDonald and Siegel (1985b) use a market equilibrium model. However, if the underlying asset is not traded, as in many cases in capital budgeting-associated options, its growth rate may actually fall below the equilibrium expected return required. In that case, the equilibrium rate necessitates an adjustment in option valuation discussed in McDonald and Siegel (1984) and McDonald and Siegel (1985).

Other researchers extend the previous discussion and they argued that any contingent claim on an asset (or any active production process) could be priced by replacing its actual growth rate with a certainty equivalent rate, which does not explicitly involve preferences (Cox, Ingersoll and Ross, 1985). Similarly, Trigeorgis (1993a) points out that since in capital budgeting we are interested in determining what the project cash flows would be worth if they were traded in the market, real options may, in principle, be valued similarly to financial options. He derives certainty-equivalent discount rates for the decision tree analysis of the real options.

4.2 Discrete-time models

Introduction: An all-equity financed project

In discrete time processes, the values of the variables can change only at discrete points of time. Suppose a company invests an amount $\boldsymbol{I}$ for the complete construction of a plant with gross project value $\boldsymbol{V}$ and the price of the plant's "twin security" $\boldsymbol{SP}$ that is traded in the financial markets moves over the next year, following a multiplicative binomial process, each period either increasing by a multiplicative factor u or falling to d of its earlier stage.

Lets assume both the project and the twin security have an expected rate of return (or discount rate) $\boldsymbol{r_k}$, expressed by the equation

$$r_k = \frac{E_0\left[SP_1\right]}{SP} = \frac{[pSP^{+} + (1-p)SP^{-}]}{SP_0} \tag{4.1}$$

where

$E_0[SP_1]$ is the expected value of security SP at time 1

SP_o is the value of security SP at time 0

SP^+ is the price of SP if the upside change takes place

SP^- is the price of SP if the downside change takes place

p is the probability of upside change

$(1-p)$ is the probability of downside change

Then, according to DCF techniques, ***the project's value*** is

$$V_p = V_0 - I \tag{4.2}$$

where

$$V_o = \frac{E_0[V_1]}{(1+r_k)} = \frac{[pV^{+} + (1-p)V^{-}]}{(1+r_k)} \tag{4.3}$$

given that

I is the amount of investment

$E_0[V_1]$ is the expected gross value of the project at time 1

V_o is the gross value of the project at time 0

p is the probability of upside change in V

r_k is the expected rate of return

If $I>V$, then $V_p<0$, and the naïve interpretation of the DCF approach suggests that management should reject the project. However, if managerial flexibility or various kinds of operating options are present, the investment in the plant may become economically desirable even if the project's static NPV is negative. The formulas 4.1, 4.2 and 4.3 were developed by Cox, Ross and Rubinstein (1979) and are used by Trigeorgis and Mason (1987).

The value of the opportunity to start construction on a new plant, ***E***, will move in a perfectly correlated manner with the movements in ***V*** or ***SP***.

Borrowing and the value of the investment

The company's management would construct a portfolio consisting of ***N*** shares of the twin security ***SP*** partly financed by borrowing of amount ***B*** at the rate ***r***. This portfolio can be chosen in a way that it will exactly replicate the opportunity to build a new plant, independently of whether the project does well (SP^+) or poorly (SP^-).

If the portfolio can be specified precisely (in particular, if we specify what percentage of shares is financed by borrowing), then the investment opportunity, Ψ, will have the same value as the equivalent portfolio or else profitable arbitrage opportunities will be evident. If we borrow an amount ***B*** of debt to buy ***N*** securities ***SP***, then the value of investment opportunity will be

$$\Psi = N\,SP - B$$

If the project goes well, then the value of the opportunity will be

$$\Psi^+ = N\,SP^+ - (1+r)B$$

otherwise it will be

$$\Psi^- = N\,SP^- - (1+r)B$$

Treating the conditions of equal payoffs as equations, it follows that

$$N = \frac{(\Psi^{+} - \Psi^{-})}{(SP^{+} - SP^{-})}$$

and

$$B = \frac{[\Psi^{+} SP^{-} - \Psi^{-} SP^{+}]}{(SP^{+} - SP^{-})}(1+r)$$

where

N is the number of borrowed securities SP

B is the borrowed amount

Consequently, the management can replicate the payoff to the new investment opportunity by purchasing N shares of SP and financing the purchase in part by borrowing an amount B at risk-free rate r.

The present value of the opportunity is given then by

$$\Psi = \frac{[p' \Psi^{+} + (1 - p')\Psi^{-}]}{(1+r)} \qquad (4.4)$$

where

p' is the «risk-neutral» probability that allows expected values to be discounted at the risk-free rate,

and it is expressed by the equation

$$p' = \frac{[(1 + r)SP - SP^{-}]}{(SP^{+} - SP^{-})}$$

A market utility approach provides more general versions of decision analysis for determining the market value of real options with different risk structures, other than risk neutrality. Kasanen and Trigeorgis (1995) develop this approach.

The use of Bellman equation of dynamic programming is also used to value investment opportunities by Kulatilaka (1993), Kulatilaka (1995a), and Kulatilaka (1995b). Kulatilaka (1995a) uses the concept of a "mode of operation". She values the "time- to- build option" the abandonment option and the shutdown option. In another study, Kulatilaka (1995b) uses the same concept and simulation to evaluate the "wait-to-invest" option, the option to shutdown, and the option to expand.

The option to abandon

The management's flexibility to abandon a project for its salvage value translates into the equity holders' flexibility to choose the maximum of the project's value in its present use, *V*, or its salvage value *A*.

In other words, it holds, in general

$$\Psi = max(V, A)$$

and is expressed for two possible outcomes (upside and downside outcome) as

$$\Psi^{+} = max(V^{+}, A^{+}),$$

and

$$\Psi^{-} = max(V^{-}, A^{-})$$

where

Ψ is the expected gross value of the project in general, Ψ^{+} if the upside outcome takes place, Ψ^{-} if the downside outcome takes place

V is the project's gross value in its present use

A is the project's gross abandonment value

The summation of the project's static NPV and of the option to abandon is

$$\Psi_0 = \frac{[p'\Psi^{+} + (1 - p')\Psi^{-}]}{(1 + r)} - I_0 \qquad (4.5)$$

where

p' is the certainty equivalent possibility to increase value

I_0 is the amount of investment

r is the risk-free rate

The value of the option to abandon is

$$P = \Psi_0 - V = \frac{[p'\Psi^+ + (1-p')\Psi^-]}{(1+r)} - \frac{[pV^+ + (1-p)V^-]}{(1+r_k)} \qquad (4.6)$$

where

P is the value of the option to abandon

r_k is the project's expected rate of return

V^+ is the project's value if the upside change takes place, V^- if the downside change takes place

The formula 4.6 developed by Brealey and Myers (1991), is used by Trigeorgis (1993a) and Trigeorgis (1996a). Also, a link of formula 4.6 with residual income valuation is developed by Stark (2000).

The option to default

If part (I_o^D) of the initial investment is debt financed and will be repaid in n years, equity-holders have an option to acquire the project's value V by paying back the debt (with interest) at exercise price, at time 1. Thus at time 1, equity-holders will pay back what they owe to debt-holders only if the project's value exceeds the promised payment, otherwise they will default. In other words, the investment's value will be

$$\Psi_n = max(V - D, 0) \qquad (4.7)$$

where

D is the invested amount, partly debt financed

The summation of the project's static NPV and of the option to default is

$$\Psi_0 = \frac{[p'\Psi^+ + (1-p')\Psi^-]}{(1+r)} - (I_o - I_o^{\,D}) \tag{4.8}$$

where

$\Psi^+ = max(V^+ - D,0)$

$\Psi^- = max(V^- - D,0)$

I_o is the initial investment

I_o^D is the part of the initial investment which is debt financed

The value of the option to default is

$$\Psi_0 = \frac{[p'\Psi^+ + (1-p')\Psi^-]}{(1+r)} - (I_0 - I_0^{\,D}) - \frac{[pV^+ + (1-p)V^-]}{(1+r_k)} + I_0$$

$$= \frac{[p'\Psi^+ + (1-p')\Psi^-]}{(1+r)} - I_0^{\,D} - \frac{[pV^+ + (1-p)V^-]}{(1+r_k)} \tag{4.9}$$

where

n is the number of years the debt will be repaid

p is the probability of V to rise in the examined period

p' is the «risk-neutral» probability that allows expected values to be discounted at the risk-free rate,

Trigeorgis (1993a) develops equations 4.7, 4.8 and 4.9 and provides their proof. Also, a lattice binomial approach to handle the situation in which the payoff from the option depends on more than one state variable was developed by Boyle (1988), who extended equations 4.1, 4.2 and 4.3.

Formulas 4.7 and 4.8 in conjunction with Monte Carlo simulation are utilised by Schwartz and Moon (2000) to value an Internet company.

The option to expand

The management may have the flexibility to alter an existing project in various ways at different times during its life. To illustrate, suppose the management has the option to invest an additional I', at time 1 after the initial investment that would increase the scale and value of the project by a times the value of the initial project. Then, in year n', management has the option either to maintain the same scale of operation or to increase a times the scale and receive $(a+1)$ times the project value by paying the additional cost.

In this case,

For a>0,

$$\Psi = max(V,(a+1)V - I') = V + max(aV - I',0) \tag{4.10}$$

so that

$$\Psi^+ = max(V^+,(a+1)V^+ - I')$$

and

$$\Psi^- = max(V^-,(a+1)V^- - I')$$

Consequently, management will exercise its option to expand if market conditions are favourable, otherwise it will let the option expire unexercised.

The summation of the project's static NPV and of the option to expand value is

$$\Psi = \frac{[p'\Psi^+ + (1-p')\Psi^-]}{(1+r)^{n'}} - I \tag{4.11}$$

given that

$$\Psi^+ = max(V^+,(a+1)V^+ - I')$$

and

$$\Psi^- = max(V^-,(a+1)V^- - I')$$

where

n' is the option's lifetime expressed in number of years

I' is the amount of additional investment to be invested,

a is the per cent increase in scale and value of the project compared to the initial project, if the additional investment takes place

The value of the option to expand is

$$C = \Psi - V = \frac{[p'\Psi^{+} + (1-p')\Psi^{-}]}{(1+r)^{n'}} - \frac{[pV^{+} + (1-p)V^{-}]}{(1+r_k)^{n'}} \tag{4.12}$$

where

p is the probability of V to rise in the examined period

The principles of the valuation of the option to expand (valuation formulas 4.10, 4.11 and 4.12) have been developed by Cox, Ross and Rubinstein (1979). Trigeorgis and Mason (1987), Ritchken and Rabinowitz (1988) and Brealey and Myers (1991) use these formulas (4.10, 4.11 and 4.12) to illustrate real option cases. Moreover Trigeorgis (1996) uses the same formulas to evaluate leases and Panayi and Trigeorgis (1998) use them to value an IT infrastructure expansion by a telecommunications authority and the international expansion option by a bank.

Optimum investment rules in an option to expand in the case of a vacant land are derived by Titman (1985) who uses the same lattice binomial approach. He concludes that[6] if the value

$$\Psi = \frac{p'\Psi^{+} + (1-p')\Psi^{-}}{1+r}$$

[6] Given that E^{+}, E^{-}, p' and $(1-p')$ are the value of land for high and low price states of nature, and the corresponding risk-neutral probabilities, respectively. The risk-neutral probability p' is expected to be $p' = \frac{S - S^{-} + \frac{R_{ur}}{(1+r)}}{S^{+} - S^{-}}$, where R_{ur} is the unit rental rate and S, S^{+}, S^{-} is the value of building for expected, high and low price states of nature.

of the vacant land exceeds the value V from building at present day, the wealth-maximising landowner will choose to have the land remain vacant until the following year.

The growth option

The growth option in discrete-time models is valued like the option to expand (Trigeorgis, 1996a). However, since the growth option is an option on an option, then there are at least two stages of expansion. Following the methodology developed by Trigeorgis (1996a) the **summation** of the project's static NPV and of the growth option value is

$$\Psi = \frac{[p'\Psi^{+} + (1 - p')\Psi^{-}]}{(1+r)^{n'}} - I \qquad (4.13)$$

where

$$\Psi^{+} = \frac{[p'\Psi^{++} + (1 - p')\Psi^{+-}]}{(1+r)^{n''}}$$

$$\Psi^{-} = \frac{[p'\Psi^{-+} + (1 - p')\Psi^{--}]}{(1+r)^{n''}}$$

where

$\Psi^{++}=max(V^{++}-I,0)$

$\Psi^{-+}= \Psi^{+-}=max(V^{+-}-I,0)$

$\Psi^{--}=max(V^{--}-I,0)$

The value of the growth option is

$$C_E = \Psi_0 - V = \frac{[p'\Psi^{+} + (1-p')\Psi^{-}]}{(1+r)^{n'}} - \frac{[pV^{+} + (1 - p)V^{-}]}{(1+r_k)^{n'}} \qquad (4.14)$$

where

$V^{+}=[pV^{++}+(1-p)V^{+-}]/(1+r_k)^{n''}$

$V^{-}=[pV^{-+}+(1-p)V^{--}]/(1+r_k)^{n''}$

where

I_o is the initial investment

n' is the number of years during period 1 (introductory period)

n'' is the number of years during period 2 (late period)

Ψ^{++} is the value of investment opportunity, if the upside change takes place during the first and the second stage of investment, Ψ^{+-} if the downside change takes place during the second stage of investment and the upside change takes place during the first stage, Ψ^{-+} if the upside change takes place during the second stage of investment and the downside change takes place during the first stage and Ψ^{--} if the downside change takes place during the first and the second stage of investment.

V^{++} is the project value, if the upside change takes place during the first and the second stage of investment, V^{+-} if the downside change takes place during the second stage of investment and the upside change takes place during the first stage, V^{-+} if the upside change takes place during the second stage of investment and the downside change takes place during the first stage and V^{--} if the downside change takes place during the first and the second stage of investment.

The formula 4.14 is used by Kellogg, Charnes and Demirer (1999) to value a biotechnology company. We note, however, that although the examined discrete-time models are conceptually easy to understand, they are of limited value in practice because they assume a small number of possible outcomes, something unusual in most real-life projects. In practice, there are many possible outcomes that can be expressed by a mathematical function that assumes a certain distribution. Besides, discrete-time models require a large number of inputs, in terms of expected prices at each node.

In addition, discrete-time models assume that the value of the asset is not continuous which is actually used in the study. Continuous-time analytic models provide a solution to these limitations since they reduce the information requirements substantially. Nevertheless, under specific assumptions discrete-time models can be transformed to equivalent continuous-time models. This transformation is useful because it provides a methodology to understand how the examined cases can be formed in a continuous-time base which is actually used in the study. In the following paragraph we will examine how this transformation can be achieved.

4.3 From Discrete-time to Continuous-time models

Although there are many types of discrete-time models, we will examine the assumptions under which the prevailing type of discrete time model, the binomial model, can be transformed into a continuous-time model. In practice if the time interval (t) between price movements is shortened, the limiting distribution, as t approaches zero, can take one of two main forms:

1. If, as ***t*** approaches zero, price changes become smaller, the limiting distribution is the normal distribution and the price process is a continuous one.
2. If, as ***t*** approaches zero, price changes remain large, the limiting distribution is the Poisson distribution, that is, a distribution that allows for price jumps.

In the first case, the necessary inputs to real option pricing can be converted to a suitable form for a continuous-time formula, by using the methodology proposed by Brealey and Myers (1991), Hull (1993) and Damodaran (1996). The methodology, consists of three main steps, namely they consist of the variance estimation, the dividend period estimation and the valuation at late stages. To estimate the probability of a rise, it can be proved[7] (Cox, Ross, Rubinstein, 1979) that

[7] The formula is applied in real option valuation by Brealey and Myers (1991).

$$p = \frac{(r - d)}{(u - d)} \tag{4.15}$$

where

r is the risk free rate

u is the upside change

d is the downside change

where

$u = e^{\sigma\sqrt{h}}$ and

$d = 1/u$

where

σ=standard deviation of annual returns

h=interval as a fraction of year

given that

T is the life of the option in years, m is the number of periods within the option's lifetime, and the volatility σ is given, to estimate up and down movements, Damodaran (1996) provides the following formulas

$$u = e^{\{[\frac{r-\sigma^2}{2}][\frac{T}{m}]+\sqrt{[\frac{\sigma^2 T}{m}]}\}} \tag{4.16}$$

$$d = e^{\{[\frac{r-\sigma^2}{2}][\frac{T}{m}]-\sqrt{[\frac{\sigma^2 T}{m}]}\}} \tag{4.17}$$

Then the period in which the dividends will be paid is specified and it is assumed that the price will drop by the amount of the dividend in that period. In addition, the option is valued at each node of the tree, allowing for the possibility of early exercise just before cash outflow (ex-dividend) dates. There will be early exercise if the remaining time premium on the option is less than the expected drop in option value as a consequence of the cash outflow (dividend payment).Finally, we value the option at time zero, using the standard binomial approach. To understand further the association between continuous- and discrete-time models, we get into the description of the principles of continuous-time valuation.

Continuous-time models assume variables vary continuously through time. In our study we assume that the price of the asset follows the Brownian motion (or Wiener process) that is a specific continuous-time stochastic process. The Wiener process has three important properties:

It is a Markov process. This means that the probability distribution for all future values of the process depends only on its current value, and is unaffected by past values or any other current information.

It has independent increments. This means that the probability distribution for the change in the process over any time interval is independent of any other time interval.

Changes in the process over any finite interval of time are normally distributed, with a variance that increases linearly with the time interval.

The first property is useful in the study because it implies that only current information is useful for forecasting the future path of the process, so it fits with the assumption of the thesis that publicly available information is quickly incorporated in share prices, the assumption of a semi-strong form of market efficiency.

In general, if $z(t)$ is a Wiener process, then any change in z, Δz, corresponding to a time interval Δt, satisfies the following conditions:

the relationship between Δz and Δt is given by

$$\Delta z = \varepsilon_t \sqrt{\Delta t}$$

where

ε_t is a normally distributed random variable with a mean of zero and a standard deviation of 1

$E[\varepsilon_t \varepsilon_s]=0$ for $t><s$. That means the random variable ε_t is serially uncorrelated.

Thus the values of Δz for any two different intervals of time are independent. We will illustrate how these assumptions fit in the case of an option to abandon and then we will examine the developed models in the case of an option to expand as well as in the case of an option to default and in the case of a growth option.

4.4 The option to Abandon

The option to abandon units of production

Initially, the development of real option research, in the case of the option to abandon for a salvage value, examined this option at an incremental base. In particular it was considered that invested capital, at each time t can produce one unit of output selling for PS_t, while production incurs a variable unit production cost UPC_t, assuming that the output price PS_t follows the continuous time stochastic process

$$\frac{dPS_t}{PS_t} = g_{ps}dt + \sigma_{ps}dz_{ps} \qquad (4.18)$$

where

- g_{ps} is the expected growth rate of the output price
- σ^2_{ps} is the per-unit-time variance of that growth rate
- dz_{ps} is the random increment to the Wiener process z_{ps}
- the variable unit production cost, UPC_t, is known at time zero with certainty
- the firm can temporarily with no cost incurred change the level of production without affecting future prices and costs
- the risk free rate of interest, r, is constant and known with certainty,

in a world with risk neutral investors the present value of an uncertain cash flow is equal to the expectation of the cash flow discounted by the risk-free interest rate, viewing operation in each period as an option to acquire PS_t by paying UPC_t as exercise price, McDonald and Siegel(1985), show that a current claim, $V_0(t)$, on time t profits is equal to

$$V(USP_0, UPC_t, t) = USP_0 e^{-\delta_p T} N(d_1) - UPC_t e^{-rT} N(d_2) \tag{4.19}$$

where

$$d_1 = \frac{ln(\frac{USP_o}{UPC_t}) + [(r - \delta_p) + \frac{1}{2}\sigma_{ps}^2]T}{\sigma_{ps}\sqrt{T}}$$

$$d_2 = d_1 - \sigma_{ps}\sqrt{T}$$

and

$$\delta_p = r - g_p$$

where

UPC_t is the variable unit production cost

USP_t is the unit output price

δ_p is the risk premium

T is the option's time to expiration

The researchers show that the present value of operating a project, V_p, is the summation of differences between USP_t and UPC_t expressed by the term $V(t)$ and discounted at the appropriate rate, that is to say

$$V_p = \sum_{t=0}^{T} V(t)$$

Under risk aversion, assuming the Merton's (1973) Intertemporal Capital Asset Model (ICAPM) holds, they show that δ_p will be

$$\delta_p = r_p - g_{ps}$$

and

$$r_p = r + \beta[\mathrm{E}[r_m] - r]$$

where

g_{ps} is the expected rate of price appreciation on a commodity

r is the risk free rate

r_m is the market rate of return

r_p is the expected return of the project

β is the project beta.

Therefore, the risk free rate is replaced by the cost of capital, developed in the Capital Asset Pricing Model. More generally, risk premium can be defined by different equations if the life and the cost pattern of the project are different. Assuming the project is not infinitely lived, it can be shown (by Davis, 1998) that the risk premium, is given by the following equation

$$\delta_p = (\delta_s - r)\,\varepsilon + r + \frac{(\pi\omega\, UPC_t e^{\pi T})}{V_t} \tag{4.20}$$

given that

$$\varepsilon = (1 + \frac{(\omega UPC_t e^{\pi T})}{V_t}) \geq 1$$

The value of constant ω depends on whether production is fixed or declining[8] (for example, it is declining, in the case of an oil field).

δ_s is the convenience yield on the project output

r is the risk-free interest rate

ε is the price elasticity of the project's value , or the sensitivity of project value to changes in the spot price of the project's output good

UPC_t is the unit cost

π is unit costs growth rate during project operation

V_t is the value of the project

For infinitely lived and costless[9] projects

$$\delta_p = \frac{(1 - \tau_a)USP_t K}{V_p} \tag{4.21}$$

For this type of project the dividend yield is constant and equal to the value of project cash flow to project value (Myers and Majd ,1990)[10]. When the project has finite life,

$$\delta_p = \frac{(1 - \tau_a)(USP_t - UPC_t)K}{V_p} \tag{4.22}$$

This approach is also examined by Myers and Majd (1990).

Other researchers make somewhat different assumptions to value the option to abandon[11]. While some researchers (Trigeorgis, 1990) assume that the risk premium δ_p is zero, others assume that the risk premium (or dividend) is equal to the convenience yield (look at Davies (1998) for overview). Majd, Pindyck (1987) and Quigg (1993) make other arbitrary assumptions for the price of risk premium.

In any case, the formula 4.19 implies that a company can, with no cost incurred, shut down a project temporarily whenever the unit output price is not sufficiently high to cover variable unit production costs. However as Dixit and Pindyck (1994) prove and observed business practice indicates, businesses do not

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[8] If production is fixed, $\omega = \frac{(1-\tau_A)K}{(r-\pi)}$. If production is declining, $\omega = \frac{(1-\tau_A)}{(r-\pi+\gamma)} q[1 - e^{-(r-\pi+\gamma)T}]$, given that q denotes output and γ is is the constant exponential rate of decline of output.

[9] If production is fixed, $\theta = \frac{(1-\tau_A)K}{\delta_s}$. If production is declining, $\theta = \frac{(1-\tau_A)}{(\delta_s+\gamma)} q[1 - e^{-(\delta_s+\gamma)T}]$ given that q denotes output and γ is is the constant exponential rate of decline of output.

[10] Similar conclusions can be derived for D" when an option to expand is examined. If the project is similar to that owned by a listed company, that company's (Earnings per Share)/(Share Price) ratio could provide this estimate (McDonald and Siegel ,1986).

[11] Especially in the case of market data, the convenience yield is

$$\delta_s = -\frac{[(ln(\frac{CP_f}{CP_s})) - r^T]}{T}$$

where CP_f is the commodity future price and CP_s is the commodity spot price.

switch off production whenever the unit output price is not sufficiently high to cover variable unit production costs. As discussed in Brennan and Schwartz[12] (1985) this is evident because of the incurring of shutting costs. It is argued that it is not optimal to shut down a project (for example a mine) unless the value of the project's abandonment value exceeds the expected value of the operating mine by the amount of the shutting costs. Considering that in most projects there is also initial investment and resale value that must be considered as well, it becomes apparent that the value of the option to abandon must compare, in principle, the value of the project in operation with the project salvage value that takes into account the discussed factors. The valuation of the option to abandon a project for its salvage value arranges these issues. Effectively, the valuation of the option to abandon for salvage value stems from Margrabe (1978) who examined the mathematical aspects of the option to exchange one asset for another.

The option to permanently abandon a project for its salvage value

The value of the option[13] to exchange an asset (1) for another asset (2) is expressed by the equation

$$C_E(S_1, S_2, T)=max(S_1 - S_2, 0)=S_1 e^{(b_1-r)T} N(d_1) - S_2 e^{(b_2-r)T} N(d_2) \qquad (4.23)$$

where

$$d_1 = \frac{ln(S_1/S_2) + (b_1 - b_2 + \sigma^2/2)T}{\sigma\sqrt{T}}$$

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

$$\sigma = \sqrt{(\sigma_1^2 + \sigma_2^2 - 2\rho\sigma_1\sigma_2)} \qquad (4.24)$$

where

S_1 is the price of the underlying asset 1

S_2 is the price of the underlying asset 2

[12] A more extensive discussion over these issues is provided in Chapter Two of the thesis.

[13] Margrabe (1978) provides a valuation formula for a European option.

ρ is the correlation coefficient between S_1 and S_2

T is the option's time to maturity

σ_1 is the volatility of S_1

σ_2 is the volatility of S_2

b_1 is the cost of carry of S_1

b_2 is the cost of carry of S_2

According to Margrabe (1978), the option in equation 4.24 is simultaneously a call option on asset one with exercise price S_1 and a put option on asset two with exercise price S_2.

Other researchers developed formulas that extend previous work. The valuation of European options on the maximum of two risky assets is developed by Stultz (1982). However, both the formulas developed by Margrabe and Stultz are not suitable to value American options. An analytic formula to value American put options was developed by Geske and Johnson (1984). An extension, of the formula developed by Geske and Johnson, to value American analytic exchange options is developed by Carr (1995). Besides, Myers and Majd (1990) point out that Margrabe's analysis assumes no payouts from the assets, so it would not strictly apply to the abandonment option. The researchers use the approach used by early option researchers (Merton (1977) and others) who rely on continuous trading on specified assets to replicate the payoffs to the contingent claim. According to that methodology, the value of the contingent claim is the cost of forming the replicating portfolio.

Myers and Majd (1990) assume that project value V_P and Salvage Value V_S follow a lognormal diffusion process

$$\frac{dV_p}{V_p} = r_p d_t - \gamma_p d_t + \sigma_p dz_p$$

and

$$\frac{dV_s}{V_s} = r_s d_t - rd_t + \sigma_s dz_s$$

where

V_p is the project value

r_p is the expected return of the project

σ_p is the standard deviation of the rate of change of V_P

dz_p is the standard Weiner process generating the unexpected changes in V_P

r represents the riskless rate of return

γ_p is the payout ratio

Assuming also that the value of the project is determined by the present value of the expected cash flows.

they put

$$X = \frac{V_p}{V_s} \qquad (4.25)$$

$$\sigma_x = \sqrt{(\sigma_p^2 + \sigma_s^2 - 2\rho_{fs}\sigma_p\sigma_s)}$$

where

V_p is the project value

V_s is the Salvage value

σ_p is the volatility of project value

σ_s is the volatility of salvage value

σ_x is the volatility of project value in units of salvage value ($X=S_p/S_s$)

ρ_{fs} is the correlation coefficient of project and salvage values

X is the exercise price (strike price) of the option

Damodaran (2001) uses a put option formula assuming

$b_1 = r - \delta$

$b_2 = 0$

$\delta = \frac{1}{T_p}$

$\sigma_2 = 0$

$\sigma = \sigma_1$

it follows that

$$P_E(V_p,V_s,T)= V_p e^{(-\delta)T}[N(d_1)-1]-V_s e^{(-r)T}[N(d_2)-1]$$

$$d_1 = \frac{ln(V_p/V_s)+(r-\delta+\sigma^2/2)T}{\sigma\sqrt{T}}$$

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

where

T is the option's time to maturity

T_p is the remaining life of the project

Effectively, the exchange option and the put option valuation, which is the base to value abandonment option, is used to value the option to default. It differs, however, in the sense that the option to default is an option to exchange part of the equity for part of the debt.

4.5 The Option to Default

Valuation of the option to default as an exchange option

The value of the option to exchange asset S_2 for S_1 in return for a fixed quantity Q of asset S_2 is (according to Carr, 1988)

$$C=S_2e^{(b_2-r)T_2}M(d_3,y_2,-\sqrt{T_1/T_2})-S_1e^{(b_1-r)T_2}M(d_4,y_1,\sqrt{T_1/T_2})+ \\ +QS_2e^{(b_2-r)T_1}N(d_3) \tag{4.26}$$

where

$$d_3 = \frac{\ln(US_2 / S_1) + (b_2 - b_1 + \sigma^2/2)T_1}{\sigma\sqrt{T_1}}$$

$$d_4 = d_3 - \sigma\sqrt{T_1}$$

$$y_1 = \frac{\ln(S_1 / S_2) + (b_1 - b_2 + \sigma^2/2)T_2}{\sigma\sqrt{T_2}}$$

$$y_2 = y_1 - \sigma\sqrt{T_2}$$

$$\sigma = \sqrt{\sigma_1^2 + \sigma_2^2 - 2\rho\sigma_1\sigma_2}$$

where

U is the unique critical price ratio, expressed by the equation

$$U = \frac{S_1 e^{(b_1 - r)(T_2 - T_1)}}{S_2 e^{(b_2 - r)(T_2 - T_1)}}$$

solving

$$UN(z_1) - N(z_2) = Q \ ,$$

$$z_1 = \frac{\ln(U) + (T_2 - T_1)\sigma^2/2}{\sigma\sqrt{T_2 - T_1}}$$

$$z_2 = z_1 - \sigma\sqrt{T_2 - T_1}$$

where

T_1 is the time to expiration of the "original option"

T_2 is the time to expiration of the underlying option $(T_2 > T_1)$

Q is the Quantity of asset S_2 delivered if option is exercised

Valuation of the option to default as a put option

However, other approaches are also developed that use simple call option formulas or value options to default as put options. A useful alternative is to value the summation of the project's NPV and of the option to default as a call option. In that case the Black Scholes (1973) formula is used. According to Damodaran (1996), the value of the option to default in debt payment will be

$$P_E = C_E(V, X_d, T) - Ve^{-\delta T} + X_d e^{-rT}$$

where

X_d is the value of debt

given that

$$C_E(V, X_d, T) = Ve^{-\delta T} N(d_1) - X_d e^{-rT} N(d_2) \qquad (4.27)$$

and

$$d_1 = \frac{[(ln(\frac{V}{X_d}) + (r - \delta + \frac{\sigma^2}{2})T]}{\sigma\sqrt{T}}$$

$$d_2 = \frac{[(ln(\frac{V}{X_d}) + (r - \delta - \frac{\sigma^2}{2})T]}{\sigma\sqrt{T}}$$

it follows that

$$P_E = Ve^{-\delta T}[N(d_1) - 1] - X_d e^{-rT}[N(d_2) - 1] \qquad (4.28)$$

where

T is the option's time to expiration expressed in years, equal to the average duration of the company's debt

V is the net present value of company assets (including debt)

r is the risk free rate, equal to the government bond rate that corresponds to the option's life-time

δ is the expected company dividend yield

σ is the company asset volatility, expressed by the equation

$$\sigma = \sqrt{\frac{E}{(D+E)}\sigma_1^2 + \frac{D}{(D+E)}\sigma_2^2 + \frac{E*D}{(D+E)}\rho\sigma_1\sigma_2}$$

given that σ_v is the project volatility and σ_x is the volatility of debt.

Another study shows that equity-holders hold the option to default in the form of an American put option P on equity value under continued operations, V_G-X_dV_G, with an exercise price equal to the equity value under liquidation, V_L-X_dV_L, given that the examined firm has issued debt, denoted by X_d, having a single payment due at maturity, an immediate liquidation value (V_L) and a going-concern value (V_G) (Vila & Schary, 1995). Whereas the option to default and the option to abandon are valued either as exchange options or as put options, the option to expand and the growth option are valued as call options. This is due to the nature of these options. In both of them the firm has the opportunity to discontinue existing operations for a fixed amount of value. On the contrary, concerning the option to expand and the growth option, the company has the opportunity to invest a predetermined amount of funds to receive future benefits if conditions prove favourable. Thus the option to expand is valued as a simple call option.

4.6 The Option to Expand

Some researchers use a transformation of the classic Black-Scholes (1973) formula to value an option to expand (Siegel, Smith, Paddock (1988), Brealey and Myers, 1991), whereas other researchers discuss the necessity for dividend yield adjustments (Trigeorgis, 1996a, Davis, 1988).

The option to expand into assets that yield a holding gain

The Black-Scholes (1973) approach has been developed for financial options, based on the argument that if options are correctly priced it should not be possible to make sure profits by creating portfolios of long and short positions in options and their underlying asset.

Given that

N() is the cumulative normal density function

T is the time to expiration of the option in years

SP is the share price

X_{BS} is the strike price of the option

σ_{BS} is the stock price volatility

the value of the call option[14] is expressed by the equation

$$C_E(SP, X_{BS}, T) = SP\ N(d_1) - X_{BS}\ e^{rT}\ N(d_2) \tag{4.29}$$

where

$$d_1 = \frac{[(ln(\frac{SP}{X_{BS}}) + (r + \frac{\sigma_{BS}^2}{2})T]}{\sigma_{BS}\sqrt{T}}$$

$$d_2 = \frac{[(ln(\frac{SP}{X_{BS}}) + (r - \frac{\sigma_{BS}^2}{2})T]}{\sigma_{BS}\sqrt{T}}$$

Brealey and Myers (1991) transformed the formula 4.29, to apply it in real option cases.

The value of the option to expand is expressed by the equation

$$C_E(V, I, T) = VN(d_1) - Ie^{rT}\ N(d_2) \tag{4.30}$$

where

$$d_1 = \frac{[(ln(\frac{V}{I}) + (r + \frac{\sigma_{BM}^2}{2})T]}{\sigma_{BM}\sqrt{T}}$$

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[14] Assuming that

- the short-term interest rate is known and is constant over time
- the stock price follows a random walk in continuous time with a variance rate proportional to the square of the stock price. Thus they assume the distribution of possible stock prices at the end of any finite interval is lognormal
- the variance rate of the return on the stock is constant
- the stock pays no dividends or other distributions
- the option is European, that is, it can only be exercised at maturity
- there are no transaction costs in buying or selling the option or the stock
- it is possible to borrow any fraction of the price of a security at the short-term interest rate
- there are no penalties for short selling,

$$d_2 = \frac{[(ln(\frac{V}{I}) + (r - \frac{\sigma_{BM}^{2}}{2})T]}{\sigma_{BM}\sqrt{T}}$$

given that

I is the value of investment, expressed in current (discounted) value

σ_{BM} is the investment's (expected) cash inflow volatility

Benaroch and Kauffman (1999) applied equation 4.29 to value IT investments. However, the Black-Scholes approaches do not account for the "dividend yield", whilst the Merton (1973) approaches account for dividends.

The option to expand into assets that generate cash flows

Following Merton (1973), the value of an American Call option paying a known dividend yield is

$$C_A(SP,X,T) = SP\, e^{-qT} N(d_1) - Xe^{-rT} N(d_2) \qquad (4.31)$$

given that,

$$d_1 = \frac{[(ln(\frac{SP}{X}) + (r - q + \frac{\sigma^2}{2})T]}{\sigma\sqrt{T}}$$

$$d_2 = \frac{[(ln(\frac{SP}{X}) + (r - q - \frac{\sigma^2}{2})T]}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}$$

where

q is the dividend yield

σ is share price volatility

Assuming that

r is computed bond rate that corresponds to the option's life

q is the cost of capital

σ is expected cash inflow volatility, computed from industry average standard deviation

V, the value of the expected cash inflows, expressed in current (discounted) value, replaces ***SP,***

I is the value of investment, expressed in current (discounted) value replaces ***X,***

the formula is used by Damodaran (1996).

A transformation of formula 4.31 to value the undeveloped oil reserves is made by Siegel, Smith and Paddock (1987). The analogy is illustrated in the following table (Table 4.1).

Table 4.1: Comparison between a call option on a share and a real option embedded in undeveloped petroleum reserves

Call option on share	Real option in Undeveloped Petroleum Reserves
Current value of share (***SP***)	Current Value of Developed Reserve
Exercise price (***X***)	Development cost
Time to expiration (***T***)	Relinquishment Requirement
Variance of Rate of return on the Share (σ)	Variance of Rate of change of the Value of a Developed Reserve
Risk free interest rate (***r***)	Risk free interest rate
Dividend (***q***)	Net Production Revenue less Depletion

Source: Siegel, Smith and Paddock(1987)

McDonald and Siegel (1986), Majd and Pindyck (1987), Paddock, Siegel and Smith (1988) and Gibson and Schwartz (1991) applied Merton's (1973) formula to value real options. However, McDonald and Siegel (1986) consider the payment of a sunk cost I_{MS} in a return for a project worth *V,* where *V* and I_{MS} evolve as Geometric Brownian motions, while Majd and Pindyck (1987) assume that only the value of project *V* evolves as a Geometric Brownian motion[15].

15 Whereas the assumption that sunk costs evolve as a Geometric Brownian Motion may apply in some cases. these approaches inherently have certain limitations (analytic approaches are complicated,

Even though the valuation formulas of expansion options are useful, they do not properly value opportunities that consist of phased investments. Growth option, valuation models, examined on the following paragraph, value these complicated opportunities properly.

4.7 The Growth Option

To illustrate, valuing a pioneer project should give the management the right to acquire a commercial venture by paying its second phase investment outlay[16]. First, management must decide whether to continue or not with the pioneer venture (Year 0 decision). Once the decision has been made, it would take ***t*** years to build the pioneer venture. The building of a follow-up commercial project would take an additional time period, ready to start production in Year t^{**}.The time profile of the decision situation is presented on Table 4.2, developed by Kemna (1993).

Table 4.2: Pionner projects and growth options

Planning situation			
First stage		Second stage	
Year 0	Year t	Year t*	Year t**
Go ahead with pioneer venture or stop	Start-up production of pioneer project	Decision moment to start commercial venture	Start-up production of commercial venture

Source : Kemna (1993)

The maturity date of the option was set equal to the earliest possible time that, from a technological point of view, building of the first commercial venture could start. The estimated lead on competition, that determines the time to maturity of the

incremental approaches do not take into account of sunk costs). Other approaches include an efficient analytic American call option approach (Barone-Adesi and Whaley, 1987) , valuation of incremental units of production examine as an option to expand(Pindyck, 1988 and Bell, 1995) that extended Pindyck's model to incorporate exit options and to include an analysis of hysteresis when the source of uncertainty is exchange rates rather than product price.

16 In option pricing terms, "buying" the pioneer venture would give management the right to acquire a commercial venture by paying for its investment outlay. Thus, investing in the pioneer venture today is similar to investing in a growth option. The option will only be exercised if the commercial venture is profitable at the maturity date of the option. If we consider a pioneer project as a growth option, the value of the project consists of the value of a series of call options on the market value of the installed project. Therefore, valuing the project by using the option to expand methodology will not justify the investment in the pioneer venture.

option, was estimated to be in Year t^*, after (t^*-t) years of production of the pioneer venture.

Given the described time schedule, the pioneer project can be naively seen as a call option on a futures contract, where the futures price, F, is equal to the value of the commercial venture in t^* years. The exercise price is equal to the investment outlay in Year t^*. The time to maturity is equal to t^* years. The mathematical formula of this standard European call option on a futures contract is given by Equation 4.32, described as follows.

The European futures valuation formula

Assuming that

- the variance rate of the return on the forward or futures contract is constant
- there are no dividends or other distributions
- the short-term interest rate is known and is constant over time
- the futures price follows a random walk in continuous time with a variance rate proportional to the square of the stock price. Thus we assume the distribution of possible futures prices at the end of any finite interval is lognormal
- the option is European, that is, it can only be exercised at maturity
- there are no transaction costs in buying or selling the option or the futures
- it is possible to borrow any fraction of the price of a security at the short-term interest rate
- there are no penalties to short selling,
- the value of a European call option , when the underlying security is a forward or futures contract is expressed by the equation

$$C(CP_f, X, T_f) = e^{-rT_F}\,[CP_f\; N(d_1) - X_B N(d_2)] \qquad (4.32)$$

given that,

$$d_1 = \frac{[(ln(\frac{CP_f}{X}) + (\frac{\sigma_f^2}{2})T]}{\sigma_f \sqrt{T}}$$

$$d_2 = \frac{[(ln(\frac{CP_f}{X}) - (\frac{\sigma_f^2}{2})T]}{\sigma_f \sqrt{T}} = d_1 - \sigma\sqrt{T}$$

where

X is Strike(exercise) price of option

T is time to expiration in years of the forward or futures contract

σ_f is the annual volatility of the forward or the volatility of the futures contract

Equation 4.32 is developed by Black (1976).

Damodaran (2001) uses equation 4.31, under the following adjustments

SP is replaced by V, the value of the expected cash inflows from phase 2 expansion

X, replaced by I, is the value of phase 2 expansion cost

T is the time the company can delay phase 2 expansion

σ is the industry average standard deviation

q replaced by r_k, is the cash flows foregone by waiting, divided by market value

The complication, in case equation 4.32 is applied to value growth options, is the opportunity by managers to either continue or stop the investment at some specific time during the early stages of the project. Thus, instead of deciding to start and finish the whole pioneer venture at that time, management has to decide to continue with the next phase.

In the first phase, the management has an option to continue with the production of pioneer project, including the option on the commercial venture. At the end of the first phase, the management has the option to exercise the first option, the option to complete the pioneer project. If the option is left to expire unexercised, the management aborts the entire investment opportunity. The decision to exercise the option depends on the remaining value of the pioneer venture, which is an option on the commercial venture. If the value of the commercial venture is sufficiently large, the management will exercise the option.

Expressed in a different way, the first call option is written on the value of the pioneer venture (Phase 2), which in turn depends on the value of the commercial venture (Phase 3 and Phase 4). If the first option has a time to maturity τ^*, the time to maturity of the second option is $\tau-\tau^*$, and the cost of exercising the first option equals the remaining NPV of the pioneer venture, defined as U^*. In other words, the first call option (option to introduce the project) depends on the option to commercialise the project. This option is better valued by compound option formulas.

Equation 4.32 assumes that the variance rate of the return on the share (underlying asset) is constant[17]. This proves to be an unrealistic assumption. Luckily compound option formulas lack these deficiencies.

The compound call option formula

Assuming that

- investors are insatiate
- security markets are perfect and competitive
- unrestricted short sales with full use of proceeds is allowed
- the risk-free rate of interest is known and constant over time
- trading takes place continuously in time
- the firm has no payouts
- changes in the value of the firm follow a random walk in continuous time with a variance rate proportional to the square root of the value of the firm and that investors agree on this variance, then

the value of a compound call option (a call option on a call option) is described by the equation[18]

$$C_E = V_P e^{-r\tau} M(k,h;\rho) - I_G e^{-r\tau} M(\kappa - \sigma_P\sqrt{\tau^*}, h - \sigma_P\sqrt{\tau}\,;\rho) - - I_G^* e^{-r\tau^*} N(\kappa - \sigma_P\sqrt{\tau^*}) \qquad (4.33)$$

[17] Geske (1979)

given that

$$h = \frac{ln(\frac{V_P}{I_G}) + (\frac{\sigma_P^2}{2})\tau}{\sigma_P\sqrt{\tau}}$$

$$\kappa = \frac{ln(\frac{V_P}{I_C}) + (\frac{\sigma_P^2}{2})\tau^*}{\sigma_P\sqrt{\tau^*}}$$

where

N(.) is univariate normal distribution function,

M(a,b;ρ) is bivariate normal distribution function with a and b as upper and lower integral limits, and correlation coefficient ρ,

$\rho=(\tau^*/\tau)^{1/2}$

I_c is the critical value of the project above which the first call option will be exercised

V_P is the value of the developed project (second stage)

σ_p is the volatility of the rate of change of the developed project

I_G is the expenditure for the developed project (second stage)

I_G^* is the expenditure for the initial project (first stage)

τ is the time to maturity of the simple option

τ^* is the time to maturity of the first call option

Equation 4.33 which is developed by Geske (1979) is used by Kemna (1993) to value oil fields. Though useful to value most types of growth options, it is not suitable to value values that are not continuous. Jump formulas are suitable to value these types of assets.

The valuation of growth options assuming jump processes

Jump formulas may better capture the essence of the discovery (jump) component of an asset. A jump-formulation to value start-up ventures is developed by Willner (1995), based on valuation formulas in Cox, Ross (1976).

[18] Kemna (1993) provides a way to apply the model developed by Geske (1979) for real option purposes

Similarly, a formula to value growth options in the area of Research and Development investments is developed by Pennings and Lint (1997). Assuming that the costs associated with the irreversible investment, required for market introduction, and the necessary time for R&D can be given with reasonable accuracy, there are no dividend payments and the expected present value of future cash flows follows a jump process

$$dV_P(t) = g_d V_P(t)dt + V_P(t)d_n \tag{4.34}$$

where

g_d is the drift factor

V_p is the present value of future cash flows

$V_p(t)$ is the market value of future net cash flows conditional on industrialization, based upon all information at time t

$d_n=0$ with probability $1-\lambda dt$

and

$d_n=\Xi$ (a jump of size Ξi) with probability λdt

where

Ξ denotes the jump amplitude and is expressed by the equation

$\Xi = X_i \Gamma_i$,

where

$X_i=1$ with probability p, and $X_i=-1$ with probability $(1-p)$,

$\Gamma_i \mid X_i \sim Wei(\gamma_x, 2)$

The jump amplitude is symmetric, so its mean and variance are

$E[\Xi_i \mid X_i] = \frac{1}{2}\sqrt{\pi} X_i \gamma_{xi}$

$Var[\Xi_i \mid X_i] = (1-\pi/4)\gamma^2_{xi}$

Then, the value of the growth option is expressed by the following equation

$$C_E(t) = V_p(t)N(d + \sqrt{\lambda(T - t)\gamma}) - Ie^{-r(T-t)}N(d) \quad (4.35)$$

where

$$d = \frac{(ln(\frac{V_p(t)}{I}) + (r - \frac{\lambda\gamma^2}{2})(T - t)}{\sqrt{\lambda(T - t)\gamma}}$$

I is the investment made

λ is the intensity parameter of strategic information flow in Poisson process, expressed by the equation

$\lambda=1/\theta$, so as

$\lambda(T-t)$ is the expected number of arrivals of strategic information during the research period

$T-t$ is the research period

T is the time of industrialization

t is present time

γ^2 is the variance of $[\Xi_i+1]$

Although equations 4.34 and 4.35 should provide more accurate estimation of growth options in the IT sector and elsewhere, compared to other methods, they are difficult to estimate because they require detailed analysis of strategic information that is not always disclosed.

The capitalised earnings method

The "Capitalised earnings" method estimates the value of corporate growth options. The method treats anticipated earnings as a perpetuity, so capitalises them by dividing them by the discount rates. We subtract the capitalised values from the market value of the companies. The differences are the estimated value of growth options. The value of the growth option is, therefore, expressed by the following equation

$$C = MVE - \frac{E_t}{r_d} \qquad (4.36)$$

where

MVE is the equity market value

E_t is the company's 12-month trailing after tax earnings.

r_d is equity discount rate

Kester (1984) and Ottoo (2000) use equation 4.36.

Other researchers examined the optimisation issue in growth options (Roberts, Weitzman, 1981) or the valuation of investments when they are irreversible (Baldwin, 1982).

4.8 Other Issues

The developed continuous-time option valuation models are inadequate if the price of the underlying asset V is not continuously observable. Unfortunately in most real option cases, the underlying asset is difficult to observe. Merton (1998) proposes specific solution to that problem, as follows.

Suppose the price of the underlying asset is observed at $t=0$ and then again at the maturity of the option contract, $t=T$.

In between there is neither direct observation nor inferential information from payouts on the asset. Hence $D_1(V,t)=0$, and the derivative security has no payouts or interim "stopping points" prior to maturity contingent on $V(t)$. Merton(1998) proves that if the expected value of $X(t)$ equals 1, the variance of $ln[X(t)]$ equals to $\theta^2 t$, for all $t<T$, the best estimate of $V(t)$ is $SP(t)$.

However, at $t=T$, $V(T)$ is revealed and the value of SP "jumps" by the total cumulative tracking error of $X(T)$ from its value SP at $t=T^-$ to $SP(T)=V(T)$. The solution to the equation

$$0 = \frac{\delta^2 SP^2 F_{11}[SP,t]}{2} + r\ SP\ F_1[SP,t] - rF[SP,t] \tag{4.37}$$

which is subject to the terminal-time boundary condition that for $SP(T)=SP$,

$F[SP,T] = E\{h(SPX)\}$

with

$h(V)=max[0,V-L]$

is given by, for $0<t<T$,

$$F[S,t] = SP\ N(u) - Le^{-r[T-t]}\ xN(u - \sqrt{\gamma}) \tag{4.38}$$

where

$$u = \frac{ln(\frac{SP}{L}) + r(T-t) + \frac{\gamma}{2}}{\sqrt{\gamma}}$$

$$\gamma = \delta^2(T-t) + \theta^2 T$$

and

$N(.)$ is the cumulative density function for the standard normal distribution.

Equations 4.37 and 4.38 are developed by Merton (1998).

The key difference in the option-pricing formula with and without continuous observation of the underlying asset price is that the variance over the remaining life of the option does not go to zero as t approaches T, because of the "jump event" at the expiration date corresponding to the cumulative effect of tracking error. Being more precise, equation 4.38 reduces to the classic Black-Scholes if we replace SP with V, u with d and γ with $\sigma^2(T-t)$.

Merton (1998) proves also that developed option pricing models apply even in assets that are not traded. He argues that in all equilibrium asset-pricing models, assets that have only non-systematic or diversifiable risk are priced to yield an expected return equal to the riskless rate of interest. The condition satisfied by the tracking-error component of the hedging portfolio satisfies an even stronger no-correlation condition than either a zero-beta asset in the CAPM, a zero multibeta asset in the ICAPM, or a zero risk-factor asset of the Arbitrage Pricing theory. He proves that the equilibrium price for the derivative security is the same as if the underlying asset is traded continuously. Therefore, the Black-Scholes formula would apply even in those applications in which the underlying asset is not traded. Merton (1998) argues that as is well known from the literature on incomplete markets, the equilibrium condition need not be obtained if the creation of the new derivative security helps complete the market for a large subset of investors. Markets tend to remain incomplete because the cost of creating the securities necessary to span that risk exceeds the benefits, or because non-verifiability, moral hazard, or adverse-selection problems render the viability of such securities untenable. Generally, in those cases, major macro risks are not controllable by a specific group of investors and it is unlikely that any group would have a systematic access to materially better information about those risks. Merton (1998) notes that in most applications of the option pricing model tracking-error variations are likely to be specific to the underlying project, firm, institution, or person and thereby they do not normally represent macro-risk, so these observations support the prospects for risk equilibrium condition to obtain.

Also, although the use of a geometric Brownian motion as a model for V is convenient, in many cases may not be realistic. In the case of projects whose output are commodities or in periods where the share market is overvalued or undervalued, the assumption that V follows a mean-reverting process is more appropriate. Moreover, as Dixit and Pindyck (1994) prove, the combined Brownian motion and jump process could better describe a situation in which a company has a patent that gives it the option to invest in a project whose value is V, but other companies are also doing research which, if successful, will allow them to invest in a similar project. If and when one of these competitors is successful, the resulting competition will reduce profits and consequently reduce V.

4.9 Conclusions

The chapter provides an illustration of the theoretical developments in real option pricing. Initially the development of financial option pricing, that provides the fundamentals of real option valuation, is examined. Then both the development of discrete-time and continuous-time valuation models in the area of real options is examined. Initially an incremental investment approach has been developed to value the option to abandon for salvage value. The option to abandon is valued either as an exchange option, or as a put option. When valued as an exchange option the underlying assets are the expected value of the project and the salvage value. When the option to abandon is valued as a put option, salvage value is used as strike price while the expected value of the project is the underlying asset. The option to default is valued also either as an exchange option or as a put option. When valued as an exchange option the underlying assets are the expected value of the company and the value of debt. The option to default is valued as a put option, assuming the strike price is the value of debt while the value of company assets is the underlying asset. On the contrary, growth options and options to expand are valued as call options, using investment outflows as strike price and expected project cash inflows as underlying assets. Since the price of the underlying assets of real options is claimed to be not continuously observable, recent research gives attention to formula adjustments for non-observable assets. Although research in mathematical formulation of real options has been enormous, the interest in the empirical investigation of real option valuation has been scant. The next chapter examines prior empirical evidence in that area.

CHAPTER FIVE

PRIOR RESEARCH ON REAL OPTIONS AND COMPANY VALUATION

Although the mathematical formulation of real option models has received considerable attention, the empirical testing of such models has been more limited. Nevertheless, the empirical work that has been reported to date on real options not only investigates the effect of real options on corporate value, but it also considers the fit between theoretical and market valuation practices and the significance of real options in investment decisions. So far, however, the study of real options has not adopted an integrated applied valuation approach by taking into account such factors as the market response to real option signalling or the potential role of real options as additional explanatory factors in contemporary valuation models. Bearing this in mind, the present thesis attempts to apply established theoretical approaches in real option valuation to the assessment of stock market values in this context.

Chapter 5 first provides a review of recent empirical research on real options, and then considers relevant research into the market pricing of company equity, first with respect to the comparison of pre- and post-announcement prices when real options are announced or otherwise signalled and, second, with regard to contemporary approaches to establishing the firm's market value such as residual income analysis.

5.1. Real options

Growth options have attracted most of the interest of real option researchers, and this is probably because their economic significance is so great by comparison with other types of real option. The first evidence that growth options account for a significant part of company value is provided by Kester (1984) who defines real option value as excess market value (that is to say market value less a normative valuation based on the Price/Earnings multiple) in order to estimate the value of growth options among large US companies. The results show that 60%-76% of the total value of leading companies in the electronics sector and 61%-77% in the computer sector is due to the existence of corporate growth options. Kester's study looks at fifteen leading U.S. companies belonging to five main sectors, not only in electronics and computers, but also in food processing, chemicals and tires and rubber, and, although the latter are less high-tech sectors, it was still the case that a considerable proportion of corporate value could be attributed to growth options – at the time, these made up nearly 55% of total value in chemicals, 40% in tires & rubber and 25% in food-processing. Table 5.1 illustrates the findings of Kester (1984).

Table 5.1 : Growth option value as a component of market value

Industry	Firm	Market value of equity (USD millions)	Anticipated earnings	Capitalized value of earnings using various discount rates			Estimated value of growth options		Percent of market value represented by growth options	
				15%	20%	25%	Min	max	Min	Max
Electronics	Motorola	5,250	210	1,400	1,050	840	3,850	4,410	73%	84%
>>	Genrad	550	17	113	85	68	437	482	79%	88%
>>	RCA	2,200	240	1,600	1,200	960	600	1,240	27%	56%
Computers and peripheral	Apple Computers	2,000	99	660	495	396	1,340	1,604	67%	80%
>>	Digital Equipment	5,690	285	1,900	1,425	1,140	3,790	4,550	67%	80%
>>	IBM	72,890	5,465	36,433	27,325	21,860	36,457	51,030	50%	70%
Chemicals	Celanese	1,010	78	520	390	312	490	698	49%	69%
>>	Monsanto	4,260	410	2,733	2,050	1,640	1,527	2,620	36%	62%
>>	Union Carbide	4,350	280	1,867	1,400	1,120	2,483	3,230	57%	74%
Tires and Rubber	Firestone	1,090	88	587	440	352	503	738	46%	68%
>>	Goodyear	2,520	300	2,000	1,500	1,200	520	1,320	21%	52%
>>	Uniroyal	400	47	313	235	188	87	212	22%	53%
Food processing	Carnation	1,790	205	1,367	1,025	820	423	970	24%	54%
>>	Consolidated Foods	1,190	171	1,140	855	684	50	506	4%	43%
>>	General Foods	2,280	317	2,113	1,585	1,268	167	1,012	7%	44%

Source: Kester (1984)

More recently, the effect of growth options on US companies in selected sectors, i.e. biotechnology, computers, pharmaceuticals, automotive, tires & rubber and the internet, has been examined by Ottoo (2000).

Like Kester (1984), Ottoo (2000) defines real option value as excess market value. However, instead of using a Price/Earnings multiple, two forms of the Price/Book Value ratio are used to estimate the value of growth options[1], specifically the excess market value of the firm as a whole and the excess market value of its equity, expressed by the following equations.

$$EMVA = \frac{(MVA - BVA)}{MVA} \tag{5.1}$$

and

$$EMVE = \frac{(MVE - BVE)}{MVE} \tag{5.2}$$

where

EMVA is Excess market value of the firm

MVA is Market Value of the Firm

BVA is Book Asset Value

EMVE is Excess Market Value of Equity

MVE is Market Value of Equity

BVE is Book Value of Equity

These more recent findings, illustrated in Table 5.2, show that growth options account for 98% of the equity market value of the internet companies examined, 83% of biotechnology companies, 77%-91% of computer producing companies, 83%-92% in pharmaceuticals, 0%-65% of car producers and 9%-59% of company value in tires & rubber.

[1] Both P/E and P/B ratios are used by Chung and Charoenwong (1991) to proxy for growth options.

Table 5.2 : Estimated values of growth opportunities

Industry	Firm	Excess Market Value of the firm(*EMVA*)	Excess Market value of Equity (*EMVE*)
Internet	Amazon.com	96.30%	99.20%
>>	America Online	96.80%	99.10%
>>	Ebay	99.10%	99.10%
Biotechnology	Genentech	72.20%	76.90%
>>	Amgen	86.40%	90.40%
>>	Biogen	85.00%	88.20%
Computer	IBM	56.60%	88.50%
>>	Microsoft	93.50%	95.20%
>>	Sun Microsystems	82.30%	89.10%
Pharmaceutical	Johnson & Johnson	77.60%	87.90%
>>	Merck	82.10%	92.70%
>>	Pfizer	88.90%	94.60%
Automotive	Ford	-16.10%	67.40%
>>	General Motors	-59.60%	68.00%
>>	Navistar Int'l	-54.00%	59.30%
Rubber & tire	Bandlag inc	22.80%	46.70%
>>	Cooper T&R	12.60%	76.60%
>>	Goodyear T&R	-7.60%	52.40%

Source : Ottoo (2000)

The findings reported in Ottoo (2000) are important not only because they lead overall to similar conclusions to those arrived at by Kester (1984) but also because the research design uses different growth option valuation metrics and still points to the high potential relevance of real options in company valuation.

For example, Kester finds that a significant proportion (61%-77%) of the value of computer companies is attributed to growth options, and Ottoo (2000) provides confirmation of this, estimating that 77.5% of computer company value is attributed to these options. The comparability of the two studies is not always so clear, however. In another sector (tires and rubber), while Kester (1984) finds that a lower proportion of 30%-58% of the company value is attributed to growth options, Ottoo (2000) finds that only 9.3% is attributed to these options, which is particularly low.

Nevertheless, although the results are not always the same at the sector level, when aggregated data are used, the two papers come to very similar conclusions, as mentioned above. The results from the comparison of pooled data from Kester (1984) and Ottoo (2000) are illustrated in Table 5.3. On average, 58% of the value of the companies examined by Ottoo (2000) is accounted for by the value of their growth options, which falls in the range of 42%-65% reported previously by Kester (1984).

Table 5.3: Growth options and market values in selected sectors

Study	**Kester (1984)**	**Kester (1984)**	**Ottoo(2000)**	**Ottoo(2000)**
Metrics	P/E (min value)	P/E (max value)	Excess Market Value of the firm(***EMVA***)	Excess Market value of Equity (***EMVE***)
Internet	----	----	97.4%	99.1%
Computer	61.2%	76.7%	77.5%	90.9%
Electronics	60.0%	76.0%	----	----
Chemicals	47.1%	68.3%	----	----
Pharmaceutical	----	----	82.9%	91.7%
Biotechnology	----	----	81.2%	85.2%
Automotive	----	----	0.0%	64.9%
Rubber & Tire	29.5%	57.7%	9.3%	58.6%
Food processing	11.7%	47.0%	----	----
Average	**41.9%**	**65.1%**	**58.0%**	**81.7%**

The similarity between the conclusions arrived at by Kester and Ottoo suggests that growth options account consistently for a high proportion of company market value, at least in the sectors examined. However, other papers (Schwartz and Moon, 2000, Kellogg, Charnes and Demirer, 1999, Paddock, Siegel and Smith, 1988 and Howell and Jagle, 1997) are in conflict with these findings, arguing that the high market valuations cannot be attributed fully to real options.

In a case study, Schwartz and Moon (2000) examine the valuation of Amazon.com, a leading company in the internet sector, and conclude that only a small part of the company's market value can be explained by real option theory.

More detailed evidence is provided in a research paper on option valuation in the biotechnology sector, showing how changes in assumptions about the underlying real option seem to have widely differing valuation implications (Kellogg, Charnes and Demirer, 1999). In another case study of a single firm, these researchers applied the real option methodology to evaluate Agouron Pharmaceuticals Inc., and found that the theoretical methods valued Agouron relatively well when all the projects were in the early phase of development. They compute the company value as the sum of the values of its current projects using decision-tree analysis and the binomial method. On 30th June 1994, at the time Viracept was undergoing pre-clinical trials, the stock price deviation from the predicted value computed with method A (DTA analysis) and method B (the binomial method) was 23.4% and 19.8% respectively. Similarly, on 20th October 1994, at the time the company announced that Viracept would begin trials, the stock price deviation from the predicted value with method A and method B was only 1.3% and 4.3%, respectively. However, the stock price deviation from the growth option theoretical values became significantly larger (28%-56%) during the following years.

The authors believe that the investors might have assumed that the duration of the second phase would be shorter than average, due to the political pressure on the health authorities to approve drugs for HIV positive patients. They also consider that investors may have predicted a different probability distribution for the revenue, or that the market assumed a probability of approval for Viracept greater than for an average drug. The researchers conclude that the real options approach works well, by using average assumptions when projects are in the early phase of development. However, as projects move through the development process, more specific assumptions regarding the probability of success, market size and the timing of product launch are required in order to reflect the value of the firm accurately.

Table 5.4 : Valuation of Agouron Pharmaceuticals stock using decision tree and binomial lattice methods

Date	30/6/1994	20/10/1994	30/6/1995	30/6/1996	23/12/1996
Actual stock price*	5.63	5.63	11.81	19.5	33.8
Predicted price based on decision tree analysis (Method A)*	4.31	5.7	7.17	10.26	15.05
Predicted price based on binomial method (Method B)*	4.51	5.81	8.51	10.44	15.45
Deviation between actual price and Method A	-23.4%	1.3%	-39.3%	-47.4%	-55.6%
Deviation between actual price And Method B	-19.8%	4.3%	-27.9%	-46.5%	-54.4%

**in USD. Source : Kellogg, Charnes and Demirer (1999)*

Other researchers provide evidence in the more specific context of offshore petroleum leases (Paddock, Siegel and Smith, 1988; Howell and Jagle, 1997). Twenty-one tracts in the Western and Central positions of the Gulf of Mexico are examined by Paddock, Siegel and Smith (1988) who value the offshore leases as growth options. To derive theoretical option valuations, Paddock, Siegel and Smith (1988) make assumptions about the future gas price and they then compare the option valuation against two summary measures, (i) the value arising from the use of DCF analysis by the authorities and (ii) the industry bid value.

As illustrated in Table 5.5, which reports the results that are obtained when the gas price is assumed to be high, mean option values approximate the highest (i.e.

winning) bid values better than DCF values do - the mean difference between option values and actual winning values is USD 10.75 million, while the mean difference between theoretical DCF values and actual winning values is USD 14.02 million.

Table 5.5: Real option values, DCF valuation and actual bids on offshore leases

	Sample Mean	Sample standard deviation	Standard error of the mean
Option Valuation (*OV*)	8.20	9.42	2.06
Discounted Cash Flow Valuation (*DCF*)	4.93	6.32	1.38
High/Winning Industry Bid (*HB*)	18.95	16.07	3.51
HB – OV	10.75	16.52	3.60
HB – DCF	14.02	16.19	3.53

in USD millions, N=21, gas price =$3 per mcf Source: Paddock, Siegel, Smith (1988)

Also, Table 5.6 shows that correlation between option values (***OV***) and highest industry bids (***HB***), as examined by Paddock, Siegel and Smith (1988), is greater than the correlation between the ***DCF*** values and the highest industry bids. When the gas price is assumed to be low, correlation between ***OV*** and ***HB*** is 0.21 while correlation between ***DCF*** and ***HB*** is 0.18. Similarly, when the gas price is assumed to be high, the predictive ability of option pricing theory is also greater than that of ***DCF*** as correlation between ***OV*** and ***HB*** is 0.24 while correlation between ***DCF*** and ***HB*** is 0.18.

Table 5.6 : Correlation between real option values, DCF valuation and actual bids

Panel A : Correlation coefficients assuming gas price is low

	Option Valuation (*OV*)	Discounted Cash Flow Valuation (*DCF*)	High/Winning Industry Bid (*HB*)
Option Valuation (*OV*)	1		
Discounted Cash Flow Valuation (*DCF*)	0.99	1	
Highest Bid (*HB*)	0.21	0.18	1

Panel B : Correlation coefficients assuming gas price is high

	Option Valuation (*OV*)	Discounted Cash Flow Valuation (*DCF*)	High/Winning Industry Bid (*HB*)
Option Valuation (*OV*)	1		
Discounted Cash Flow Valuation (*DCF*)	0.98	1	
Highest Bid (*HB*)	0.24	0.18	1

in USD mn, N=21, high gas price=$3 per mcf, low gas price=$2 per mcf. Source : Paddock, Siegel, Smith (1988)

Evidence of the economic significance of growth options in the oil sector is also provided in Howell and Jagle (1997) who report a higher level of agreement among oil managers than in other sectors with the assumptions required by the real options framework. However, the study of Howell and Jagle shows less over-valuation among oil managers of both options to expand and growth options than managers in other areas.

In general, the findings of Howell and Jagle are in agreement with Schwartz and Moon (2000), Kellogg, Charnes and Demirer (1999), and Paddock, Siegel and Smith (1988), each of whom claim that excess market valuations are not fully justified by real option theory. However, the study by Howell and Jagle indicates that the difference between observed valuation practices and real option theoretical valuation is due to the managers' tendency to overvalue real options, instead of claiming that other factors explain the excessive valuation.

Instead of using actual bid prices as a benchmark to examine whether option valuation theory has a higher explanatory power than DCF, Howell and Jagle (1997) use empirical valuations of hypothetical cases. That is to say, these authors asked managers in the nine leading UK companies in the oil, aerospace, telecommunications, pharmaceuticals and brewing industry (82 managers in total) to take hypothetical decisions on a series of investment case studies. Each of the 14 case studies required the managers involved to evaluate an option to expand. As illustrated in Table 5.7, in all but two cases (A_6, A_7), theoretical option values provide better predictions of empirical valuations than DCF values. In particular, real options provide better predictions in all the cases of 'out-of-the-money' options (A_1-A_3, B_1-B_5, C_1-C_2), while in two out of the four 'in-the-money' options, DCF gives equal or better prediction of empirical valuations. Notably, real option valuation fails in cases where NPV is high (NPV is equal to 15 and 20 respectively) compared to the rest of the examined cases, indicating that real options are value relevant whenever NPV is incremental. For four case studies, the theoretical option value line lies inside the 95% confidence interval around the empirical data and for three other case studies it lies only slightly above the upper 95% confidence interval. For the remaining cases, theoretical values do not predict empirical values. This might appear to suggest that the respondents' intuition is compatible with real option theory, under the particular conditions of the experiment, but there is only a weak and approximate correspondence between management intuition and theory. Indeed, Howell and Jagle (1997) conclude that "on average, the respondents overvalue the cases by 78% of the theoretical option value".

Table 5.7: Hypothetical project valuations and real options (Source: Howell and Jagle, 1997)

	Out of the money			In the money				Out of the money						
Case studies:	A_1	A_2	A_3	A_4	A_5	A_6	A_7	B_1	B_2	B_3	B_4	B_5	C_1	C_2
Empirical valuation	0	1.7	4	6.3	15	11	14	3.2	6.5	4.8	8	4.1	5.7	9.1
Theoretical Option Value (***OV***)	0.1	0.5	3	6.8	11	16	20	1.2	2.2	3.8	4.6	5.2	1	4.9
NPV	-7.5	-5	0	5	10	15	20	0	0	0	0	0	0	0
Discrepancy	-0.1	1.2	1	-0.5	4.3	-3.3	-6.6	2	4.3	1	3.4	-1.1	4.7	4.2
Discrepancy /Theoretical ***OV*** (%)	-133	240	33	-7	39	-21	-32	167	195	26	74	-21	470	86
Significance*	NS	S	S	NS	S	S	S	S	S	S	S	S	S	S
Maturity	3	3	3	3	3	3	3	3	3	3	3	3	1	5
PV of CFs	2.5	5	10	15	20	25	30	10	10	10	10	10	10	10
Volatility	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.2	0.3	0.6	0.7	0.8	0.3	0.6
Intrinsic Value	0	0	0	3	8	13	18	0	0	0	0	0	0	0
Time Value	0.1	0.5	3	3.8	3.1	2.7	2.4	1.2	2.2	3.8	4.6	5.2	1	4.9
Sample size	17	18	20	19	18	15	17	17	12	16	17	17	15	16

**Significance of the discrepancy between the empirical valuation and the theoretical OV. S=significant discrepancy at 5% level NS=not significant discrepancy at 5% level*

So far the studies examined tend to conclude that real options, especially growth options, are value relevant, although theoretical values frequently understate market valuations.

However, a study by Moel, Tufano (1999) examines real options from the perspective of investment practices and the extent to which these coincide with the approach that real option theory prescribes. Using an extended sample (2,056 events) from South American gold mines they examine whether the changes in gold prices, gold price volatility, the fixed cost of operating a mine, marginal costs of production, interest rates and gold reserves are associated with decisions to open or close a mine in the way that real option theory predicts. The results are illustrated in Table 5.10.

There are several conclusions that are in accordance with real option theory, as discussed below.

First, the probability of a mine remaining open increases with the price of gold and is higher if the mine was open in the previous year (model A in Table 5.8). Also, increasing volatility is positively related to the probability that an open mine will remain open (model B). For the mines that closed, increasing volatility is negatively related to the probability of being open in the next year (it may be noted that, although a conclusion of the study, this result is in fact statistically insignificant).

With regard to costs of production, as the variable costs of operations increase, a mine is less likely to remain open, whilst as maintenance costs increase, it is more likely to remain open (model C).

Finally, increasing reserves implies a higher probability that a mine will remain open (model D), and it is also the case that, when interest rates are higher, mines are more likely to stay open (model H).

Overall the study by Moel and Tufano (1999) contributes significantly to the hypothesis that management practices are generally in agreement with the predictions of the real option hypothesis. In that sense, the Moel and Tufano study is comparable to separate research in the electronics sector (Pennings and Lint, 1997) and the IT sector (Benaroch and Kauffman, 1999).

Pennings and Lint (1997) find jump processes appropriate for the valuation of R&D expenditure as a growth option at Philips Corporate Research. Although the growth option approach assigns a higher value to the long term strategic R&D projects than the traditional DCF models, their results are broadly consistent with corporate practice.

Benaroch and Kauffman (1999) argue that option-pricing models can be applied to capital budgeting decisions involving non-traded information technology assets. The researchers illustrate how the Black-Scholes model can be applied in the case of a real world IT investment option (combining a growth option and an option to defer), where significant uncertainties that are not appropriately handled using NPV analysis are present. The researchers estimate the value of the growth option and optimal timing of market entry. Their results are also in line with managerial practice, in this case to defer entry into the POS debit market (for a period of three years which was later recognised to have been just about optimal).

Table 5.8: Real options and the likelihood of a mine closures (Source: Moel and Tufano, 1999)

	Mean value	Predicted Sign	A	B	C	D	E	F	G	H
Intercept			-2.612	-3.473	-1.808	-3.818	-0.906	-2.937	-1.607	-3.873
			0.000	*0.000*	*0.079*	*0.000*	*0.518*	*0.009*	*0.166*	*0.000*
Gold price(in USD)		+	0.004	0.006	0.006	0.006	0.005	0.009	0.001	0.01
Nominal :	367.2		0.0016	0.0024	0.0023	0.0022	0.0019	0.0036	0.0004	0.0039
Deflated :	337.1		*0.021*	*0.011*	*0.010*	*0.012*	*0.153*	*0.000*	*0.888*	*0.000*
Gold volatility interacted with open last-yr y-1	0.12	+		1.949	2.027	2.002	1.987	3.049	1.149	3.108
				0.777	0.793	0.745	0.763	0.814	0.416	0.83
				0.047	*0.054*	*0.052*	*0.151*	*0.006*	*0.364*	*0.006*
Gold volatility interacted with closed last yr	0.12	-		-0.518	-0.975	-0.756	-0.907	-1.371	-3.008	-1.389
				-0.206	-0.382	-0.281	-0.348	-0.544	-0.728	-0.547
				0.575	*0.335*	*0.446*	*0.512*	*0.231*	*0.016*	*0.230*
Fixed costs α (in USD)		+			1.09E-7		5.99E-8	7.23E-8	8.12E-8	7.28E-8
Nominal :	3.66E6				4.27E-8		2.30E-8	2.87E-8	2.94E-8	2.87E-8
Deflated :	3.53E6				*0.001*		*0.204*	*0.080*	*0.052*	*0.051*
Marginal cost β (in USD/oz)		-			-0.009		-0.011	-0.009	0.009	-0.011
Nominal :	203.2				-0.004		-0.004	-0.004	0.003	-0.004
Deflated :	171.1				*0.000*		*0.000*	*0.000*	*0.000*	*0.000*
Reserves (in oz)	1.02E6	+				7.36E-7				
						2.74E-7				
						0.000				
Capitalised cost (M USD) interacted with open y-1		+					0.003			
							0.001			
							0.229			
Capitalised cost (M USD) inter. with closed y-1		-					0.001			
							0.0004			
							0.790			
Technology T interacted with open last yr y-1		+						-0.097	-0.111	-0.114
								-0.039	-0.04	-0.045
								0.475	*0.417*	*0.407*
Technology T interacted with closed last yr y-1		-						0.103	0.094	0.094
								0.041	0.034	0.037
								0.446	*0.488*	*0.491*
10 Year T-Bond rate		+							0.324	0.192
									0.117	0.076
									0.000	*0.057*
Gold lease rate		-							0.03	0.009
									0.011	0.004
									0.782	*0.940*
Open last yr dummy y-1		+	2.199	2.488	2.399	2.363	2.402	2.367	2.235	2.281
			0.87	0.991	0.939	0.88	0.922	0.94	0.81	0.899
			0.000	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
***Mine* fixed effects**			No	No	No	No	No	Yes	Yes	Yes
N			2056	2056	2056	2056	2056	2056	2056	2056
Pseudo-R^2			0.42	0.43	0.5	0.48	0.47	0.56	0.58	0.058

Interpretation of columns	Conclusion
A: Models the probability of a mine remaining open as a function of only the gold price and the mine's prior state.	The probability of a mine remaining open increases with gold price and the probability is higher if the mine was open in the previous year. The evidence is in line with real option theory.
B: Adds gold price volatility to the specification of column A	Increasing volatility is positively related to the probability that an open mine will remain open. For the mines that closed, increasing volatility is negatively related to the probability of being open in the next year, although this result is statistically insignificant. The evidence is in line with real option theory.
C: Adds predicted nominal fixed and marginal costs to the specification of column B	As variable costs of operations increase, a mine is less likely to remain open, and as maintenance costs increase, it is more likely to remain open. The evidence is in line with real option theory.
D: Shows the effect of increasing reserves on the likelihood of the mine being open.	Increasing reserves implies a higher probability of an open mine. The evidence is in line with real option theory.
E: Adds capitalised costs as a measure of closing and reopening costs.	According to real option theory, as capitalised costs increase, open mines should be more likely to stay open. In the study, there is no relationship between these costs and whether a mine is open or closed.
F: Shows the effect of the opening and closing costs as proxied by mine technology interacted with variables that capture the prior state.	In the study, there is no statistically significant relationship between opening and closing costs and the decision whether to close a mine.
G: Adds interest rates to the specification.	When interest rates are higher, mines are more likely to stay open. The evidence is in line with real option theory.
H: Adds deflated instead of nominal interest rates	When interest rates are higher, mines are more likely to stay open. The evidence is in line with real option theory.

** Predicted sign under real option theory*

The study of closure potential in South American mining by Moel and Tufano (1999) indicates that management practices tend to be in line with real option theory, but a survey by Busby and Pitts (1997) shows that British managers on average believe that the option to abandon is a not always present and occurs only in less than 40% of investments, as illustrated in Table 5.9. Busby and Pitts conducted an exploratory survey amongst the finance directors of FTSE 100 firms in the UK in order to examine not only abandonment options but whether a range of real option types occur in capital investments, and also to measure the importance of real options in influencing investment decisions and the existence of procedures to assess real options.

Table 5.9: Flexibility in capital investments (Source: Busby and Pitts, 1997)

Frequency	Postponement	Abandonment	Rescaling	Growth	Technical change
0-20%	21	49	30	14	43
21-40%	16	<u>28</u>	<u>23</u>	21	<u>29</u>
41-60%	<u>16</u>	9	16	12	12
61-80%	16	9	16	<u>28</u>	10
81-100%	30	5	14	26	7

Note. Underlined cells represent median responses

The Busby and Pitts study indicates a widespread recognition of growth options, these being evident in most investments (between 61% and 80%, to use the authors' range). Postponement options (for example, the option to invest) are often present and occur in 41-60% of investments. Finally, 21%-40% of investments include rescaling options (for example, option to expand). In fact, UK managers find all of the option types to be of some importance, if not universally present, as indicated in Table 5.10.

Table 5.10: The importance of flexibility in influencing investment decisions (Source: Busby and Pitts, 1997)

Importance	Postponement	Abandonment	Rescaling	Growth	Technical change
Completely unimportant	9	7	5	5	5
Not especially important	37	38	23	23	40
Moderately important	<u>21</u>	<u>29</u>	<u>30</u>	<u>33</u>	<u>28</u>
Highly important	26	23	37	37	26
Extremely important	7	2	5	2	2

Note. Underlined cells represent median responses

An important point to note, however, is that despite the economic significance of growth options in terms of their value and occurrence in capital investment projects, there appears to be a lack of business procedures amongst managers in valuing these options. Indeed, the study by Busby and Pitts (1997) shows that, although leading UK managers recognise the existence of growth options in about 60% of their investment decisions, only 25% of these managers employs specific procedures in order to value them. The lack of such valuation procedures may explain why there is only a weak and approximate correspondence between management intuition and theory.

With regard to postponement options, the survey conducted among UK finance directors by Busby and Pitts (1997) indicates that these occur in more than 40% of the cases. Furthermore, abandonment, time to build and switch options are present in more than 20% of cases on average. However, as in the case of growth options, not all firms had procedures either to identify or to evaluate other types of real options. Whilst 43% of respondents had developed procedures to value rescaling options, only 20% had done so for time to wait options and 14% for postponement options, as shown in Table 5.11 below.

Table 5.11 : The existence of procedures within the company to assess real options arising from flexibility in capital investments (Source: Busby and Pitts, 1997)

Existence of procedures	Postponement	Abandonment	Rescaling	Growth
Yes	20%	14%	43%	25%
No	80%	86%	57%	75%

Source : Busby, Pitts (1997)

In general, where they exist, management practices appear to be in line with theoretical predictions of what makes a real option valuable. Indeed, Busby and Pitts (1997) report that few decision-makers disagreed with the theoretical prediction, whenever exercise cost and maturity period were examined. However, although 90% of the respondents in the study could recall an investment that had options, and more than half of these options had been exercised, very few of them had heard of the terms "growth options", "real options", or "operating options" in the sense used in the research literature. A small proportion (5% of the examined firms) was actually in the process of assessing the usefulness of real option theory in investment appraisal. The researchers conclude that real options play a significant role in investment decision and investment appraisal, although systematic analysis of such options is uncommon even among large firms.

In studies that investigate the significance of options to defer, the value attributed to real options is not examined directly. Instead, the studies in question investigate whether managerial practice is in line with theoretical models for the option to defer. As discussed previously, Moel and Tufano (1999) provides evidence that the real options model is able to predict closure decisions in mining, and there is further evidence that the option to defer is significant in the POS debit market (Benaroch and Kauffman, 1999). An important contribution to the valuation of the option to wait is made by Quigg (1993) who examined the empirical predictions of a real option-pricing model using a large sample of land market prices in Seattle, USA. Using data on 2700 land transactions for the period 1976-1979, with properties zoned to business, commercial, industrial and low- or high-density residential, Quigg found that a mean premium of 6% of the theoretical land value is attributable to the real option. Quigg (1993) uses the following equation to estimate real option value when valuing land:

$$MV = \alpha + \beta_1 * IV + \beta_2 * (OV - IV) + \varepsilon \qquad (5.3)$$

where

MV is Market price per Square Foot

IV is Intrinsic Value per Square Foot

OV is Option Model Value per Square Foot

The following table (Table 5.12) indicates a high predictive value for the option pricing model in that, first, the estimate of the relevant slope coefficient (β_1) is generally close to one in Panel A and, although the authors do not report significance tests, the ratio of the reported coefficient to its standard error is invariably high. However, DCF values alone also seem to predict land prices with similar efficiency (see Panel B), but when the model is extended, the incremental contribution of the option value over and above the DCF valuation is seen to be highly significant.

Table 5.12 Land prices, real option values and DCF values (Source : Quigg, 1993)

Panel A : *Market price per square foot* $=\alpha + \beta_1$ * *Option model value per square foot* $+ \varepsilon$

Type of property	Year	N	α	Std. Error	β_1	Std. Error	R-square
Business	1977	76	0.7355	0.0957	0.7814	0.0179	0.963
>>	1978	64	-0.5551	0.2962	1.0913	0.0373	0.932
>>	1979	48	0.0919	0.1780	0.9781	0.0296	0.960
Commercial	1977	102	0.6387	0.0900	0.8234	0.0166	0.961
>>	1978	90	-0.8580	0.3470	1.1364	0.0293	0.945
>>	1979	73	1.8306	0.2857	0.7705	0.0304	0.900
Industrial	1977	62	-0.1859	0.1584	1.0786	0.0365	0.936
>>	1978	43	-0.4262	0.1212	1.0973	0.0196	0.987
>>	1979	25	2.0889	0.1367	0.6173	0.0264	0.960
Low-density residential	1977	490	-1.4781	0.1864	1.1566	0.0211	0.860
>>	1978	401	-0.3560	0.1079	1.0662	0.0128	0.945
>>	1979	340	0.6242	0.0727	0.8807	0.0068	0.981
High-density residential	1977	224	-0.5059	0.1200	1.1068	0.0146	0.963
>>	1978	336	0.8254	0.3344	0.9001	0.0545	0.449
>>	1979	360	1.1399	0.0818	0.7987	0.0103	0.944

Panel B: *Market price per square foot* $= \alpha + \beta_2$ * *Intrinsic DCF value per square foot* $+ \varepsilon$

Type of property	Year	N	α	Std. Error	β_2	Std. Error	R-square
Business	1977	76	0.6609	0.0798	0.9110	0.0171	0.975
>>	1978	64	-0.6102	0.2662	1.1606	0.0354	0.945
>>	1979	48	1.2966	0.1193	0.9666	0.0234	0.974
Commercial	1977	102	1.3372	0.0791	0.7985	0.0163	0.960
>>	1978	90	0.1117	0.3533	1.0826	0.0304	0.935
>>	1979	73	2.1786	0.3027	0.8182	0.0360	0.878
Industrial	1977	62	0.1157	0.1163	1.1502	0.0301	0.960
>>	1978	43	0.6801	0.1481	0.9998	0.0255	0.974
>>	1979	25	2.3146	0.1737	0.5993	0.0349	0.928
Low-density residential	1977	490	1.9440	0.1092	0.9131	0.0080	0.964
>>	1978	401	0.1129	0.1103	1.0307	0.0133	0.938
>>	1979	340	1.3223	0.0656	0.9142	0.0067	0.982
High-density residential	1977	224	-0.3230	0.1494	1.1261	0.0189	0.941
>>	1978	336	2.3718	0.2671	0.7261	0.0475	0.412
>>	1979	360	2.6650	0.0762	0.6772	0.0105	0.921

Panel C: Market price per Square Foot $= \alpha + \beta_2$ * *Intrinsic DCF value per Square Foot +* $+ \beta_3$ * *(Option model value per square foot - Intrinsic DCF value per square foot)* $+ \varepsilon$

Type of property	Year	n	A	Std. Error	β_2	Std. Error	β_3	Std. Error	R-square
Business	1977	76	0.3412	0.0753	0.9372	0.01361	0.69930	0.09605	0.985
>>	1978	64	-0.7711	0.2431	1.1721	0.03203	0.37390	0.18748	0.956
>>	1979	48	1.2424	0.4509	0.9700	0.03601	0.04240	0.34273	0.979
Commercial	1977	102	0.4839	0.1730	0.8924	0.02261	0.78350	0.14528	0.969
>>	1978	90	-1.0618	0.5015	1.1508	0.03611	1.32960	0.42118	0.942
>>	1979	73	1.4745	0.3358	0.8390	0.03356	0.64390	0.18164	0.898
Industrial	1977	62	0.1332	0.0670	1.0705	0.01881	0.52850	0.04791	0.987
>>	1978	43	0.3627	0.0746	0.9821	0.01211	0.63520	0.05281	0.994
>>	1979	25	1.4150	0.1651	0.7318	0.03203	0.55810	0.06866	0.960
Low-density residential	1977	490	0.6630	0.2016	0.9679	0.01021	0.65370	0.08228	0.968
>>	1978	401	-0.8380	0.0742	0.9719	0.00929	1.26780	0.05700	0.972
>>	1979	340	-0.2634	0.1327	1.0217	0.00990	1.29620	0.09926	0.988
High-density residential	1977	224	0.0782	0.1086	1.0093	0.01544	0.93320	0.06207	0.971
>>	1978	336	-0.0537	0.5213	0.9939	0.06778	1.51050	0.28259	0.458
>>	1979	360	0.3955	0.1520	0.8963	0.01573	1.08430	0.06712	0.954

Note : Intrinsic Value is the value of the property without the value of the option

Some limitations of prior real options research

One obvious limitation concerning evidence either against or in support of real option theory is the limited scope of prior research and the small number of research papers in the area, and there are additional limitations arising from the survey methodology used and the proxies for real options that have been adopted.

In particular, although past research provides some support for real option theory, it is apparent that there is insufficient empirical evidence to justify the application of option pricing theory for project valuation purposes. Only eight research papers provide some evidence of the use of real options in practice, five of which were conducted in the United States and two in the United Kingdom.

The surveys made to investigate whether managers use or can use option pricing theory in project valuation have been conducted generally in major firms, and cannot be generalised as they have not been extended to large samples companies. Moreover, Pike (1997) questions the results of the study carried out by Howell and Jagle (1997), arguing that managers asked for similar experiments had on average extensive experience within organizations and did not represent the average manager.

The choice of valuation metrics is another area of concern regarding the design of prior experimental work. Both Kester (1984) and Chung and Charoenwong (1991) use the Earnings to Price (***EP***) ratio to derive growth option values and growth option proxies and, although the use of the ***EP*** ratio as a growth proxy is widely used in financial literature (Lintzenberger and Rao, 1971; Beaver and Morse, 1978; Damodaran, 1996), there is limited theoretical justification in the published work on real options. In an attempt to overcome this, Chung and Charoenwong (1991) provide a rationale for the use of ***EP*** ratio as the proxy of growth opportunities, first assuming that the market equilibrium price of a common stock is expressed by the equation

$$SP = \frac{EPS}{r_d} + \frac{PVGO}{N} \qquad (5.4)$$

where

EPS/r_d is the capitalized value of the earnings that the firm would generate with the assets already in place,

given that

V_Q is the market equilibrium price

EPS_1 is the earnings per share at time 1 generated from the assets already in place at time 0,

r_d is the capitalization rate

$PVGO$ is the present value of growth opportunities

N is the number of shares

The rearrangement of (5.4) yields

$$\frac{PVGO}{V_Q} = 1 - \left(\frac{EP}{r_d}\right) \tag{5.5}$$

where

$$EP = \frac{EPS_1 N}{V_Q}$$

Differentiating $PVGO/V_Q$ with respect to EP, we obtain

$$d\left(\frac{PVGO}{V_Q}\right) = -\frac{1}{r_d} dEP \langle 0$$

Thus the larger the Earnings to Price ratio EP, the smaller the ratio of equity value accounted for by growth opportunities, *ceteris paribus*.

As shown earlier, Ottoo (2000) uses Price over Book Value as a real option value proxy. Although Price over Book Value is also used elsewhere by Damodaran (1996) as a proxy of growth option value, it lacks the kind of theoretical justification provided for EP by Chung and Charoenwong (1991). However, recent advances in the area of valuation have provided a sound approach that is able to fill the gap between theory and practice by providing the means to examine the impact of real options on the market value of a company. The next section discusses recent studies that examine the impact of long term investment on company market value, especially the residual income valuation studies.

5.2 The Impact of Long-Term Investment on Market Value

Research into the impact of long term investment on company market value follows two different paths in general, one relating to market shocks at the time of announcements of value-relevant information (often known as 'event studies'), and the other concerning the valuation of the firm and the bundle of investments that it holds (i.e. 'association studies'). In short, event studies assess the effect of investment announcements on company value, while association studies measure the relationship between those investments and the market value of the firm. This thesis attempts to integrate real option theory into the valuation of the firm, both with respect to the effect of real option announcements and similar events and, through the residual income model, the aggregation of real options into the bundle of assets that underlie the firm's overall market value. In the rest of this chapter, a brief review is provided of some of the salient points arising in relevant event studies and association studies.

Event studies and the announcement of new information

Event studies compare prices during an "estimation period"[2] to prices after the announcement with a view to detecting unusual or abnormal returns that are not in line with expectations. The existence of statistically important abnormal returns (the difference between actual and expected returns) indicates a reaction to the announcement. In general, the stock market is expected to react positively to announcements of increases in long term investments. Empirically, the stock market is known to react positively on average to announcements of the increases in planned capital expenditure and negatively to decreases in planned capital expenditure, with the exception of oil and gas exploration (McConell and Muscarella, 1985). Even when the announcement occurs in the face of an earnings decline, share price responses to announcements of increased research and development spending are significantly positive on average (Chan, Martin and Kensinger, 1990). Abnormal returns however are not uniform across industries. High-technology firms that announce increases in R&D spending experience positive abnormal returns on average, whereas announcements by low-technology firms are associated with negative abnormal returns. Besides, as Chan, Martin and Kensinger (1990) also show, higher R&D spending intensity than the industry average is found to be associated with larger stock-price increases only for firms in high-technology industries.

Thus, the value significance of the kind of events that surround real option creation - such as increases and decreases in planned capital investment and changes in R&D expenditure, or details relating to the nature of related investment projects - are amenable to testing using an 'events study' methodology. However, this may not capture the long-term impact of new investments on market value[3], and in that regard we need to look towards valuation modelling and the association between the company's value and the real options that it holds.

Association studies and the value of the firm

The investigation of the long-term impact of capital investment on market value becomes conclusive when incorporating factors that consistently affect market value. Therefore, not surprisingly, recent association studies that examine the value relevance of a company's investments also investigate the critical fundamental factors that affect the market values. This research frequently has led to a dispute over the simple CAPM model where the beta factor was assumed to drive market returns.

The standard empirical methodology was set down by Fama and MacBeth (1973), the basic theoretical claim described in FM, resulting from the Sharpe-Lintner version of the CAPM, simply stating that variability in market betas accounts for a significant portion of the cross-sectional variability of stock returns at a certain point in time.

The market relevance of the beta factor is challenged in Fama and French (1992) who test the following model:

[2] In most event studies, the estimation period is before announcements.

[3] Event study methodology may not capture the long-term impact of new investments on market value, because the effect of investment is not always ex-ante priced correctly. Mispricing of investment might be attributed to unexpected or not anticipated changes (e.g. to unexpected changes of economic or political factors or unexpected response from competitors) that affect the outcome of investment or its prospects.

$$R_t = \alpha_1 BETA + \alpha_2 \ln(MVE) + \alpha_3 \ln(\tfrac{BVE}{MVE}) + \alpha_4 \ln(\tfrac{BVA}{MVE}) + \alpha_5 \ln(\tfrac{BVA}{BVE}) + \\ + \alpha_6 (EPdummy) + \alpha_7 (\tfrac{EPS_t(+)}{SP}) + \varepsilon_i \tag{5.7}$$

where

R_t are market returns

BETA is the post-ranking beta of the size-beta portfolio they are in at the end of June of year t

MVE is the market value of equity

BVE is the book value of common equity plus balance-sheet deferred taxes

BVA is total book assets

E_t is earnings (income before extraordinary items, plus income-statement deferred taxes, minus preferred dividends)

if earnings are positive, the ***EP*** dummy is zero and ***EPS(+)/SP*** is the ratio of total earnings to market equity

if earnings are negative, the ***EP*** dummy is one and ***EPS(+)/SP*** is zero.

Their study, which runs a set of regressions to derive slopes of specific variables on monthly returns of US companies for the period from July 1963 to December 1990, indicates that size and book-to-market equity capture much of the cross-sectional variation in average stock returns and they conclude that the relation between an average return and beta is not reliable. Fama and French sort the data annually in terms of both size (***MVE***) and systematic risk (***BETA***) and estimate average portfolio slopes which are reported in Table 5.13. The study confirms the importance of ***BVE/MVE*** in explaining market returns (the coefficient of 0.33 and is 1% significant) and the relevance of size ***MVE***, which has a negative coefficient (-0.13, 5% significant). However most of the relations between ***EP*** and average returns is due to the correlation between ***EP*** and ***BVE/MVE,*** something that, given the opposite sign of the leverage measures, ***BVA/MVE*** and ***BVA/BVE,*** leads to the conclusion that the effect of ***EP*** and the leverage measures is captured by size and the book-to-market factor.

These findings are further supported by Fama and French (1993) and Fama and French (1996), who investigate additional critical factors that affect the market value. The three-factor risk-return model employed in Fama and French (1993) is found in Fama and French (1996) to be a good predictive model for portfolio returns. Pope and Stark (1997) run simulations that indicate that the factors analysed by Fama and French (1992) - market value, book-to-market value and earnings-to-price - are strongly associated with asset beta, volatility, level of demand, excess capacity and expected returns. Their model provides an economic rationale for the Fama and French (1992) risk factors.

Table 5.13 Size and the book-to-market ratio as predictors of return (Source: Fama and French ,1992)

$$R_t = \alpha_1 beta + \alpha_2 \ln(MVE) + \alpha_3 \ln(\frac{BVE}{MVE}) + \alpha_4 \ln(\frac{BVA}{MVE}) + \alpha_5 \ln(\frac{BVA}{BVE}) + \alpha_6 (EP\ dummy) + \alpha_7 (\frac{EPS(+)}{SP}) + \varepsilon_i$$

	beta	ln*(MVE)*	ln*(BVE/ MVE)*	ln*(BVA/ MVE)*	ln*(BVA/ BVE)*	*EP dummy*	*EPS(+)/SP*
Beta	0.15 *-0.46*						
Beta, Size	-0.37 *-1.21*	-0.17 *-3.41*					
Size, Book-to-Market, Earnings		-0.13 *-2.47*	0.33 *4.46*			-0.14 *-0.90*	0.87 *1.23*
Size, Assets-to-Market, Assets-to-Book, Earnings		-0.13 *-2.47*		0.32 *4.28*	-0.46 *-4.45*	-0.08 *-0.56*	1.15 *1.57*

Notes : R_t are Market returns, ***beta*** is the post-ranking beta of the size-beta portfolio they are in at the end of June of year t, ***MVE*** is the market value, ***BVE*** is the book value of common equity plus balance-sheet deffered taxes, ***BVA*** is total book assets, ***E*** is earnings (income before extraordinary items, plus income-statement deferred taxes, minus preferred dividends), if earnings are positive, ***EP dummy*** is zero and ***EPS(+)/SP*** is the ratio of total earnings to market equity, if earnings are negative, ***EP dummy*** is one and ***EPS(+)/SP*** is zero. Examined period: July 1963-December 1990

Although the Fama and French (1992) approach indicates the determinants of market risk, it does not provide us with a rationale to estimate the market value of a firm. The residual income model fills this gap.

Residual income valuation

According to the Ohlson residual income valuation model (Ohlson, 1989; Ohlson, 1995), the market value of the firm can be expressed as the summation of the book value of equity and the present value of future abnormal earnings. This is expressed by the equation

$$MVE_t = BVE_t + \sum_{i=t}^{t+n} E\left[\frac{RI_{i+1}}{(1+r_d)^i}\right] \qquad (5.8)$$

given that

$$BVE_t = BVE_{t-1} + E_t - NSCF_t \qquad (5.9)$$

$$RI_t = E_t - r_d BVE_{t-1} \qquad (5.10)$$

where

MVE_t is the value of the firm

r_d is the discount rate

BVE_t is the book value of equity

E_t denotes earnings for period t

$NSCF_t$ denotes net dividends (dividends less capital contribution) paid at date t

RI_t denotes the abnormal earnings, or residual income, for the period to t.

The time-series behaviour of residual income is described by linear information dynamics models which provide a link between current information and a firm's intrinsic value. The Ohlson (1995) linear information dynamics assume that the time-series behaviour of residual income follows

$$RI_{t+1} = \omega_{11} RI_t + v_t + \varepsilon_{1t+1} \qquad (5.11)$$

given that

$$v_{t+1} = \gamma_{vt} + \varepsilon_{2t+1},$$

while Feltham and Ohlson (1995) linear information dynamics assume that the time-series behaviour of abnormal earnings follows

$$\boldsymbol{RI}_{t+1} = \omega_{11}\boldsymbol{RI}_t + \omega_{12}\boldsymbol{BVE}_t + v_{1t} + \varepsilon_{1t+1} \qquad (5.12)$$

given that

$$\boldsymbol{BVE}_{t+1} = \omega_{22}\boldsymbol{BVE}_t + v_t + \varepsilon_{2t+1},$$

$$v_{1t+1} = \gamma_1 v_{1t} + \varepsilon_{3t+1}$$

and

$$v_{2t+1} = \gamma_2 v_{2t} + \varepsilon_{4t+1}$$

where

$\boldsymbol{RI}_t$ is residual income for period t $(\boldsymbol{RI}_t = \boldsymbol{E}_t - \boldsymbol{rBVE}_{t-1})$

v_t, v_{1t}, v_{2t} is information other than abnormal earnings

ω_{11} is the persistence parameter on abnormal earnings $\boldsymbol{RI}_t$;$(0 \le \omega_{11} < 1)$

ω_{12} the conservatism parameter; $(0 \le \omega_{12})$

ω_{22} is growth parameter of book value of equity; $(0 \le \omega_{22} < 1+r)$

$\gamma, \gamma_1, \gamma_2$ is persistence parameter of other information v_t, v_{1t}, v_{2t} respectively ;$(0 \le \gamma, \gamma_1, \gamma_2 < 1)$,

$\varepsilon_{1t}, \varepsilon_{2t}, \varepsilon_{3t}, \varepsilon_{4t}$ are error terms

The difference between Ohlson (1995) and Feltham and Ohlson (1995) lies in the model assumptions. The Ohlson (1995) model assumes that the source of abnormal earnings is monopoly rents. These may persist for some time, but market competition will force returns toward the cost of capital in the long run, so the persistence parameter ω_{11} is predicted to lie in the range $0 \le \omega_{11} < 1$. The Feltham and Ohlson (1995) model assumes that the sources of abnormal earnings are not only monopoly rents but also accounting conservatism. Similarly to Ohlson (1995), monopoly rents may persist for some time but market competition will force returns toward the cost of capital in the long run, so the persistence parameter ω_{11} is again predicted to lie in the range $0 \le \omega_{11} < 1$. Accounting conservatism depresses the valuation of assets below their market value, which generates abnormal earnings that are the result of cost of capital multiplied by the difference between market value and book value, so $\omega_{12} \leq 0$.

Thus, Ohlson (1995) linear information dynamics combined with residual income valuation yields the following valuation function where

$$MVE_t = BVE_t + \alpha_1 RI_t + \beta_1 v_t$$

given that

$$\alpha_1 = \frac{\omega_{11}}{1+r-\omega_{11}}$$

and

$$\beta_1 = \frac{1+r}{(1+r-\omega_{11})(1+r-\gamma)}$$

On the other hand, Feltham and Ohlson (1995) linear information dynamics combined with residual income valuation yield the valuation function

$$MVE_t = BVE_t + \alpha_1 RI_t + \alpha_2 NSCF_t + \beta_1 v_{1t} + \beta_2 v_{2t} \qquad (5.13)$$

given that

$$\alpha_1 = \frac{\omega_{11}}{1+r-\omega_{11}}$$

$$\alpha_2 = \omega_{12}\frac{1+r}{(1+r-\omega_{11})(1+r-\omega_{22})}$$

$$\beta_1 = \frac{1+r}{(1+r-\omega_{11})(1+r-\gamma_1)}$$

and

$$\beta_2 = \omega_{12}\frac{1+r}{(1+r-\omega_{11})(1+r-\omega_{22})(1+r-\gamma_2)}$$

Therefore, both Ohlson (1995) and Feltham and Ohlson (1995) provide valuation functions of a firm without requiring either explicit forecasts of future dividends or additional assumptions about the calculation of terminal value. In a regression form, equation 5.13 can be expressed as

$$MVE_t = \alpha_0 + \alpha_1 BVE_t + \alpha_2 E_t + \alpha_3 NSCF_t + \varepsilon \qquad (5.14)$$

where α_3 should be negative and $\alpha_1 + \alpha_3 = -1$

Importantly, model 5.14 may be restated in a number of ways so as to examine the validity of Ohlson dynamics, as below. First, given that

$$NSCF_t = D_t - CC_t$$

where

D_t are dividends

CC_t are capital contributions

then model (5.14) can be restated as

$$MVE_t = \alpha_0 + \alpha_1 BVE_t + \alpha_2 E_t + \alpha_{31} D_t + \alpha_{32} CC_t + \varepsilon \qquad (5.15)$$

Second, where earnings less dividends is equivalent to Retained profits (RE_t), i.e.

$$E_t = D_t + RE_t$$

and closing book value (BVC_t) may be reconciled to opening book value (BVO_t) as

$$BVC_t = BVO_t + RE_t + CC_t$$

it follows that

$$BVC_t - E_t = BVO_t + RE_t + CC_t - D_t - RE_t = BVO_t + CC_t - D_t$$

so

$$NSCF_t = CC_t - D_t = BVC_t - E_t - BVO_t$$

Therefore Equation 5.14 can be restated as

$$\begin{aligned} MVE_t &= \alpha_0 + \alpha_1 BVO_t + \alpha_2 E_t + \alpha_3 (BVC_t - E_t - BVO_t) + \varepsilon \\ &= \alpha_0 + (\alpha_1 - \alpha_3) BVO_t + (\alpha_2 - \alpha_3) E_t + \alpha_3 BVC_t + \varepsilon = \\ &= \alpha_0 + \alpha_1' BVO_t + \alpha_2' E_t + \alpha_3 BVC_t + \varepsilon \end{aligned} \qquad (5.16)$$

for $\alpha_1' = (\alpha_1 - \alpha_3)$

and $\alpha_2' = (\alpha_2 - \alpha_3)$

In the context of the present thesis, it is worth noting that in recent research studies that build on the Ohlson framework, a number of other factors have been put forward as predictors of part of the unexplained proportion of market value, and tested accordingly. For instance, given that earnings $\boldsymbol{E}$ can be expressed as the summation of Earnings before R&D and Advertising expenses plus R&D and Advertising expenses, equation 5.16 is expressed in Shah and Stark (2001) as

$$MVE_t = \alpha_0 + \alpha_1 A_t + \alpha_2 RD_t + \alpha_3 E_t + \alpha_4 BVC_t + \alpha_5 BVO_t + \varepsilon \qquad (5.17)$$

where

A_t denotes Advertising expenses,

RD_t denotes Research and Development Expenses

Shah and Stark (2001) test this model separately for manufacturing and non-manufacturing firms. They conclude that, on the basis of individual coefficient estimates, earnings (α_3) and closing book value (α_4) are generally positive and highly significant, being in line with the Ohlson residual income model assumptions. As indicated in Table 5.14, the coefficient of earnings (α_3) is statistically significant at the 10% level for all the reported regressions except for the medium-sized manufacturing firms. The coefficient of closing book value (α_4) is in all cases statistically significant. Advertising expenses are a significant explanatory variable for medium and large non-manufacturing firms, while R&D expenditures are a significant explanatory variable for manufacturing firms.

Table 5.14 Significance of advertising and R&D expenses (Source: Shah and Stark, 2001)

$$MVE_t = \alpha_0 + \alpha_1 A_t + \alpha_2 RD_t + \alpha_3 E_t + \alpha_4 BVC_t + \alpha_5 BVO_t + \varepsilon_i,$$

Panel A: Manufacturing Firms

Size	α_0	α_1	α_2	α_3	α_4	α_5	R^2
Small	5371.43 (.00)	.73 (.61)	3.16 (.00)	.37 (.06)	.57 (.00)	-0.4 (.72)	.20
Medium	31954.03 (.00)	.47 (.71)	3.44 (.00)	.51 (.05)	1.00 (.00)	-0.13 (.27)	.51
Large	100767.7 (.00)	3.85 (.48)	4.11 (.00)	3.45 (.00)	1.25 (.00)	.03 (.82)	.49
Pooled	-3366.12 (.00)	1.46 (.37)	6.64 (.00)	1.44 (.00)	1.81 (.00)	.08 (.54)	.18*

Panel B: Non-Manufacturing Firms

Size	α_0	α_1	α_2	α_3	α_4	α_5	R^2
Small	8510.71 (.00)	-3.38 (.14)	2.85 (.00)	.58 (.00)	.6 (.04)	.27 (.03)	.25
Medium	51349.55 (.00)	6.15 (.02)	.82 (.47)	.59 (.18)	.78 (.00)	-0.06 (.63)	.62
Large	149901.5 (.00)	12.61 (.00)	-0.09 (.95)	2.65 (.00)	1.61 (.00)	-0.03 (.88)	.43**
Pooled	1112.13 (.17)	13.60 (.00)	3.37 (.02)	1.74 (.00)	1.53 (.00)	.43 (.03)	.12**

*All regressions are estimated in deflated form using BVC as the deflator. Reported p-values are in parentheses and are based upon White's (1980) heteroscedasticity-adjusted estimates of coefficient standard errors. *(**) denotes an F-statistic statistically significant at the 5% (1%) level for the null hypothesis that $\alpha_1 = -\alpha_3$*

The regression coefficient for Advertising expenditures for non-manufacturing firms in the pooled data is high (13.60) and significant at the 1% level, and that of R&D expenses is 3.37 which is significant at the 2% level. Overall, the study indicates the significance of Advertising and R&D expenses in residual income valuation.

Building on the above, consider next a restricted version of the clean surplus equation that expresses Market Value as a function of Book Value and Discounted Future Residual Income (equation 5.9), as follows

$$MVE_t = BVE_t + \sum_{i=t}^{t+n} \mathrm{E}\left[\frac{RI_{i+1}}{(1+r_k)^i}\right] \qquad (5.18)$$

Given that Residual Income can increase at a declining rate δ, the summation of expected residual income flows can be expressed as

$$\sum_{i=t}^{t+n} E[RI_{i+1}] = (1-\delta)^n RI_t \tag{5.19}$$

Also, given that

$$\beta = \frac{1-\delta}{r_k - \delta}$$

equation (5.18) may be transformed to

$$MVE_t = BVE_t + \beta RI_t \tag{5.20}$$

A less restricted form of this clean surplus equation (Ohlson, 1989) allows for other control variables, as follows:

$$MVE_t = BVE_t + \beta(E_t - rBVE_{t-1}) + \gamma Z_t \tag{5.21}$$

where

MVE_t is the market value of the firm's stock at time t

BVE_t is the book value of equity at time t

E_t is reported accounting earnings at time t

r is the risk-free interest

$(E_t - rBVE_{t-1})$ is abnormal earnings, i.e. residual income RI_t

Z_t is a vector of other information variables at time t

Thus, other factors that reflect future value could also be added, and it is this model that will be developed later in this thesis to account for real options. Elsewhere, Green, Stark and Thomas (1996) add Research and Development expenditure and Sougiannis (1994) adds Advertising expenditure. To control for size, all factors are deflated, including Research and Development expenditures, leading to the following equation examined in Green, Stark and Thomas (1996) where the deflator is Book Value:

$$\left(\frac{MVE_{i,t}-BVE_{i,t}}{BVE_{i,t}}\right)=\alpha_0+\alpha_1\left(\frac{1}{BVE_{i,t}}\right)+\alpha_2\left(\frac{RI_{i,t}}{BVE_{i,t}}\right)+\alpha_3\left(\frac{RD_{i,t}}{BVE_{i,t}}\right)+\varepsilon_{i,t} \qquad (5.22)$$

Green, Stark, Thomas (1996) also use the following, more extensive, equation in an attempt to capture other effects on market value

$$\frac{(MVE_{i,t}-BVE_{i,t})}{BVE_{i,t}}=\alpha_0+\alpha_1\frac{1}{BVE_{i,t}}+\alpha_2\left(\frac{RI_{i,t}}{BVE_{i,t}}\right)+\alpha_3\left(\frac{RD_{i,t}}{BVE_{i,t}}\right)+\lambda_1 Z_1+\lambda_2 Z_2+\lambda_3 Z_3 +\lambda_4 Z_4+\lambda_5 Z_5+\lambda_6 Z_6+\varepsilon_i \qquad (5.23)$$

where

$MVE_{i,t}$ is market value for firm i six months after the end of year t

$BVE_{i,t}$ is book value for firm i at the end of financial year t

$RI_{i,t}$ is residual income for firm i in year t

$RD_{i,t}$ is research and development expenditure for firm i in year t

Z_1 is the market share possessed by firm i in year t

Z_2 is the degree of concentration for the industry to which firm i belongs in year t

Z_3 is the ratio of short- and long-term debt to shareholders' equity plus reserves for firm i in year t

Z_4 is the ratio of short- and long-term debt to shareholders' equity plus reserves for the industry to which firm i belongs in year t

$Z_5 = (Z_3-Z_4)^2$

Z_6 is the average variance of the stock returns for firm i for the four quarters ending in the quarter of the financial year-end.

Although the work of Green, Stark and Thomas indicates that the coefficient of Debt/Equity λ_3 is significant, the overall inclusion of additional explanatory variables does not increase the fit of the regression. Instead, residual income, book value and R&D expenditures are sufficient variables to account for excessive market value.

Table 5.15 Deflation by book value (Source: Green, Stark and Thomas, 1996)

$$\frac{(MVE_{i,t}-BVE_{i,t})}{BVE_{i,t}} = \alpha_0 + \alpha_1 \frac{1}{BVE_{i,t}} + \alpha_2 (\frac{RI_{i,t}}{BVE_{i,t}}) + \alpha_3 (\frac{RD_{i,t}}{BVE_{i,t}}) + \lambda_1 z_1 +$$
$$+ \lambda_2 z_2 + \lambda_3 z_3 + \lambda_4 z_4 + \lambda_5 z_5 + \lambda_6 z_6 + \varepsilon_i ,$$

α_0	α_1	α_2	α_3	λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	R^2
0.91 *1.79* [2.36]	4971.3 *2.59* [1.67]	4.77 *15.47* [9.42]	4.84 *82.67* [48.50]	-1.09 *-1.39* [-1.72]	0.10 *0.23* [0.26]	1.99 *4.56* [3.77]	-0.44 *-0.57* [-0.62]	0.85 *1.64* [2.01]	-0.02 *-1.76* [-2.03]	0.917
0.86 *8.63* [9.95]	4301.1 *2.51* [1.54]	4.65 *15.07* [8.03]	4.86 *82.01* [47.85]							0.914

Notes : $MVE_{i,t}$ is market value for firm i six months after the end of year t, $BVE_{i,t}$ is book value for firm i at the end of financial year t, $RI_{i,t}$ is residual income for firm i in year t, $RD_{i,t}$ is research and development expenditure for firm i in year t, z_1 is the market share possessed by firm i in year t, z_2 is the degree of concentration for the industry to which firm i belongs in year t, z_3 is the ratio of short- and long-term debt to shareholders' equity plus reserves for firm i in year t, z_4 is the ratio of short- and long-term debt to shareholders' equity plus reserves for the industry to which firm i belongs in year t, z_5 is $(z_3-z_4)^2$, z_6 is the average variance of the stock returns for firm i for the four quarters ending in the quarter of the financial year-end. Time Period 1990-1992

Residual income can also be equal to a summation of other factors. Stark (2000) defines expected residual income as a summation of present value and the value of an option to wait or to invest. In other words

$$RI = V - OVWI \qquad (5.24)$$

where

V is present value of a firm

$OVWI_t$ is the value of option to wait or invest

Similarly, Pope and Stark (1997) extend equation 5.18 to incorporate the value of real options as

$$MVE = \sum MVAP + \sum OVI \qquad (5.25)$$

where

$MVAP$ is the value of assets in place and

OVI is the value of option to invest.

Both equations 5.24 and 5.25 provide approaches that help to link residual income with real options. However, in principle, the less restricted form, expressed in equation 5.12, provides the ability to integrate existing models by simply incorporating new *z*-factors. In the context of R&D expenditure, Sougiannis (1994) utilises the Ohlson equation 5.21, which is restated as

$$MVE_t = BVE_t + \beta(E_t - rBVE_{t-1}) + \gamma Z_t \tag{5.26}$$

where

BVE_t is the book value of equity at time t

E_t is accounting earnings at time t

$(E_t - rBVE_{t-1})$ is residual income

Z_t is a vector of other information variables at time t,

In this case, the reported accounting earnings can be re-expressed as

$$E_t = EBRD_t(1 - \tau_{At}) + RD_t\tau_{At} - RD_t \tag{5.27}$$

where

$EBRD_t$ is earnings before R&D expenditures at time t,

RD_t is R&D expenditures at time t

$\tau_{A,t}$ is the firm's tax rate at time t

Sougiannis scales the earnings equation by net capital stock and the valuation equation by the book value of equity so as to mitigate heteroscedasticity and by using a natural log of examined variables in the valuation equation so as to reduce skewness.

The empirical equations that are estimated are the following

$$\begin{aligned} ln\left(\frac{MVE_{i,t}}{BVE_{it}}\right) &= \alpha\left(\frac{1}{BVE_{i,t}}\right) + \beta_0\left(\frac{BVE_{i,t}}{BVE_{i,t}}\right) + \beta_1 \frac{(EBRDA_{i,t}(1-\tau_{A,t}) - rBVE_{i,t}-1)}{BVE_{it}} + \beta_2 \frac{RD_{i,t}\tau_{i,t}}{BVE_{i,t}} + \\ &= \sum \beta_{3,l} \frac{RD_{i,t-l}}{BVE_{i,t}} + \varepsilon_i \end{aligned} \tag{5.28}$$

and

$$\frac{EBRDA_{i,t}}{BVE_{i,t}} = \alpha_0 \frac{1}{BVE_{i,t}} + \alpha_1 \frac{BVE_{i,t}}{BVE_{i,t}} + \alpha_2 \frac{A_{i,t}}{BVE_{i,t}} + \sum \alpha_{3,l} \frac{RD_{i,t-l}}{BVE_{i,t}} + \varepsilon_i \qquad (5.29)$$

where

$EBRDA_{i,t}$ is earnings before advertising and R&D expenditure by firm i at time t,

$BVE_{i,t}$ is net capital stock of firm i at time t, measured as the sum of the inflation-adjusted net book value of property, plant and equipment, the inflation-adjusted value of inventories and the inflation-adjusted value of recorded intangibles,

$A_{i,t}$ denotes advertising expenditure of firm i at time t,

$RD_{i,t-l}$ denotes R&D expenditure of firm i at time t-l

If the theory is correct in the developed model based on equation 5.28, β_0 should not be different from zero and β_1 and β_2 should be positive. Indeed, β_0 is not different from zero, β_1 is equal to 2.757 (significant at the 1% level) and β_2 is equal to 3.321 (significant at the 1% level), giving an indication that both residual income and R&D expenditures are important explanatory variables (Panel A, Table 5.16).

The findings of Panel A are important because the early work of Sougiannis (1994) has shown the importance of R&D as an explanatory variable, and has drawn the attention of other researchers who now follow a similar methodology in investigating residual income valuation.

Table 5.16 R&D expenditure and residual income (Source: Sougiannis, 1994)

Panel A: R&D expenditure and residual income

$$ln(\frac{MV_{i,t}}{BVE_{i,t}}) = \alpha(\frac{1}{BVE_{i,t}}) + \beta_0(\frac{BVE_{i,t}}{BVE_{i,t}}) + \beta_1 \frac{(EBRD_{i,t}(1-\tau_{i,t}) - rBVE_{i,t-1})}{BVE_{i,t}} + \beta_2 \frac{RD_{i,t}\tau_{i,t}}{BVE_{i,t}} +$$
$$= \sum \beta_{3,l} \frac{RD_{i,t-l}}{BVE_{i,t}} + \varepsilon_i,$$

	α_0	β_0	β_1	β_2	$\Sigma\beta_{3,l}$	R^2-adj	β_2-β_1
Mean	0.222	-0.055	2.757	3.321	-0.092	0.32	0.564
T-Ratio	*0.366*	*-0.659*	*6.453*	*7.539*	*-0.185*		*1.227*

*Notes: **$EBRD_{it}$** is earnings before R&D expenditures of firm i at time t, **BVE_{it}** is net capital stock of firm i at time t, measured as the sum of the inflation-adjusted net book value of property, plant and equipment, the inflation-adjusted value of inventories and the inflation-adjusted value of recorded intangibles, **RD_{it-l}** is R&D expenditures of firm i at time t-l. Period 1975-1985.*

Panel B: Advertising, R&D expenditure and residual income

$$\frac{EBRDA_{i,t}}{BVE_{i,t}} = \alpha_0 \frac{1}{BVE_{i,t}} + \alpha_1 \frac{BVE_{i,t}}{BVE_{i,t}} + \alpha_2 \frac{A_{i,t}}{BVE_{i,t}} + \sum \alpha_{3,l} \frac{RD_{i,t-l}}{BVE_{i,t}} + \varepsilon_i.$$

α_0	α_1	α_2	$\alpha_{3,1}$	$\alpha_{3,2}$	$\alpha_{3,3}$	$\alpha_{3,4}$	$\alpha_{3,5}$	$\alpha_{3,6}$	$\alpha_{3,7}$	$\Sigma\alpha_{3,l}$*$RD_{i,t-l}/BVE_{it}$	Mean Lag	R^2-adj
0.126 *1.999*	0.077 *13.441*	1.162 *36.704*	0.286 *5.646*	0.408 *6.475*	0.449 *13.508*	0.400 *9.476*	0.290 *3.942*	0.190 *3.729*	0.060 *2.341*	2.083	3.4	0.63

*Notes : **$EBRDA_{i,t}$** is earnings before advertising and R&D expenditures of firm **i** at time **t**, **$BVE_{i,t}$** is net capital stock of firm **i** at time **t**, measured as the sum of the inflation-adjusted net book value of property, plant and equipment, the inflation-adjusted value of inventories and the inflation-adjusted value of recorded intangibles, **$A_{i,t}$** is advertising expenditures of firm **i** at time **t**, **$RD_{i,t-l}$** is R&D expenditures of firm i at time t-l. Period 1975-1985*

Panel B illustrates the findings when advertising expenses are incorporated as an explanatory variable together with yearly R&D expenditure over 7 successive years, again with significant results.

In related work on R&D, Lev and Sougiannis (1996) run the Fama-French (1992) regression and extend it by adding an estimate of capitalised R&D. In particular, they run the following regression

$$R_{i,t+j} = \alpha_{0,j} + \alpha_{1,j}\beta_{i,t} + \alpha_{2,j} lnMVE_{i,t} + \alpha_{3,j} ln(\tfrac{BVE}{MVE})_{i,t} + \alpha_{4,j} ln(\tfrac{BVA}{BVE})_{i,t} + \quad (5.30)$$
$$+ \alpha_{5,j}(\tfrac{E(+)}{MVE})_{i,t} + \alpha_{6,j}(E/_{MVE} dummy)_{i,t} + \alpha_{7,j} ln(\tfrac{RD}{MV})_{i,t} + \varepsilon_{i,t+j}$$

where

$R_{i,t+j}$ are monthly stock returns of firm i, starting with the 7th month after fiscal t year-end, j=1,..,12

$\beta_{i,t}$ is CAPM-based beta of firm i, estimated from 60 monthly stock returns up to month t (one month preceding the return calculation); a minimum of 24 months is required

$MVE_{i,t}$ is the market value of firm i, calculated as price times number of shares outstanding at t

$BVE/MVE_{i,t}$ is ratio of book value of common equity plus deferred taxes to market value of equity of firm i at fiscal year-end

$BVA/BVE_{i,t}$ is ratio of book value of total assets to book value of common equity of firm i at fiscal year-end

$E(+)/MVE_{i,t}$ is ratio of positive earnings before extraordinary items (plus income-statement deferred taxes, minus preferred dividends), to the market value of equity of firm i at fiscal year-end; this variable is set equal to 0 when earnings are negative

$E/MVE\ dummy_{i,t}$ is set 1 if earnings of firm i for fiscal t are negative, and 0 otherwise

$RD/MVE_{i,t}$ is estimated capitalized R&D over market value of equity at year end

They apply the instrumental variable method by running a two-stage[4] least squares regression[5]. The study provides evidence that R&D investments are associated with profit increases. Benefits for a single dollar of R&D investments range from $2.628 for Chemicals and Pharmaceutics to 1.663 in Machinery and Computer Hardware, implying 15%-28% annual internal rate of return (operating income) of R&D investment. On average, a one-dollar increase in R&D leads to a

[4] In the first stage, for every year and two-digit industry, firms' scaled R&D expenditures (RD/S) are cross-sectionally regressed on the industry R&D level *(IRD/S)*: $(RD/S) = a + b(IRD/S) + u$. In the second stage fitted values are used in the main regression they run, substituting for the actual value of **(RD/S)**. A similar procedure is used to estimate Operating earnings to tangible capital, advertising intensity, and the R&D lag structure, for each year. The reason for the cross-sectional estimation of the main regression coefficient is that data limitations preclude an efficient estimation from individual firms' time series.

[5] They scaled variables by total sales so as to mitigate heteroscedasticity and they use the instrumental variable method to account for simultaneity issues. Simultaneity issues arise when a shock to the regression residual affects both the dependent (output) and one or more independent variables (capital), the latter correlated with the residual term, leading to inconsistent regression estimates. In their model, R&D investment variable is statistically significant and improves the model's predictive ability.

2.083 dollar increase in profit over a seven-year period and a 5.561 increase in market value. They conclude that "R&D capitalisation yields statistically reliable and economically relevant information".

Table 5.17 R&D expenditures and the Fama-French model (Source: Lev, Sougiannis, 1996)

$$R_{i,t+j} = \alpha_{0,j} + \alpha_{1,j}\beta_{i,t} + \alpha_{2,j} \ln MVE_{i,t} + \alpha_{3,j} \ln(\tfrac{BVE}{MVE})_{i,t} + \alpha_{4,j} \ln(\tfrac{BVA}{BVE})_{i,t} +$$
$$+ \alpha_{5,j}(\tfrac{E(+)}{MVE})_{i,t} + \alpha_{6,j}(E/_{MVE}\, dummy)_{i,t} + \alpha_{7,j} \ln(\tfrac{RD}{MVE})_{i,t} + \varepsilon_{i,t+j},$$

Panel A :Total Sample

Intercept	β	lnMVE	ln BVE/MVE	ln BVA/BVE	E(+)/MVE	E/MVE dummy	ln (RD/MVE)	R^2-adj
0.0251 *5.95*	-0.0012 *-0.66*	-0.0014 *-2.74*	0.0033 *2.90*	-0.0007 *-0.52*	0.0002 *0.02*	-0.0030 *-1.46*		0.036
0.0286 *6.32*	-0.0014 *-0.79*	-0.0013 *-2.61*	0.0022 *1.91*	-0.0013 *-1.00*	0.0022 *0.27*	-0.0031 *-1.58*	0.0015 *3.10*	0.042

Panel B: Upper Quartile

Intercept	β	lnMVE	ln BVE/MVE	ln BVA/BVE	E (+)/MVE	E/MVE dummy	ln (RD/MVE)	R^2-adj
0.0303 *4.12*	-0.0009 *-0.30*	-0.0019 *-2.76*	0.0043 *2.44*	0.0021 *0.70*	-0.0181 *-0.87*	-0.0072 *-1.60*		0.053
0.0474 *5.91*	-0.0011 *-0.41*	-0.0014 *-1.99*	-0.0051 *-1.52*	-0.0082 *-2.12*	-0.0231 *-1.09*	-0.0102 *-2.25*	0.0114 *3.88*	0.056

*Notes : $R_{i,t+j}$ are monthly stock returns of firm I, starting with the 7th month after fiscal t year-end, j=1,..,12, $\beta_{i,t}$ is CAPM-based beta of firm i, estimated from 60 monthly stock returns up to month t (one month preceding the return calculation); a minimum of 24 months is required, MVE_{it} is the market value of firm i, calculated as price times number of shares outstanding at t, BVE/MVE_{it} is ratio of book value of common equity plus deferred taxes to market value of equity of firm i at fiscal year-end, BVA/BVE_{it} is ratio of book value of total assets to book value of common equity of firm i at fiscal year-end, $E(+)/MVE_{it}$ is ratio of positive earnings before extraordinary items (plus income-statement deferred taxes, minus preferred dividends), to the market value of equity of firm i at fiscal year-end; this variable is set equal to 0 when earnings are negative, **E/MVE dummy**$_{it}$ is set 1 if earnings of firm i for fiscal t are negative, and 0 otherwise, RD/MVE_{it} is estimated R&D capital over market value of equity at year end*

Similarly to Lev and Sougiannis (1996), Akbar and Stark (2001) include R&D expenditures, but incorporating it instead in models 5.14 and 5.15. They run the following set of regressions to estimate the impact of dividends and capital contributions on the value of UK firms in 1990-1998 period:

$$MVE_t = \alpha_0 + \alpha_1 BVE_t + \alpha_2 E_t + \alpha_3 RD_t + \alpha_4 NSCF_t + \varepsilon_i \qquad (5.31)$$

$$MVE_t = \alpha_0 + \alpha_1 BVE_t + \alpha_2 E_t + \alpha_3 RD_t + \alpha_4 D_t + \varepsilon_i \qquad (5.32)$$

$$MVE_t = \alpha_0 + \alpha_1 BVE_t + \alpha_2 E_t + \alpha_3 RD_t + \alpha_{41} D_t + \alpha_{42} CC_t + \varepsilon_i \qquad (5.33)$$

They find that one pound increase in R&D expenses results in 8.98 up to 10 pound increase in Market Value, depending on the set of factors included in the model. Dividends are found to be a positive and significant factor (the coefficient varies from 13.03 to 17.04), while capital contributions are found to have a significant negative effect on market value. Earnings are also found to have a positive though less significant impact when dividends are included as a separate factor in the model. Finally, the book value of equity is found to contribute positively (the regression coefficient varies from 0.88 to 1.92) and is significant in all examined regression models.

Table 5.18 Net dividends, capital contributions and dividends (Source: Akbar and Stark, 2001)

$$MVE_t = \alpha_0 + \alpha_1 BVE_t + \alpha_2 E_t + \alpha_3 RD_t + \alpha_4 NSCF_t + \varepsilon_i,$$

$$MVE_t = \alpha_0 + \alpha_1 BVE_t + \alpha_2 E_t + \alpha_3 RD_t + \alpha_{41} D_t + \varepsilon_i,$$

$$MVE_t = \alpha_0 + \alpha_1 BVE_t + \alpha_2 E_t + \alpha_3 RD_t + \alpha_{41} D_t + \alpha_{42} CC_t + \varepsilon_i,$$

α_0	α_1	α_2	α_3	α_4	α_{41}	α_{42}	R^2
Panel A : Sales as deflator							
1899.71	1.32	.44	9.39	-1.12			.37
(.00)	*(.00)*	*(.26)*	*(.00)*	*(.00)*			
2119.96	1.25	-1.17	10.56		13.31		.36
(.00)	*(.00)*	*(.01)*	*(.00)*		*(.00)*		
1882.56	.92	-.63	8.73		16.03	-1.36	.41
(.00)	*(.00)*	*(.00)*	*(.00)*		*(.00)*	*(.00)*	
Panel B : Number of Shares as deflator							
881.90	.80	3.90	9.39	-.93			.32
(.00)	*(.00)*	*(.00)*	*(.00)*	*(.00)*			
1405.52	.34	1.55	7.29		16.93		.44
(.07)	*(.00)*	*(.00)*	*(.00)*		*(.00)*		
1314.15	.30	1.73	6.77		16.46	-1.27	.47
(.00)	*(.02)*	*(.00)*	*(.00)*		*(.00)*	*(.00)*	
Panel C : Opening Market Value as deflator							
1116.84	.81	1.38	6.96	-1.07			-.75
(.00)	*(.00)*	*(.00)*	*(.00)*	*(.00)*			
1364.61	.44	.18	6.06		14.88		-.52
(.00)	*(.00)*	*(.04)*	*(.00)*		*(.00)*		
1235.88	.37	.31	5.74		14.64	-1.28	-.37
(.00)	*(.00)*	*(.05)*	*(.00)*		*(.00)*	*(.00)*	
Panel D : Opening Book Value as deflator							
2357.37	1.92	1.40	10.00	-1.11			.15
(.00)	*(.00)*	*(.00)*	*(.00)*	*(.00)*			
2702.14	1.05	.40	9.73		17.00		.24
(.00)	*(.00)*	*(.08)*	*(.00)*		*(.00)*		
2339.01	.88	.53	8.98		17.04	-1.61	.28
(.00)	*(.00)*	*(.02)*	*(.00)*		*(.00)*	*(.00)*	

Note : P-values are in parentheses. Time period :1990-1998

Real options and the residual income approach

As the above review demonstrates, the residual income valuation approach has provided a framework within which researchers have been able to evaluate the value relevance of forward looking investments and other expenditure such as R&D and advertising, although it should be added that the results published to date are not consistent and R&D significance appears to decline when correction for heteroscedacticity is made (Pope and Walker, 1996). At the same time, it should be recognised that the residual income approach cannot take account of value-creating announcements of projects that are not yet reported as investment or expenditure as these are not captured in a timely way in 'clean surplus' accounting (Ryan, 1996).

Another recent criticism of research in residual income valuation is that differences in growth expectations among industries and companies are not sufficiently investigated by past researchers (Higson, 1996), which again suggests the need for a real options perspective. In some ways, however, the studies mentioned in this chapter have taken an indirect approach to the inclusion of real options in the valuation model, because R&D and advertising reflect opportunities for growth and expansion that, elsewhere, have been modelled successfully as real options. This thesis take a more direct approach in the light of this recent research, and will incorporate real options relating to a wide variety of projects as a variable in the valuation model.

5.3 Conclusions

Past research provides contradictory results concerning the use of real options in project valuation. On the one hand, there is support from Kester (1984), Busby and Pitts (1997) and Ottoo (2000) for the significance of growth options for the firm's total value (up to 98% in some industries) and for their widespread recognition (they are evident in more than 60% of the investments). In the area of land development and mining, postponement options appear to provide significant predictive power (Quigg, 1993; Busby and Pitts, 1997; Moel and Tufano, 1999). Besides, with regard to investment decision making, there is an indication from Paddock, Siegel and Smith (1988) and Kellogg, Charnes and Demirer (1999) that a proportion of project value can be attributed to growth options, especially when the company's projects are in an early stage, and there is some support for the use of more sophisticated real option models in valuing growth options in the area of R&D (Pennings and Lint, 1997; Benaroch and Kauffman, 1999).

However, findings suggest that there is only a weak and approximate correspondence between management intuition and real option theory among UK managers, according to the surveys made by Howell and Jagle (1997) and Busby, Pitts (1997). These studies indicate that few leading UK firms have procedures either to identify or to evaluate most types of real options. Furthermore, some researchers identify factors that make real options theory inadequate either to value companies correctly or to explain managerial decisions in areas where real options are expected to prevail. For instance, Kellogg, Charnes and Demirer (1999) identify political pressure as a factor that may lead to higher market value for a biotechnology firm that develops products whose social usefulness is supposed to be considerable. Similarly, Moel and Tufano (1999), who examine managerial decisions in gold mines find that the decisions to shut or to keep open a mine depends also on the profitability of other mines in the firms' portfolio and on the firms' other businesses.

Of particular concern is the fact that past research in real options lacks an integrated methodology that links real options with other corporate valuation studies. Nevertheless, recent advances in studies in the area of valuation provide useful approaches that fill the gap between theory and practice and provide the means to examine the impact of real options on the market value of a company. These are studies that examine the impact of long term investment on company market value, and examine either the effect of investment announcements on share price, or the effect of investments on market value in the context of residual income valuation. The methodology applied in these studies is utilised in this thesis, as discussed in the following chapter.

CHAPTER SIX
REAL OPTION ANNOUNCEMENTS: RESEARCH DESIGN AND EMPIRICAL RESULTS

The aim of the empirical study is to investigate whether real options are value relevant in the market place. As a first step, the present chapter reports on an initial analysis of the effect of real option announcements on stock prices. Chapter 7 then assesses the impact of real options on the value of the firm.

The study focuses on plans and decisions about capital expenditure and new projects undertaken by companies that are listed on the Athens Stock Exchange, covering the years 1989 till 1999. First, the hypothesis that real option announcements are recognised by the ASE market is tested, by examining abnormal returns over the real option announcement period. This is followed by an assessment of different types of real option, and whether they are associated with different premiums in the market.

The research is also extended to the effect of option exercising, and the investigation considers whether companies that exercise their options have a premium over companies that let them expire. To examine whether the real options contribute during their lifetime to the company's value in the share market, the difference between the stock return and the index performance over the examined periods is also computed.

The study then considers whether there is any 'information content' in the market place regarding the possibility of a real option being exercised in the future. Finally, the empirical analysis assesses the extent to which theoretical option values are associated with excess returns.

6.1 Real Option Data

As mentioned above, the study examines events that reveal the existence and exercising of real options held by companies listed on the Athens Stock Exchange. For this purpose, the sample involves plans and decisions about company-wide capital expenditures and about specific projects. In addition, plans regarding funds for the purpose of acquisitions and tender offers are also included.

The sample of events covers the period from 1989 to 1999, and was compiled from information in the press concerning the company plans outlined above, which was followed up with an examination of companies' capital increase leaflets and annual reports and discussions with management.

Articles were collected from the following daily and weekly newspapers: Naftemboriki (ΝΑΥΤΕΜΠΟΡΙΚΗ), Kerdos (ΚΕΡΔΟΣ), Vima (ΤΟ ΒΗΜΑ), Kathimerini (ΚΑΘΗΜΕΡΙΝΗ), Imerisia (ΗΜΕΡΗΣΙΑ), Isotimia (ΙΣΟΤΙΜΙΑ) and Ependitis (ΕΠΕΝΔΥΤΗΣ). We also use the electronic database of Reuters Business Briefing to crosscheck the time of information releases.

To be included in the sample, a company had to be listed on the Athens Stock Exchange at the time the management's intentions were revealed and at the time the announcement was made.

The empirical study uses daily closing share prices, which are restricted to only one type of share of every company, the most marketable one, and the share prices are adjusted for capital increases and dividends. Price data were obtained from the electronic "EFFECT" database.

6.2 Basic Assumptions

Several assumptions are made in the study. In particular, it is assumed that

1. In the actual market place, real options have value if investors and analysts can foresee their occurrence. More specifically we assume that the option is evident if, first, some kind of information is revealed to the press and, second, the information, depending on the type of option, implies one of the following :

    A. the company may make a follow-up investment (option to expand or growth option)

    B. a court or other authorities may take the decision for the company to go bankrupt (option to default)

    C. the management may sell some of the company's assets (option to abandon for salvage value)

    D. the company may make investments in new areas (growth option)

    E. the company's management may propose the acquisition of another company to enter a new sector (growth option)

2. On the day investors and analysts foresee the option's occurrence, it is uncertain to them whether actually the company's management (or other critical factors, e.g. a court) will proceed or not to an investment or divestment decision.

3. The option is exercised (or expires) at the time the managers (or other critical factors) will announce their official decision to make (or not) the investment, or divestment. For example, the

option that relates to an acquisition expires at the time the bid expires.

4. In cases where the manager postpones the critical decision for less than a year, we will adjust the values of the option at the time of announcement. However, we will exclude from our sample those cases where the management postpones the investment for more than a year.

5. It is assumed that from the time the company announces its decision about the investment (or divestment), the market price will adjust gradually so as to incorporate the present value of the expected cash flows from the investment or divestment. However, it normally takes some days for analysts and investors to examine the project details. The latter justifies our belief that a five-day period after the event is necessary for price adjustments. That is, it is assumed that it takes a five-day period for analysts to incorporate the present value of the expected cash flows from the investment or divestment.

6. Finally, it should be recognised that the research study assumes that the semi-strong form of efficient market hypothesis holds. If this form of EMH holds, the market price will adjust to publicly available information flow. Published evidence supporting the EMH in the Athens Stock Exchange is summarised in Appendix E.

If the assumptions are fulfilled, the value of each critical variable is estimated, in order to compute the option's value. This involved contact with management officials, and gathering information released in the press and in company leaflets that unveil information about the examined projects, together with the quantification of project-related characteristics. The procedure is described in greater detail in the following section.

6.3 Option Recognition

The study examines ten types of business decisions that have real option characteristics and where their economic effect can be quantified. These are the options involved:

- to acquire other companies,
- to become an acquisition target,
- to merge,
- to take an exclusive representation of a series of products,
- to expand production capacity/ distribution network,
- to sell factory facilities,
- to sell a production unit /or part of the distribution network,
- to proceed to a capital increase,
- to develop a production unit in a new area,
- to launch an advertisement campaign.

A summary of the classification into specific types of options is provided below in Table 6.1.

In those cases where the management considers acquiring other companies, it may do so in order to expand the company's production capacity, to extend its distribution network, or to enter new markets. If the scope of the acquisition is to expand the acquirer's production capacity or the acquisition aims to result in the expansion of a current distribution network, then the company holds an option to expand. However, if the acquisition leads to the entry into new markets, then the company holds a corporate growth option.

The option to merge and the option to acquire other companies are examined whenever the merger or the acquisition induces identifiable benefits for the potential merging companies or for the potential acquirer. Similarly, when the company becomes an acquisition target, options are examined whenever acquisitions may solve liquidity problems or in cases acquisitions may induce economies of scale (or economies of scope).

The option to take an exclusive representation of a series of products is regarded as growth option or as expansion option, depending on whether it is associated with a considerable expansion of products/services provided by the company or not.

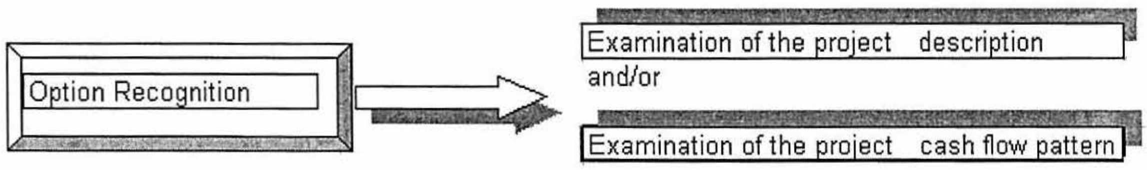
The option to expand production capacity is an expansion option. Similarly, a company's plan to expand a distribution network in the same country is regarded as an expansion option, whereas the expansion of the company's distribution network in another country is regarded as a growth option.

Table 6.1: Classification of managerial plans as real option types

Managerial plans	Scope	Option to expand	Growth option	Option to default	Option to abandon
To acquire other companies	To expand the company's production capacity	V			
	To extend its distribution network	V			
	Or to enter new markets		V		
To become an acquisition target	To reduce liquidity problems			V	
	To induce economies of scale/scope	V			
To merge	To reduce liquidity problems			V	
	To induce economies of scale/scope	V			
To take an exclusive representation of a series of products	Associated with Considerable expansion of products/services		V		
	Not associated with considerable expansion of products/services	V			
To expand production capacity/ distribution network	In countries the company already operates	V			
	In countries where the company does not already operate		V		
To sell factory facilities					V
To sell a production unit or part of the distribution network					V
To proceed to a capital increase	To finance a capacity expansion	V			
	To solve liquidity problems			V	
To develop a production unit in a new area			V		
To launch an advertisement campaign			V		

An option to abandon for salvage value exists whenever the management considers selling factory facilities or selling a production unit (or part of company's distribution network). Possible capital increases are treated as options to expand (whenever the company uses capital increase to finance a capacity expansion) or as options to default (to solve liquidity problems). When the company plans to launch an advertisement campaign, or to develop a production unit in a new area, then a growth option is evident.

To recognise the option characteristics, the procedures proposed by Luehrman (1997a) are followed in this study. In all the examined cases (option to expand, growth option, option to default, abandonment option), option recognition requires a project description and details concerning the project cash flow pattern.



The project description is examined in three ways:

- by reading company capital increase leaflets and annual reports, where most important projects are described;
- by gathering information released in the press regarding the company project;
- by contacting the company management to verify and enrich the information gathered.

However, slightly different procedures are used to examine the project description for different types of real options:

- To identify Options to Expand, statistically important changes in the company are examined including working capital increases, distribution and research expenses, fixed capital investments and other expenses.
- To identify Growth Options, in the case of a project that consists of more than one phase, these phases are distinguished, to formulate the model more accurately. However, the project cash flow pattern is examined by identifying statistically important changes in the company in the same way as above. In general, investments for the introduction of a new product or a new market or the acquisition of another company that operates in another market will be regarded as growth options.

- To identify Abandonment Options, information about management's intention to sell part of the company's assets is gathered and verified.

- To identify Default Options, we gather and verify information about the authorities' or management's intention to default the company and about the timing of relative critical decisions.

6.4 Investment Project Characteristics

After recognizing a real option, the project's characteristics are quantified, as follows:

- The exercise price (X) is the expenditure required to acquire the phase 2 assets. In the case of Growth Options, only projects having two main stages (phases) are included, as the estimation bias in valuing further growth options (projects that consist of more than two main stages) is likely to be very large.

- The value of the underlying assets (V_p) is the summation of discounted expected cash flows.

- The time to expiration (*t*) was determined after a discussion with the company's managers.

- The risk-adjusted discount rate (r_k) consists of the summation of the risk-free interest plus a risk premium, usually different for every phase of the project, using the method described in 4.2. Risk-free interest is taken as the interest offered for bonds or T-Bills having a duration that matches the option's time to expiration.

- The variance (σ^2) is measured by computing volatility from similar projects in the past; otherwise we use the implied variance from peer group companies.

- In the case of cash flows, judgement has been exercised to determine what spending is discretionary and what is not, based on the information gathered (press, discussion with managers, annual reports and capital increase leaflets). In the case of a growth option, the judgement is made about which cash flows are associated with phase 1 as opposed to those that are associated with phase 2.

6.5 Estimation of Theoretical Option Values

The option to expand

We will use both the Brealey and Myers (1991) and the Merton (1973) formula. According to the Black-Scholes (1973) formula transformed by Brealey and Myers (1991) the value of the option to expand is expressed by the equation

$$C_E(V, I, T) = VN(d_1) - Ie^{-rT} N(d_2) \qquad (6.1)$$

where

$$d_1 = \frac{[(ln(\frac{V}{I}) + (r + \frac{\sigma_{BM}^2}{2})T]}{\sigma_{BM}\sqrt{T}}$$

$$d_2 = \frac{[(ln(\frac{V}{I}) + (r - \frac{\sigma_{BM}^2}{2})T]}{\sigma_{BM}\sqrt{T}},$$

given that

N() is the cumulative normal density function

T is the time to expiration of the option to expand in years

V is the value of the expected cash inflows, expressed in current (discounted) value

I is the value of investment, expressed in current (discounted) value

r is the risk free rate

σ_{BM} is the investment (expected) cash inflow volatility

According to Merton (1973) formula, as adjusted by Damodaran (1996), the value of the option is

$$C_E(V,I,T) = Ve^{-r_k T} N(d_1) - Ie^{-rT} N(d_2) \qquad (6.2)$$

given that

$$d_1 = \frac{[(ln(\frac{V}{I}) + (r - r_k + \frac{\sigma^2}{2})T]}{\sigma\sqrt{T}}$$

$$d_2 = \frac{[(ln(\frac{V}{I}) + (r - r_k - \frac{\sigma^2}{2})T]}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}$$

r is risk free rate, expressed by the computed bond rate that corresponds to the option's life

r_k is the dividend yield, expressed by the cost of capital

T is time to expiration in years

σ is expected cash inflow volatility, computed from industry average standard deviation

The growth option

According to Black (1976), as adjusted for the purpose of the study, the value of the option, is expressed by the equation

$$C_E(V,I,T) = e^{-rT}[VN(d_1) - IN(d_2)] \qquad (6.3)$$

where

$$d_1 = \frac{[(ln(\frac{V}{I}) + (\frac{\sigma^2}{2})T]}{\sigma\sqrt{T}}$$

$$d_2 = \frac{[(ln(\frac{V}{I}) - (\frac{\sigma^2}{2})T]}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}$$

given that

V is the value of the expected cash inflows from phase 2 expansion

I is the value of phase 2 expansion cost

r is risk free rate

T is the time the company can delay phase 2 expansion

σ is the industry average standard deviation

$N(.)$ is the cumulative normal distribution function

Damodaran (2001) uses equation 6.2

$$C_E(V, I, T) = Ve^{-r_k T} N(d_1) - Ie^{-rT} N(d_2)$$

given that

$$d_1 = \frac{[(ln(\frac{V}{I}) + (r - r_k + \frac{\sigma^2}{2})T]}{\sigma\sqrt{T}}$$

$$d_2 = \frac{[(ln(\frac{V}{I}) + (r - r_k - \frac{\sigma^2}{2})T]}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}$$

under the following adjustments

V is the value of the expected cash inflows from phase 2 expansion

I is the value of phase 2 expansion cost

T is the time the company can delay phase 2 expansion

σ is the industry average standard deviation

r_k is the cash flows foregone by waiting divided by market value, expressed by the cost of capital

According to Geske (1979), as adjusted for the purpose of the study, the value of growth option will be[1]

$$C_E = Ve^{-r\tau} M(k,h;\rho) - I_G e^{-r\tau} M(\kappa - \sigma\sqrt{\tau^*}, h - \sigma\sqrt{\tau}; \rho) - - I_G e^{-r\tau^*} N(\kappa - \sigma\sqrt{\tau^*}) \qquad (6.4)$$

where

$$h = \frac{ln(\frac{V}{I_G}) + (\frac{\sigma^2}{2})\tau}{\sigma\sqrt{\tau}}$$

$$\kappa = \frac{ln(\frac{V}{V_C}) + (\frac{\sigma^2}{2})\tau^*}{\sigma\sqrt{\tau^*}}$$

given that

N(.) is univariate normal distribution function,

M(a,b;ρ) is bivariate normal distribution function with a and b as upper and lower integral limits, and correlation coefficient ρ,

$\rho=(\tau^*/\tau)^{1/2}$

V_c is the critical value of the project above which the first call option will be exercised, equal to the expenditure for the developed project

[1] Kemna(1993) provides a way to apply the model developed by Geske(1979) for real option purposes.

V is the value of the developed project (second stage)

σ is the volatility of the rate of change of the developed project

I_G is the expenditure for the developed project (second stage)

r is the discount rate (risk free rate of return)

τ is the time to maturity of the simple option

τ^* is the time to maturity of the first call option, assumed to be 3 years.

6.6 Hypothesis Testing

The market response to real option announcements

The event-study methodology is used in this study to examine the reaction of investors to real option announcements. The ordinary least squares market model procedure (originally suggested by Masulis,1980, and Brown and Warner,1980) described by Brown and Warner (1985) is used to test the hypothesis that a sample's event period abnormal return (AR), or cumulative abnormal return (CAR), is equal to zero.

The methodology is based on the assumption that capital markets are sufficiently efficient to evaluate the impact of new information on expected future cash flows of the firms.

It involves the prediction of a "normal" return during the event window in the absence of the event, estimation of the abnormal return within the event window, where the abnormal return is defined as the difference between the actual and predicted returns; and testing whether the abnormal return is statistically different from zero.

The study uses two methods to estimate abnormal returns: the single-index model (also called constant mean return model) and the market model. To avoid confusion, we name the abnormal returns estimated from the single-index model as "abnormal returns", while calling the abnormal returns estimated from the market model as "excess returns".

Estimation of Abnormal returns

To test the null hypothesis that ARs and CARs for companies that possess real options are smaller than or equal to those of the companies that do not possess real options, we compute standard parametric one-tailed t statistics for comparing the equality of the means of two samples. The research hypothesis is that the portfolio of the companies that possess real options will have a greater negative AR or CAR. Rejection of the null hypothesis (at the 0.05 significance level) offers support for the real option signalling models. The variances are assumed unequal if F values support rejection of the hypothesis that portfolio variances are equal.

Day 0 is the day of real option announcement. We report AR results for event days between day –5 and day +5 and CAR results for a three day event period (-1,0, and +1), for eleven day event period (-5 through +5) and for the "life of the option" period (-5 through 5 days after the option is exercised[2]). An estimation period of days –190 to –10 before the event day is used[3]

In particular, the model assumes that the stochastic process generating returns is stationary and of the form

$$\bar{R}_{j,t} = \mu_j + \tilde{\varepsilon}_{j,t}$$

where

$$E(\varepsilon_{j,t})=0,\ cov(\varepsilon_{j,t},\ \varepsilon_{j,t-1})=0,\ \forall j,t.$$

Based on this model, an unbiased estimate of the security expected daily return, μ_i, is obtained from the time series of its realised returns in the pre-event period. Sample standard deviation, S_i, is estimated using the same pre-event data. For each stock at any point in time abnormal return, $AR_{i,t}$, is defined as

[2] In the case the option is not exercised within 12 months, we assume it expires (see paragraph 6.1 for details).

[3] Alternatively, we use other estimation periods to investigate whether ARs and CARs differ significantly.

$$AR_{i,t} = R_{i,t} - \mu_i$$

where $R_{i,t}$ is the return on security i at time t.

Next we form an equally weighted portfolio of the individual abnormal returns in event time. The average abnormal return is

$$\overline{AR_t} = \frac{1}{N}\sum_{i=1}^{N} AR_{i,t}$$

If some cross-sectional dependence among individual standardised excess returns cannot be ruled out, then assuming inter-temporal independence, under the null hypothesis the portfolio abnormal returns, AR_t, are distributed normally with mean o and variance σ^2.

The test statistic for any day in the event period is given by

$$t_{stat} = \frac{\overline{AR_t}}{\hat{S}_p} \tag{6.8}$$

where S_p is the standard deviation of the mean abnormal returns over the pre-event period

$$\hat{S}_p = \sqrt{\frac{1}{180}\sum_{t=-190}^{-10}\left[\overline{AR_t} - \overline{\overline{AR_t}}\right]^2}$$

where

$$\overline{\overline{AR}} = \sum_{t=-190}^{-10}(1/180)\overline{AR_t}$$

The statistic is distributed as Student-t with 179 degrees of freedom.

Cumulative abnormal returns will be

$$\overline{CAR}(I_1,I_2)=\frac{1}{N}\sum_{i=1}^{N}\sum_{t=T_1}^{T_2}AR_{i,t}$$

and the variance of cumulative abnormal returns is

$$Var\left(\overline{CAR}(I_1,I_2)\right)=\frac{1}{N^2}\sum_{i=1}^{N}\sigma_i^2(T_1,T_2)$$

given that

i denotes the company of the sample

and

$$T_a \leq T_1 < t < T_2 \leq T_b$$

for an event window that has T_a and T_b as lower and upper limits, respectively, given that T_2 is the smaller between the day of option expiration and the day of option exercise.

Estimation of Excess returns

The market model assumes a linear relationship between the return of any security to the return of the market portfolio:

$$R_{i,t}=\alpha_i+\beta_i R_{m,t}+e_{i,t}$$

given that

$$E(e_{i,t})=0$$

and

$$Var(e_{i,t})=\sigma_{e_t}^2$$

where t is the time index, i= 1,2,..., n stands for security, $R_{i,t}$ and $R_{m,t}$ are the returns on security i and the market portfolio respectively during period t, and $e_{i,t}$ is the error term for security i.

An estimation period of days –190 to –10 before the event day is used.

The prediction error (the difference between the actual return and the predicted normal return), in this study referred to as excess return, denoted as AR', is then calculated as:

$$AR'_{i,t}=R_{i,t}-\hat{\alpha}_i-\hat{\beta}_i R_{m,t}$$

Under the null hypothesis, the excess returns will be jointly normally determined with a zero conditional mean and conditional variance

$$\sigma^2\left(AR'_{i,t}\right)=\sigma^2_{e_t}+\frac{1}{180}[1+\frac{(R_{m,t}+\overline{R_m})^2}{\sigma^2_m}]$$

which, given the sample is large, reduces to

$$\sigma^2\left(AR'_{i,t}\right)=\sigma^2_{e_t}$$

where $\overline{Rm}$ is the mean of the market portfolio.

For a subset of N events, the cumulative excess returns at each instant t within the event window are computed as

$$\overline{AR'}_t=\frac{1}{N}\sum_{i=1}^{N}AR'_{i,t}$$

The test statistic for any day in the event period is given by

$$t_{stat}=\frac{\overline{AR'}_t}{\hat{S}_p}$$

where S'_p is the standard deviation of the mean excess returns over the pre-event period

$$\hat{S}_p=\sqrt{\frac{1}{180}\sum_{t=-190}^{-10}\left[\overline{AR'_t}-\overline{\overline{AR'_t}}\right]^2}$$

where

$$\overline{\overline{AR'}}=\sum_{t=-190}^{-10}(\,{}^{1}\!/_{180})\overline{AR'}_t$$

The statistic is distributed as Student-t with 179 degrees of freedom.

Cumulative excess returns will be

$$\overline{CAR}'(I_1,I_2)=\frac{1}{N}\sum_{i=1}^{N}\sum_{t=T_1}^{T_2}AR'_{i,t}$$

and the variance of cumulative excess returns is

$$Var\left(\overline{CAR}'(I_1,I_2)\right)=\frac{1}{N^2}\sum_{i=1}^{N}\sigma_i^2(T_1,T_2)$$

given that

i denotes the company of the sample

and

$$T_a \le T_1 < t < T_2' \le T_b$$

for an event window that has T_a and T_b as lower and upper limits, respectively, given that T_2 is the smaller between the day of option expiration and the day of option exercise.

Regressions of abnormal returns over DCF and real option values

We compute portfolio beta estimates[4] on 24 to 60 monthly returns before the examined periods [5]and then we assign a portfolio's beta to each share in the portfolio[6]. We use a one-year Treasury bill rate as an estimate of the risk-free interest rate r. We also use after tax profits adjusted for the effect of minority interest and preferred dividends.

Following Damodaran (1996), we compute the theoretical Discounted Cash Flow[7] value of a project[8],as[9]

[4] Portfolios include comparable companies

[5] Assuming a linear relationship between the return of any security to the return of the market portfolio

$$R_{i,t}=\alpha_i+\beta_i R_{m,t}+e_{i,t}$$

[6] Then the equity discount factor is estimated as $r_e = r + [E(R_m) - r]\beta_i$

[7] given that the discount rate is $r_k = \frac{(BVA - BVE)}{(BVA - BVE) + MVE} r_b (1-\tau) + \frac{MVE}{(BVA - BVE) + MVE} r_e$

where ***BVA*** is the book value of the assets and ***BVE*** is the book value of the equity. We assume that the market value of debt is equal to the book value of the debt.

[8] We assume the Cash Flows will have zero growth (g=0) after the period n.

[9] where CF_t are the expected Cash Flows for annual period t, r_k is the cost of capital and n=3.

$$DCF_t = \sum_{t=1}^{n} \frac{CF_t}{(1+r_k)^t} + \frac{CF_n}{(1+r_k)^n (r_k - g)}$$

The ordinary least squares market model procedure is used to make inferences about the validity of the examined models.

Our model assumes that the relationship between y_t (the dependent variable) and $x_{1t}, x_{2t}, \ldots, x_{kt}$ (the k regressors) is a linear one :

$$y_t = \sum_{i=1}^{k} \beta_i x_{i,t} + u_t$$

t=1,2,...,n, where $u_t s$ are unobserved "disturbance" or "error" terms, subject to the following assumptions:

A1: The disturbances u_t have zero means:

$$E(u_t) = 0$$

A2: The disturbances u_t have a constant conditional variance:

$$V(u_t | x_{1t}, x_{2t}, \ldots, x_{kt}) = \sigma^2$$

A3: The disturbances u_t are serially uncorrelated:

$$Cov(u_t, u_s) = E(u_t u_s) = 0$$

for all t<>s.

A4: The disturbances u_t and the regressors $x_{1t}, x_{2t}, \ldots, x_{kt}$ are uncorrelated:

$$E(u_t | x_{1t}, x_{2t}, \ldots, x_{kt}) = 0$$

for all t

A5: The disturbances u_t are normally distributed.

We run the following regressions

$$CAR_i = \alpha + \beta_1 \frac{DCF_{i,}}{MVE_i} + \beta_2 \frac{OV_i}{MVE_i} + \beta_3 OD_i + \varepsilon_i$$

and

$$CAR_i' = \alpha + \beta_1 \frac{DCF_i}{MVE_i} + \beta_2 \frac{OV_i}{MVE_i} + \beta_3 OD_i + \varepsilon_i$$

where

CAR_i are the cumulative abnormal returns, over the life of the option,

CAR'_i are the cumulative excess returns, over the life of the option,

DCF_i are the expected discounted cash flows

OV_I is the Theoretical real option value

OD_i is the dummy variable so that

OD_i=1, if the real option is exercised or

OD_i=0, if the real option is expired

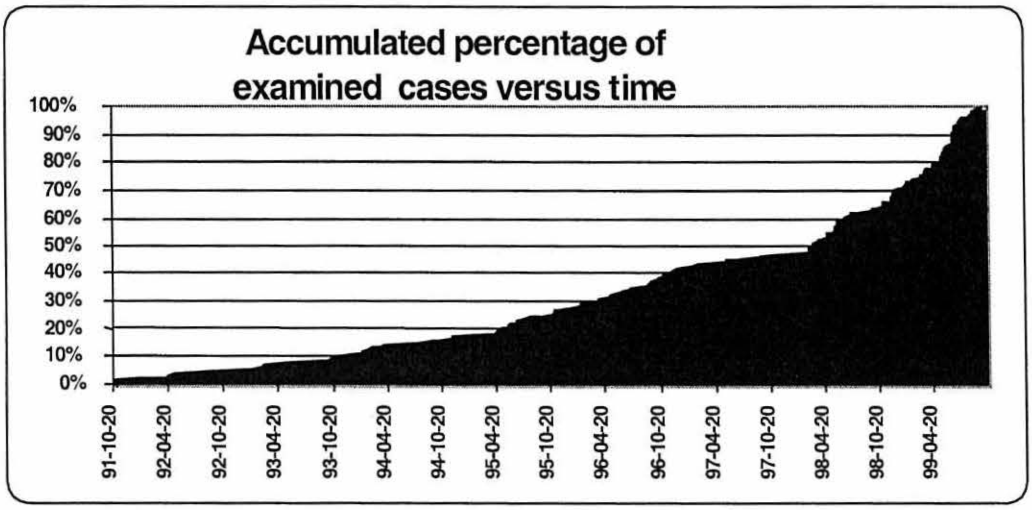
MVE_i is the market value of firm i, calculated as price times number of shares outstanding at the time of option announcement.

6.7 Data Description

Based on the review of funding and capital expenditure plans described in Section 6.1, it was found that 61 out of the 251 companies officially listed on the Athens Stock Exchange between 19889 and 1999 announced real options during the period examined. On average there were 147 companies whose shares were traded in the examined period, ranging from 93 companies in January 1990 to 235 companies in December 1999.

Nearly sixty per cent of the real option announcements took place during the period January 1996 - December 1999, as illustrated in Figure 6.1 below.

Figure 6.1: Distribution of real options over the sample period (1991-1999)



Nearly eighteen per cent of the examined companies operate in Food & Beverages. Construction companies account for fifteen percent of the total number of the examined companies. Financial companies (including Banks) account for twenty-two per cent, while ten per cent of the sample is Metal processing companies.

More detailed presentation of the sector weighting with respect to the number of companies and the number of real option cases examined is provided in Table 6.2.

Table 6.2: The sample of real options, by sector

Sector	Number of Companies	Number of Real Option Cases	% of Companies	% of Real Option Cases
Food & Beverages	11	44	18%	27%
Metal Processing	6	13	10%	8%
Banks	7	22	11%	14%
Other Companies in the financial sector	7	7	11%	4%
Shipping	1	5	2%	3%
Pharmaceuticals and Chemicals	4	11	7%	7%
Wholesalers	1	2	2%	1%
Hotels	1	1	2%	1%
Communications (Computers, Telecom, Electronics)	5	13	8%	8%
Cement producers	1	5	2%	3%
Office furniture	1	3	2%	2%
Construction	9	20	15%	12%
Apparel	5	11	8%	7%
Spinning Mills	2	4	3%	2%
Total	61	161	100%	100%

Further details of the 161 real option cases are given in Appendix B and a brief description of the 61 companies involved is provided in Appendix C.

A further analysis of the examined cases by option type is given in the following table:

Table 6.3: The sample of real options, by type of option

Real Option Type	Number Of Cases Examined (Total)	Number Of Expired Real Options	Number Of Exercised Real Options	Percentage Of Cases Examined	Percentage Of Expired Real Options	Percentage Of Exercised Real Options
Growth option	75	23	52	46.6	14.3	32.3
Option to expand	58	20	38	36.0	12.4	23.6
Option to abandon For salvage value & option to default	28	14	14	17.4	8.7	8.7
Total	161	51	110	100	35.4	64.6

There are four main research questions investigated in the study. First, it is investigated whether real options are recognised in the marketplace. Second, it is examined whether real options contribute during their lifetime to a company's value. Third, the extent to which excess market value can be attributed to real option value or to DCF value is estimated.

Fourth, the contribution of real options to a company's value in the context of residual income valuation is examined. To investigate whether real options are recognised in the marketplace, we proceed to hypothesis testing which is described as follows.

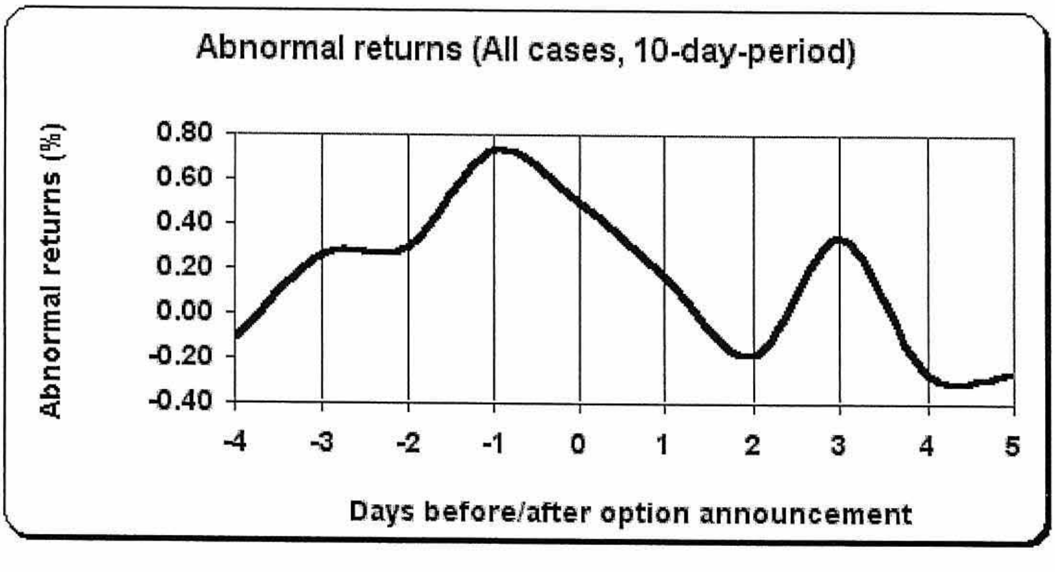
6.8 The Market Response to Real Option Announcements

To examine the validity of the assumption made by finance researchers (e.g. Trigeorgis (1996a)) that real options contribute significantly to a firm's value, the hypothesis that real options are recognised by the ASE market is tested, by examining the abnormal returns over the real option announcement period (or real option signalling period).

Daily abnormal returns

Initially the study examines the abnormal returns during a 10-day real option signalling period, i.e. the period that starts five days before a real option announcement and finishes five days after the announcement. Figure 6.2 gives an indication that the announcement period is associated with abnormal returns. Descriptive statistics are illustrated in Table 6.4. They indicate that real option announcements are associated with statistically significant cumulative abnormal returns (at the 10% level of significance) during the (-5,4) period. Significant cumulative abnormal returns are also reported during the (-5,0), (-5,-1) and (-5,3) periods, at 5%, 10% and 10% levels of significance respectively.

Figure 6.2: Abnormal returns during the real option signalling period



The results reject the hypothesis that the real options are not recognised in the market place. Surprisingly, the results are statistically significant for the period (-2, -1), while their significance is weak for the period (-1, 0). The results give an indication that market participants are normally informed one day before the announcement.

The methodology used has similarities to other well-established event studies (e.g. in the area of acquisitions), and the statistical significance of these findings provides some support to real option theory. However, the sole interpretation of daily abnormal returns is not enough to substantiate a real option effect on firm value. Therefore, a second step examines whether the cumulative abnormal returns of companies that possess real options are also statistically significant.

Cumulative abnormal returns

As illustrated below in Figure 6.3, the average cumulative abnormal return of companies that possess real options increases till the third day after a real option announcement. This is in line with other event studies and indicates that the option announcement can affect the value of a company.

Figure 6.3: Cumulative abnormal returns during the real option signalling period

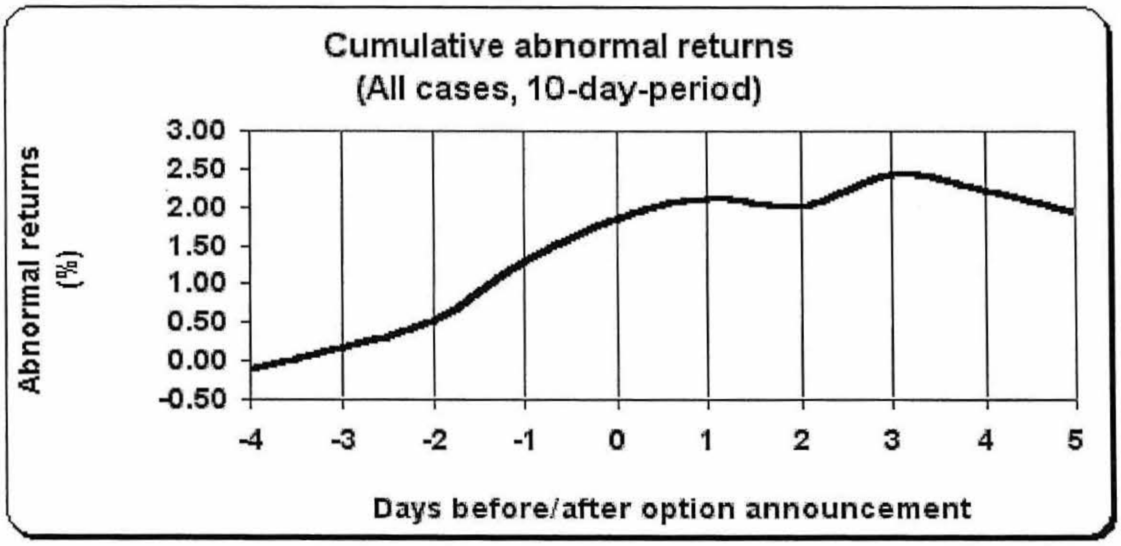


Table 6.4 shows that, starting five days before the real option announcement, the existence of a real option gives rise to an overall premium of 2.45%, for the period

(-5, 3). Statistically significant cumulative abnormal returns are also reported for shorter periods; however, the premium is smaller for those periods.

Table 6.4: Abnormal returns during the real option signalling period

Period	Daily Returns		Period	Cumulative Returns	
	Mean	Semean		Mean	Semean
(-5,-4)	-0.11%	0.26%	(-5,-4)	-0.11%	0.26%
(-4,-3)	0.26%	0.27%	(-5,-3)	0.20%	0.44%
(-3,-2)	0.30%	0.26%	(-5,-2)	0.53%	0.55%
(-2,-1)	**0.74%*** **	0.27%	(-5,-1)	**1.31%***	0.68%
(-1,0)	**0.50%***	0.26%	(-5,0)	**1.87%****	0.78%
(0,1)	0.17%	0.27%	(-5,1)	**2.13%****	0.92%
(1,2)	-0.18%	0.28%	(-5,2)	**2.03%***	1.05%
(2,3)	0.35%	0.27%	(-5,3)	**2.45%****	1.15%
(3,4)	-0.26%	0.26%	(-5,4)	**2.23%***	1.20%
(4,5)	-0.26%	0.25%	(-5,5)	1.95%	1.21%

Day 0: the day of option announcement
, **, * indicate null hypothesis rejected at 10%, 5% and 1% level respectively.*

We then examine whether the type of option is associated with different premiums. The results are statistically significant in the case of growth options. Companies that possess these options have significant positive cumulative abnormal returns that exceed 3% for the ten day period surrounding the announcement, (-5, 4). Table 6.5 presents the results.

In contrast, companies that have an option to default or an option to abandon have negative cumulative abnormal returns three days before the option announcement (-5,-3).

Companies that possess the option to expand do not, on average, have statistically significant CARs, over the examined period. These findings indicate that, on average, the presence of growth options is associated with a premium, while companies that possess the option to default trade on a discount **before** the option initiation. However, the existence of an option to increase capacity does not have any effect on company value, probably because analysts have already accounted for it well before the announcement.

Table 6.5: Cumulative abnormal returns during the signalling period by type of option

Period	Growth Option		Option to Expand		Option to Default/Abandon	
	Mean	Semean	Mean	Semean	Mean	Semean
(-5,-4)	**0.60%***	0.34%	-0.45%	0.45%	**-1.28%***	0.65%
(-5,-3)	**1.10%***	0.62%	0.05%	0.73%	**-1.94%***	1.04%
(-5,-2)	1.25%	0.77%	0.34%	0.91%	-1.03%	1.47%
(-5,-1)	**1.84%***	0.94%	1.18%	1.20%	0.20%	1.68%
(-5,0)	**1.97%***	1.03%	2.27%	1.45%	0.75%	1.97%
(-5,1)	**2.24%***	1.20%	2.47%	1.72%	1.15%	2.34%
(-5,2)	1.99%	1.25%	2.39%	2.00%	1.41%	2.89%
(-5,3)	**2.73%***	1.40%	2.49%	2.23%	1.61%	2.92%
(-5,4)	**3.07%***	1.59%	1.60%	2.17%	1.26%	3.11%
(-5,5)	2.86%	1.76%	1.26%	1.98%	0.94%	3.15%

Day 0: the day of option announcement
, **, * indicate null hypothesis rejected at 10%, 5% and 1% level respectively.*

It may be noted that when the existence of a real option premium is tested over a three-day period, the results are found to be statistically insignificant. There is no indication that the null hypothesis may be rejected over the 3-day period (-1, 1), which underlines the importance of allowing for a longer event window.

Table 6.6: Abnormal returns at the announcement date, by type of option

Type of real option	N	Mean CARs period (-1,1)	Semean
All cases	161	0.70%	0.42%
Growth	75	0.30%	0.51%
Expand	58	1.10%	0.75%
Default	24	0.83%	1.35%

N: Indicates the number of observations

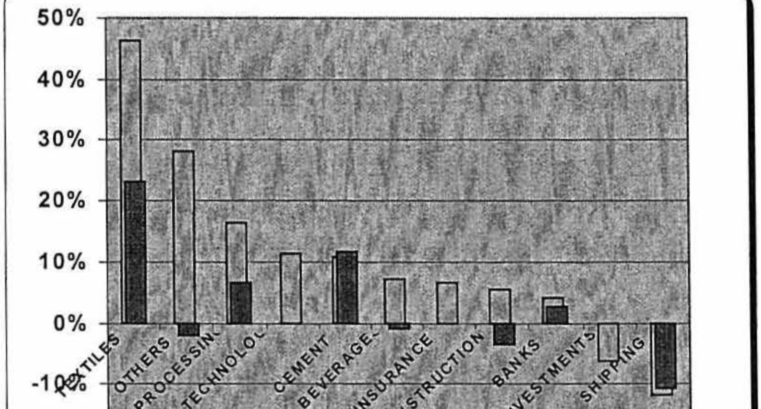
6.9 Contribution during the lifetime of the option

To examine whether the real options contribute during their lifetime to the company's value in the share market, we also compute the difference between the stock return and the index performance over the examined periods and we denote that difference as '**excess returns**'. Our methodology is based on the fact that the ASE is highly volatile, and the pre-event period (-180, -10) may not capture share market volatility over a long period.

Expiry, exercise and real option value

Our findings (Table 6.7) indicate that the companies that exercised real options have a statistically significant abnormal return (19.19% on average), while companies that let options expire do not have any gain over the examined period. In all but two sectors (the shipping and the F&B sector) cumulative abnormal returns of companies that possessed and exercised real options were higher than CARs of companies that didn't exercise the real options. Average cumulative excess returns during the life of real options vary among companies that belong to different sectors. As illustrated on Figure 6.4, average excess returns of textile companies during real option life are positive , while excess returns for companies in the shipping industry during real option life are negative.

Figure 6.4: Cumulative excess returns during the real option life, by sector



Alternative time periods are used to investigate whether the selection of a particular time period leads to other inferences. An average premium of 12.94% is reported (Table 6.7 Panel A) over the period (-5, x), where the negative number (-5) denotes five days before option announcement and the letter (x) denotes the exercise day. Smaller premiums were reported for other periods.

The study initially investigates whether companies that exercise their options have a premium over the market (Table 6.7, Panel C). Similarly, it is examined whether companies that let their options expire outperform the market (Table 6.7, Panel B). Not surprisingly, investors give on average a small discount to companies that let their real options expire. An average discount of 7.87% is reported over the period (0,x), where zero (0) denotes day of option announcement and the letter (x) denotes exercise day. However, the discount is statistically insignificant, as illustrated in Table 6.7, Panel B.

On the other hand, investors give a premium to companies that exercise their options. An average premium of 22.37% is reported over the period (-5,x), where the negative number (-5) denotes five days before option announcement and the letter (x) denotes the exercise day (Table 6.7, Panel C).

Now, it is interesting, from both the statistical and the practical view, to examine whether there is any "information content" in the market place regarding the possibility of a real option being exercised in the future. If market appreciation during the announcement period is followed by a statistically significant appreciation during the life of real options, then the announcement period indicates the possibility for management to exercise a real option, so investors should choose shares of companies that possess these options, so as to outperform the market.

To examine the existence of that "information content", we split cumulative abnormal returns into two periods, (-5, 5) and (5, x). Our results indicate that there is "information content" in the share market about the possibility exercising real options. Companies who possess options that expired had on average low and statistically insignificant abnormal returns. On the other hand, companies who possess options that did not expire had on average high abnormal returns. Moreover, nearly 28% of excess returns are realised around the signalling period (-5, 5), in the case of exercising real options. That is in line with real option theory. We do not know why there is information content during the signalling period, but we assume that market participants assess during early stages the possibility for company managers to exercise the option.

Table 6.7: Abnormal and excess returns during the life of real options

Period	N	Mean cumulative returns	
		Abnormal	Excess
Panel A : Full sample			
(0,x)	161	9.61%**	6.99%***
(0,x+5)	161	9.81%**	6.94%**
(-5,x)	161	12.94%***	9.71%***
(-5,5)	161	1.95%	2.66%
(5,x)	161	10.56%	6.82%
Panel B: Real options that expired			
(0,x)	57	-7.87%	-3.17%
(0,x+5)	57	-7.61%	-2.68%
(-5,x)	57	-4.26%	-1.00%
(-5,5)	57	-1.04%	-0.23%
(5,x)	57	-3.25%	-0.20%
Panel C: Options that were finally exercised			
(0,x)	104	19.19%***	12.56%***
(0,x+5)	104	19.36%***	12.21%***
(-5,x)	104	22.37%***	15.58%***
(-5,5)	104	3.59%**	4.24%***
(5,x)	104	18.13%***	10.66%***

N: Indicates the number of observations
Day 0: the day of option announcement
Day x: the day of option expiration or the day of option exercise
, **, * indicate null hypothesis rejected at 10%, 5% and 1% level respectively.*

Company size and real option value

To examine whether there is any correlation between real option value and company size, cases are split into three categories, relative to the company's dominance in a particular sector (or sub-sector, in the case of a niche market). Companies that have a dominant position in the domestic market have "size 1", whilst companies that have a weak position in the sector have "size 3". Companies that do not have either a dominant or a weak position in their market were assigned "size 2". No association between size and market performance was found, as illustrated on the following Table (Table 6.8).

Table 6.8: Company size and excess returns

Size	Period	N	Mean	Semean
1	(-5,5)	55	1.70%	1.74%
	(5,x)	55	5.79%	3.78%
2	(-5,5)	59	1.90%	1.57%
	(5,x)	59	7.79%	4.20%
3	(-5,5)	47	4.73%	2.68%
	(5,x)	47	6.37%	4.42%

N: Indicates the number of observations
Day 0: the day of option announcement
Day x: the day of option expiration or the day of option exercise
, **, * indicate null hypothesis rejected at 10%, 5% and 1% level respectively.*
SIZE: 1. Includes companies having dominant position in their sector
2. Includes firms that have relatively strong position in the market they operate
3. Includes companies having weak position in their sector.

So far, the findings of the study indicate that companies that exercised their real options significantly outperformed the market. It is therefore useful to investigate to what extent the appreciation shows that investors acted in accordance with real option theory. If investors took it for granted that strategic actions will take place, then theoretically computed DCF values (instead of Theoretical Real Option values) should be enough to explain market appreciation.

6.10 Excess returns over DCF and real option values

To examine the extent theoretical real option values are associated with observed abnormal returns, we run several multiple regressions.

In our models, abnormal returns and excess returns are regressed against

- computed DCF project values
- computed real option values and
- a variable that has a value equal to zero if the option is finally exercised or its value is equal to one if the option expires unexercised.

Both DCF Values and Real Option Values are deflated by Market Value so as to reduce size effects. Following other finance researchers we test the full sample of observations and a sample that excludes outliers (5% of observations). We examine Damodaran (2001), Geske (1979), Black (1976), Black-Scholes (1973) Merton (1973) and Damodaran (1996) models respectively. In the case of the Growth option, the predictive ability of the Damodaran theoretical option value to explain abnormal returns is significant. However, the market tends to overvalue growth options by comparison with their theoretical value (the coefficient of "option value" is 2.0 in Model 2). Adjusted R square of model 2 is significant (21.07% and 20.27% respectively for the trimmed sample and the full sample) and higher than the predictive ability of DCF Value. Regression coefficient of Damodaran Real Option Value is significant at 1% level.

Theoretical option values also explain successfully a significant part of excess returns for the examined growth option cases. When we account for index movements, the results indicate that the market tends to value the Damodaran theoretical value in a way that theory expects. The coefficient on the option value is 0.857 for the trimmed sample.

In the case of the option to expand, the theoretical option value is also significant in explaining abnormal stock returns. The "Exercise" dummy variable increases the predictive ability of the model. Theoretical values are higher than observed results, and significant in the case of the Black-Scholes model (the Merton and Damodaran models lead to identical results in the case of the option to expand). When the dependent variable is excess returns (Table 6.9, Panel B), DCF values and theoretical option values are insignificant in the case of the option to expand.

Table 6.9: Regression of returns on DCF and theoretical option values : growth options

Panel A: $AR_{i,t} = \alpha_0 + \alpha_1 \frac{DCF_{i,t}}{MVE_{i,t}} + \alpha_2 \frac{OV_{i,t}}{MVE_{i,t}} + \alpha_3 OD_{i,t} + \varepsilon$

Panel B: $AR'_{i,t} = \alpha_0 + \alpha_1 \frac{DCF_{i,t}}{MVE_{i,t}} + \alpha_2 \frac{OV_{i,t}}{MVE_{i,t}} + \alpha_3 OD_{i,t} + \varepsilon$

	Trimmed sample (5% of observations excluded)					Full sample				
	DCF	Option (Damo.)	Option + Exercised (Damo.)	(Geske)	(Black)	DCF	Option (Damo.)	Option + Exercised (Damo.)	(Geske)	(Black)
Panel A										
Intercept	0.062	0.037	0.037	0.045	0.046	0.051	0.024	0.032	0.045	0.049
	0.769	*0.461*	*0.415*	*0.491*	*0.496*	*0.656*	*0.306*	*0.369*	*0.533*	*0.573*
DCF	0.568***					0.563***				
	3.883					*3.952*				
OV		2.000***	2.001***	-1.356	-0.531		1.963***	1.970***	-0.383	-0.315
		4.437	*4.394*	*-0.534*	*-0.443*		*4.452*	*4.427*	*-0.361*	*-0.436*
OD			-0.001	0.169	0.171			-0.030	0.162*	0.161*
			-0.005	*1.560*	*1.562*			*-0.219*	*1.623*	*1.622*
R^2	17.93%	22.20%	22.20%	3.64%	3.52%	17.62%	21.35%	21.40%	3.75%	3.83%
Adjusted R^2	16.74%	21.07%	19.91%	0.81%	0.68%	16.50%	20.27%	19.22%	1.08%	1.16%
St Error	0.565	0.550	0.555	0.409	0.409	0.553	0.540	0.544	0.399	0.398
Observations	71	71	71	71	71	75	75	75	75	75
F	15.079	19.685	9.700	1.285	1.239	15.618	19.818	9.804	1.404	1.435
Panel B										
Intercept	0.082	0.080	-0.038	0.045	0.046	0.095*	0.089	-0.039	0.045	0.049
	1.405	*1.368*	*-0.416*	*0.491*	*0.496*	*1.732*	*1.582*	*-0.434*	*0.533*	*0.573*
DCF	0.282**					0.184*				
	2.380					*1.809*				
OV		0.857**	0.684**	-1.356	-0.531		0.624*	0.665**	-0.383	-0.315
		2.386	*2.148*	*-0.535*	*-0.443*		*1.944*	*2.099*	*-0.361*	*-0.436*
OD			0.199*	0.169	0.171			0.177*	0.162	0.162
			2.007	*1.560*	*1.562*			*1.828*	*1.623*	*1.622*
R^2	7.59%	7.62%	10.66%	3.64%	3.52%	4.29%	4.92%	9.14%	3.75%	3.83%
Adjusted R^2	6.25%	6.28%	8.04%	0.81%	0.68%	2.98%	3.62%	6.61%	1.08%	1.16%
St Error	0.397	0.397	0.387	0.409	0.409	0.395	0.393	0.387	0.399	0.398
Observations	71	71	71	71	71	75	75	75	75	75
F	5.663	5.693	4.059	1.285	1.239	3.273	3.778	3.620	1.404	1.435

*Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively. Damo, Geske and Black, denote Damodaran (2001), Geske (1979) and Black (1973) results respectively*

Table 6.10: Regression of returns on DCF and theoretical option values : options to expand

Panel A: $AR_{i,t} = \alpha_0 + \alpha_1 \frac{DCF_{i,t}}{MVE_{i,t}} + \alpha_2 \frac{OV_{i,t}}{MVE_{i,t}} + \alpha_3 OD_{i,t} + \varepsilon$ **Panel B:** $AR'_{i,t} = \alpha_0 + \alpha_1 \frac{DCF_{i,t}}{MVE_{i,t}} + \alpha_2 \frac{OV_{i,t}}{MVE_{i,t}} + \alpha_3 OD_{i,t} + \varepsilon$

	Trimmed sample (5% of observations excluded)					Full sample				
	DCF	Option (Bl-S)	Option + Exercised (Bl-S)	Option + Exercised (Damo.)	Option + Exercised (Merton)	DCF	Option (Bl-S)	Option + Exercised (Bl-S)	Option + Exercised (Damo.)	Option + Exercised (Merton)
Panel A										
Intercept	-0.051	-0.059	-0.285	-0.274	-0.274	-0.043	-0.049	-.272***	-0.269***	-0.269***
	-0.830	*-0.938*	*-3.267*	*-3.053*	*-3.053*	*-0.713*	*-0.797*	*-3.146*	*-3.054*	*-3.054*
DCF	0.214*					0.146*				
	1.934					*1.621*				
OV		0.214*	0.171*	0.782	0.782		0.147*	0.101	0.628	0.628
		2.007	*1.749*	*0.923*	*0.923*		*1.689*	*1.237*	*0.781*	*0.781*
OD			0.369***	0.393***	0.393***			0.364***	0.382***	0.382***
			3.441	*3.621*	*3.621*			*3.406*	*3.594*	*3.594*
R^2	6.48%	6.94%	23.94%	21.08%	21.08%	4.48%	4.85%	21.42%	20.12%	20.12%
Adjusted R^2	4.75%	5.22%	21.07%	18.10%	18.10%	2.78%	3.15%	18.56%	17.22%	17.22%
St Error	0.420	0.419	0.382	0.390	0.390	0.417	0.416	0.382	0.385	0.385
Observations	56	56	56	56	56	58	58	58	58	58
F	3.741	4.029	8.339	7.080	7.080	2.628	2.852	7.497	6.927	6.927
Panel B										
Intercept	0.088*	0.091*	0.001	0.006	0.006	0.086*	0.090*	0.000	0.006	0.006
	1.890	*1.928*	*0.011*	*0.083*	*0.083*	*1.910*	*1.950*	*-0.004*	*0.085*	*0.085*
DCF	-0.047					-0.049				
	-0.671					*-0.720*				
OV		-0.052	-0.078	-0.778	-0.778		-0.053	-0.072	-0.778	-0.778
		-0.766	*-1.171*	*-1.150*	*-1.150*		*-0.813*	*-1.107*	*-1.217*	*-1.217*
OD			0.157*	0.140*	0.140*			0.147*	0.137	0.137
			1.789	*1.619*	*1.619*			*1.719*	*1.618*	*1.618*
R^2	0.83%	1.08%	6.91%	6.76%	6.76%	0.92%	1.17%	6.20%	6.63%	6.63%
Adjusted R^2	-1.01%	-0.76%	3.39%	3.24%	3.24%	-0.85%	-0.60%	2.79%	3.23%	3.23%
St Error	0.318	0.318	0.311	0.311	0.311	0.312	0.312	0.307	0.306	0.306
Observations	56	56	56	56	56	58	58	58	58	58
F	0.451	0.587	1.966	1.922	1.922	0.518	0.662	1.819	1.952	1.952

*Notes. t-statistics in italics. *, **, *** indicate null hypothesis rejected at 10%, 5% and 1% level respectively. Bl-S, Damo and Merton, denote Black-Scholes (1973), Damodaran (1996) and Merton (1973) results respectively*

6.11 Comparison with previous studies

The value relevance of real options

Concerning the value relevance of real options, the study confirms and, in a way, extends the findings in Kester (1984), Paddock, Siegel and Smith (1988), Panayi and Trigeorgis (1999), Benaroch and Kauffman (1999), Kellog, Charmes and Demirer (1999). Similar to Kester (1984) and Ottoo (2000) our study confirms that growth options contribute significantly to company value, whilst Kester (1994) and Ottoo (2000) reported that growth options account from 4% up to 88% of total equity value. A key finding in this thesis is that growth options that were finally exercised were associated with 22.4% abnormal returns and 15.6% excess returns during the period that starts five days before the real option announcement and finishes by the time the option is exercised. Moreover, the magnitude of the real option contribution is found to be significant at the 1% level when options are exercised, but insignificant otherwise.

Real options and DCF valuations

Concerning the extent by which real options provide better valuations than DCF valuation does, the thesis also confirms the findings in Paddock, Siegel, Smith (1988) that real option estimations proximate actual values better than DCF values do. In our study, the theoretical DCF value and the theoretical growth option value are regressed against abnormal stock returns and excess stock returns with the result that real options are associated with a better regression fit compared to DCF values. This agrees with the findings of Howell and Jagle (1997) who studied hypothetical cases as a benchmark for examinuing whether Option Value Theory has higher explanatory power than DCF. They found that in twelve out of fourteen types of growth options, the theoretical option values provide better predictions of empirical valuations than theoretical DCF values do. We also find that theoretical values are generally in line with Option to Expand values, since the coefficient of Option to Expand is close to the unity in the respective models.

Real option overvaluation

In addition, the study shows that the capital market tends to overvalue growth options. Indeed, the coefficient on the growth option theoretical value is 2.0. These findings are in line with the conclusions in Kellogg, Charnes and Demirer (1999) and in Schwartz and Moon (2000). In particular, Kellogg, Charnes and Demirer (1999), who applied real option theory to evaluate a biotechnology firm, conclude that the theoretical methods valued the examined company (Agouron) relatively well when all the projects were in the early phase of development, but the stock price deviation from theoretical values became significantly larger (28%-56%) during the following phases. Schwartz and Moon (2000) applied real option theory to evaluate an internet firm and found that company market value is significantly higher than what real option theory indicates.

6.11 Summary

In this chapter, assuming the semi-strong form market efficiency holds, theoretical DCF and real option values are regressed against unexpected returns at the time when real options are created by companies. The empirical evidence reported in this chapter indicates that real option announcements are recognised in the stock market. In this thesis, regression analysis also indicates that a significant proportion of abnormal returns during the life of an option can be explained if we account for the theoretical "real option value". Also, it is shown that the Damodaran and Black-Scholes models provide far higher regression fit compared than other option pricing models.

Research in the context of residual income may indicate that market appreciation is associated with other fundamental factors, apart from those examined above (theoretical DCF values, option types, option exercise). If the context of residual income valuation is statistically sound and real options are value relevant, then we could incorporate real options into that context. This is the subject of the following chapter.

CHAPTER SEVEN

RESIDUAL INCOME VALUATION: RESEARCH DESIGN AND EMPIRICAL RESULTS

In this chapter models are developed that explain the corporate valuations that the capital market places on firms and, in particular, the role of new information in these models. To achieve this target, we investigate whether real options are significant explanatory variables in the context of the 'clean surplus' hypothesis. The models employed in the related cross-sectional regressions assume that the value of the assets in place (the market value of company equity) can be modelled theoretically as the sum of book value plus the discounted value of the residual income stream. In other words, the market value of a company is modelled in its restricted form as a linear function of earnings, closing book value and net dividends, while a less restricted form of the 'clean surplus equation' allows for other control variables that capture the value not attributable to these factors. To explore the extent that real options account for part of the future residual income stream, the study investigates the predictive ability of real options by including them as dummy variables.

7.1 Main procedures

The regression methodology uses mainly the procedures followed in Fama and French (1992) and in Green, Stark and Thomas (1996).

We examine the association between portfolio assignments based on information available at the end of year ***t*** and returns realised over the twelve month period beginning in July of calendar year ***t+1***, so we ensure that the accounting variables are known before the returns we explain, following Fama and French(1992).

We compute portfolio beta estimates on 24 to 60 monthly returns before the examined periods [1]and then we assign a portfolio's beta to each share in the portfolio[2]. We use a one-year Treasury bill rate as an estimate of the risk-free interest rate r_f[3]. We also use after tax profits adjusted for the effect of minority interest and preferred dividends.

The market value of a firm's common equity, $MVE_{i,t}$, is calculated as share price, adjusted for stock splits and dividends, times the number of common shares outstanding at a fiscal year end. The firm must also have available data on total book assets, book equity, and earnings for the examined periods. The currency of the financial statements is the Euro. We use the share price of common shares, only. Whenever more than one type of common shares is available for the same company, we use the most actively traded type of share.

Then we examine the association between portfolio assignments based on information available at the end of the accounting year and returns realised over the twelve month period beginning in July of the next calendar year. The resulting annual cross-sections are then trimmed to remove the top and bottom 0.5% of observations. Transaction costs and information costs are ignored.

The residual income approach to real option valuation

The ordinary least squares market model procedure is used to make inferences about the validity of the examined models.

Our model assumes that the relationship between y_t (the dependent variable) and $x_{1t}, x_{2t}, \ldots, x_{kt}$ (the k regressors) is a linear one :

$$y_t = \sum_{i=1}^{k} \beta_i x_{i,t} + u_t \tag{7.1}$$

[1] Assuming a linear relationship between the return of any security to the return of the market portfolio $R_{i,t} = \alpha_i + \beta_i R_{m,t} + e_{i,t}$

[2] Then the equity discount factor is estimated as $r = r_f + [E(R_m) - r_f]\beta_i$

[3] As in Sougiannis (1996). However, Fama and French (1996) use one-month Treasury bill rate observed at the beginning of the month to compute risk free rate.

t = 1,2,...,n, where $u_t s$ are unobserved "disturbance" or "error" terms, subject to the following assumptions:

A1: The disturbances u_t have zero means:

$$E(u_t) = 0$$

A2: The disturbances u_t have a constant conditional variance:

$$V(u_t | x_{1t}, x_{2t}, \ldots, x_{kt}) = \sigma^2$$

A3: The disturbances u_t are serially uncorrelated:

$$Cov(u_t, u_s) = E(u_t u_s) = 0$$

for all $t<>s$.

A4: The disturbances u_t and the regressors $x_{1t}, x_{2t}, \ldots, x_{kt}$ are uncorrelated:

$$E(u_t | x_{1t}, x_{2t}, \ldots, x_{kt}) = 0$$

for all t

A5: The disturbances u_t are normally distributed.

According to the Ohlson residual income valuation model (Ohlson, 1989; Ohlson, 1995), the market value of the firm can be expressed as the summation of the book value of equity and the present value of future abnormal earnings. This is expressed by the equation

$$MVE_t = BVE_t + \sum \mathrm{E}\left[\frac{RI_{t+1}}{(1+r)^i}\right] \quad (7.2)$$

given that

$$BVE_t = BVE_{t-1} + E_t - NSCF_t \quad (7.3)$$

$$RI_t = E_t - rBVE_{t-1} \quad (7.4)$$

where

MVE_t is the value of the firm

r is the discount rate

BVE_t is the book value of equity

E_t denotes earnings for period t

$NSCF_t$ denotes net dividends (dividends less capital contribution) paid at date t

RI_t denotes the abnormal earnings, or residual income, for the period to t.

The time-series behaviour of residual income is described by linear information dynamics models which provide a link between current information and a firm's intrinsic value. The Ohlson (1995) linear information dynamics assume that the time-series behaviour of residual income follows

$$MVE_{i,t} = BVE_{i,t} + \alpha_1 RI_{i,t} + \beta_1 v_t \tag{7.5}$$

given that

$$a_1 = \frac{\omega_{11}}{1+r-\omega_{11}} \tag{7.6}$$

and

$$\beta_1 = \frac{1+r}{(1+r-\omega_{11})(1+r-\gamma)}$$

In a regression form, equation 5.13 can be expressed as:

$$MVE_{i,t} = \alpha_0 + \alpha_1 BVE_{i,t} + \alpha_2 E_{i,t} + \alpha_4 NSCF_{i,t} + \varepsilon \tag{7.7}$$

where

$MVE_{i,t}$ is market value

$NSCF_{i,t}$ is net dividends (dividends-cap.contribution)

α_4 should be negative and

$\alpha_1 + \alpha_4 = -1$.

Given that

$$NSCF_{i,t} = D_{i,t} - CC_{i,t}$$

the model 7.7 can be expressed as:

$$MVE_{i,t} = \alpha_0 + \alpha_1 BVE_{i,t} + \alpha_2 E_{i,t} + \alpha_{41} D_{i,t} + \alpha_{42} CC_{i,t} + \varepsilon \quad (7.8)$$

A less restricted form of the "clean surplus equation", (Ohlson, 1989) allows for other control variables:

$$MVE_{i,t} = BVE_{i,t} + \beta(E_{i,t} - rBVE_{t-1}) + \gamma Z_{i,t} \quad (7.9)$$

where

$MVE_{i,t}$ is the market value of the firm's stock at time t

$BVE_{i,t}$ is the book value of equity at time t

$E_{i,t}$ is reported accounting earnings at time t

r is the discount factor

$(E_{i,t}-rBVE_{i,t-1})$ is abnormal earnings

$Z_{i,t}$ is a vector of other information variables at time t

We investigate the value relevance of real options by incorporating this information factor as a **Z** in the model.

The less restricted form of the "clean surplus equation", equation 7.9, can be transformed to the following equation that is deflated by book value, so as to allow for control for size factors:

$$\left(\frac{MVE_{i,t} - BVE_{i,t}}{BVE_{i,t}}\right) = \alpha_0 + \alpha_1\left(\frac{1}{BVE_{i,t}}\right) + \beta\left(\frac{RI_{i,t}}{BVE_{i,t}}\right) + \gamma Z_t + \varepsilon_{i,t} \quad (7.10)$$

Our study has similarities as well as many differences to other studies in the area of residual income valuation. Similarities stem from the common assumptions between these studies and our study for the main factors that are relevant for the valuation of a firm's equity. Differences stem from the research question to be answered in our study. Whereas our study tries to investigate whether real options are value relevant, other studies investigate the importance of other factors for the valuation of a company's equity. Therefore, with the exception of some common explanatory variables, our regressions differ from those examined by previous researchers.

For Green, Stark and Thomas (1996), equation 7.10 can be transformed into the following restricted form that accounts only for Research and Development expenditures as an additional explanatory variable:

$$\left(\frac{MVE_{i,t}-BVE_{i,t}}{BVE_{i,t}}\right)=\alpha_0+\alpha_1\left(\frac{1}{BVE_{i,t}}\right)+\beta\left(\frac{RI_{i,t}}{BVE_{i,t}}\right)+\gamma\left(\frac{RD_{i,t}}{BVE_{i,t}}\right)+\varepsilon_{i,t} \qquad (7.11)$$

whilst in our study we examine the following equation:

$$\left(\frac{MVE_{i,t}-BVE_{i,t}}{BVE_{i,t}}\right)=\alpha_0+\alpha_1\left(\frac{1}{BVE_{i,t}}\right)+\beta\left(\frac{RI_{i,t}}{BVE_{i,t}}\right)+\gamma_1 z_1+\gamma_2 z_2+\gamma_3 z_3+ +\gamma_4 z_4+\gamma_5 z_5+\gamma_6 z_6+\varepsilon_{i,t} \qquad (7.12)$$

given that

z_1 is the number of months of life of growth option before it became exercised

z_2 is the number of months of life of growth option before it expired unexercised

z_3 is the number of months of life of option to expand before it became exercised

z_4 is the number of months of life of option to expand before it expired unexercised

z_5 is the number of months of life of option to default (or abandon for salvage value) before it became exercised

z_6 is the number of months of life of option to default (or abandon for salvage value) before it expired unexercised

Similarly, if we account for real options as an additional control variable, Equation 7.7 can be transformed into the following equation:

$$MVE_{i,t} = \alpha_0 + \alpha_1 BVE_{i,t} + \alpha_2 E_{i,t} + \alpha_4 NSCF_{i,t} + \gamma_1 z_1 + \gamma_2 z_2 + \gamma_3 z_3 + + \gamma_4 z_4 + \gamma_5 z_5 + \gamma_6 z_6 + \varepsilon_{i,t} \qquad (7.13)$$

Equation 7.13 can be transformed into the following equation, if we use book value as deflator, and the methodology developed in Green, Stark and Thomas (1996):

$$\left(\frac{MVE_{i,t} - BVE_{i,t}}{BVE_{i,t}}\right) = \alpha_0 + \alpha_1\left(\frac{1}{BVE_{i,t}}\right) + \alpha_2\left(\frac{E_{i,t}}{BVE_{i,t}}\right) + \alpha_3\left(\frac{NSCF_{i,t}}{BVE_{i,t}}\right) + \gamma_1 z_1 + + \gamma_2 z_2 + \gamma_3 z_3 + \gamma_4 z_4 + \gamma_5 z_5 + \gamma_6 z_6 + \varepsilon_{i,t} \qquad (7.14)$$

In addition, Equation 7.8 can be transformed into the following equation, if we account for real options, as an additional control variable:

$$MVE_{i,t} = \alpha_0 + \alpha_1 BVE_{i,t} + \alpha_2 E_{i,t} + \alpha_{41} D_{i,t} + \alpha_{42} CC_{i,t} + \gamma_1 z_1 + + \gamma_2 z_2 + \gamma_3 z_3 + \gamma_4 z_4 + \gamma_5 z_5 + \gamma_6 z_6 + \varepsilon_{i,t} \qquad (7.15)$$

where

$MVE_{i,t}$ is market value (share price multiplied by the number of ordinary shares in issue) for firm i six months after the end of year t. Market value is measured at a six month lag from the financial year-end because stock exchange requirements demand the publication of financial statements within six months from the financial year-end. As a consequence, the market value figures used should reflect the information contained in the financial statements from which all of the accounting data are drawn, since ASE listed firms have six months to prepare and release their annual accounts at their final form.

$BVE_{i,t}$, is book value for firm i at the end of financial year t, calculated as the sum of shareholder equity plus reserves

$RI_{i,t}$ is residual income for firm i in year t

$E_{i,t}$ are measured as earnings as reported in the financial statements.

$D_{i,t}$, dividends, are measured as dividends declared.

$CC_{i,t}$, capital contributions, are measured as the negative of the sum of equity raised for cash and for acquisitions.

$NSCF_{i,t}=D_{i,t}+CC_{i,t}$ are net shareholder cash flows and are measured as the summation of dividends declared and the negative of the sum of equity raised for cash and for acquisitions.

Number of shares equals number of shares outstanding at the end of the year.

The empirical analysis focuses on regressions 7.12, 7.13, 7.14 and 7.15.

7.2 Empirical results

To examine whether real options contribute during their lifetime to the company's value in the share market, we compute regression coefficients and t-statistics for the following model:

$$\left(\frac{MVE_{i,t}-BVE_{i,t}}{BVE_{i,t}}\right)=\alpha_0+\alpha_1\left(\frac{1}{BVE_{i,t}}\right)+\beta\left(\frac{RI_{i,t}}{BVE_{i,t}}\right)+\lambda_1 GRO+\lambda_2 GRO_{xt}+$$
$$+\lambda_3 EXP+\lambda_4 EXP_{xt}+\lambda_5 ABD+\lambda_6 ABD_{xt}+\varepsilon_{i,t}$$

where

GRO is the number of months of presence of growth option before it became exercised

GRO_{xt} is the number of months of presence of growth option before it expired unexercised

EXP is the number of months of presence of option to expand before it became exercised

EXP_{xt} is the number of months of presence of option to expand before it expired unexercised

ABD is the number of months of presence of option to default (or abandonment option) before it became exercised

$\boldsymbol{ABD_{xt}}$ is the number of months of presence of option to default (or abandonment option) before it expired unexercised

If α_1 (the coefficient of $1/BVE_{i,t}$) and β (the coefficient of $RI_{i,t}/BVE_{i,t}$) are positive and significant, our study will provide some evidence that supports the "clean surplus" hypothesis. Besides, if a real option dummy variable is statistically significant, this will provide evidence that the real option and its exercise/expiry are value relevant.

The sample in this case (N=1285) excludes a number of firm-years for which residual income could not be calculated because the prior market data was unavailable. For the pooled data, the results are reported in the last column of Panel A of Table 7.1. The results are not entirely supportive of the "clean surplus" hypothesis in the Athens Stock Exchange during the 1991-1999 period. The coefficient of $1/BVE_{i,t}$ is positive (2.321) and significant at 1% confidence level, but the coefficient of residual income ($RI_{i,t}/BVE_{i,t}$) is negative and insignificant. The regression fit is somewhat weak, since adjusted R square is only 5.05%.

Separate regressions for each of the examined years (1991-1999) indicate that the "clean surplus" hypothesis is strongly supported by market data in the Athens Stock exchange for four of the years examined (1993, 1995, 1997 and 1999). The coefficient α_1 is positive for all the examined years and significant for all years except 1998 and coefficient β is positive and significant in five years. On the contrary, the growth option as an explanatory variable is found to be significant only in 1996 and then only at the 10% level and the option to expand is significant only in 1997.

It is of interest to examine whether the results are different if we exclude companies that have $MVE_{i,t}/BVE_{i,t}$ over 9. We note that the exclusion of these extreme observations from our sample makes our regressions comparable to those of other researchers in the area. Panel B of Table 7.1 provides evidence, based on the pooled data that excluding extreme $MVE_{i,t}/BVE_{i,t}$ observations leads to the support of the clean surplus hypothesis, and the growth options coefficients also become significant. Both the coefficients of $1/BV_{i,t}$ and $RI_{i,t}/BVE_{i,t}$ are positive (0.38 and

1.153 respectively) and significant at the 1% level of significance. The presence of the growth options for a month increases the company's market value by 26.5% of the book value (i.e. the coefficient of ***GRO***, λ_1 is equal to 0.265). Growth options that expired unexercised had an insignificant effect on company value.

The regression fit remains low after excluding extreme values (adjusted R square is 5.05%). Equally, the effect of real options on company value is weak and insignificant when we examine the data on an annual basis. Although growth options have a positive effect on corporate market value in most of the years (five out of seven, regression coefficients are unstable over time and statistically significant only in 1998. The option to expand is found to be a significant explanatory variable only in 1997, and the coefficients of the options to expand are also highly unstable over time. The small sample size may give an explanation of real option coefficient instability as well as to their generally low statistical significance in annual regressions.

Table 7.1 : Real options and residual income
Panel A : Full sample

$$\left(\frac{MVE_{i,t}-BVE_{i,t}}{BVE_{i,t}}\right)=\alpha_0+\alpha_1\left(\frac{1}{BVE_{i,t}}\right)+\beta\left(\frac{RI_{i,t}}{BVE_{i,t}}\right)+\lambda_1 GRO+\lambda_2 GRO_{xt}+\lambda_3 EXP+\lambda_4 EXP_{xt}+\lambda_5 ABD+\lambda_6 ABD_{xt}+\varepsilon_{i,t}$$

$MVE_{i,t}$: Market value; ***$BVE_{i,t}$***: Book value; ***$RI_{i,t}$***: Residual income

GRO: growth option; ***EXP***: option to expand; ***ABD***: Option to abandon or default - months before exercise

GRO_{xt}, EXP_{xt}, ABD_{xt} - months before expiry unexercised

PERIOD	1991	1992	1993	1994	1995	1996	1997	1998	1999	Pooled
Intercept	2.711*** *3.144*	-0.158 *-0.203*	0.952*** *3.557*	0.958*** *4.096*	0.842*** *5.724*	0.101 *0.811*	0.795*** *4.929*	2.395*** *7.056*	6.745*** *12.657*	2.961*** *8.777*
$1/BVE_{i,t}$	0.688* *1.789*	2.953*** *6.143*	0.708*** *3.820*	1.408*** *7.160*	1.155*** *9.574*	2.363*** *17.374*	1.149*** *5.142*	0.516 *1.073*	9.238*** *5.375*	2.321*** *7.866*
$R_{i,t}/BVE_{i,t}$	-9.674*** *-5.689*	2.563 *1.314*	0.867* *1.923*	1.257 *1.458*	2.116*** *4.650*	-0.007 *-0.050*	6.461*** *7.447*	10.235*** *5.485*	4.012** *2.129*	-0.577 *-0.81*
GRO			-0.029 *-0.116*	-0.064 *-0.030*	0.078 *0.226*	0.308* *1.710*	-0.194 *-0.480*	0.169 *0.953*	-0.096 *-0.423*	0.112 *0.386*
GRO_{xt}	0.043 *0.040*		-0.034 *-0.070*			-0.054 *-0.315*	1.886 *1.010*	-0.097 *-0.210*	0.438 *0.735*	0.132 *0.214*
EXP		-0.313 *-0.600*			-0.215 *-0.543*	0.031 *0.160*	0.325** *2.129*	-0.194 *-0.535*	0.387 *1.193*	0.243 *0.606*
EXP_{xt}		0.379 *0.361*		-0.167 *-0.156*	-0.132 *-0.274*	0.002 *0.030*		-0.591 *-0.595*	-0.176 *-0.385*	-0.13 *-0.275*
ABD				-0.098 *-0.503*	-0.066 *-0.329*			0.224 *0.539*		-0.387 *-0.6*
ABD_{xt}			0.08 *0.101*		-0.088 *-0.390*	-0.149 *-1.201*		0.038 *0.083*	-0.797 *-1.015*	-0.347 *-0.576*
R-sq	38.96%	40.36%	14.16%	33.77%	41.79%	69.83%	31.99%	15.74%	15.53%	5.64%
R-sq-adj	36.55%	36.11%	9.68%	30.56%	38.94%	68.51%	30.08%	12.11%	12.69%	5.05%
Sample	80	61	102	109	151	167	184	195	216	1285

*Notes: t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively.*

Table 7.1 : Real options and residual income
Panel B : Restricted sample

$$\left(\frac{MVE_{i,t}-BVE_{i,t}}{BVE_{i,t}}\right)=\alpha_0+\alpha_1\left(\frac{1}{BVE_{i,t}}\right)+\beta\left(\frac{RI_{i,t}}{BVE_{i,t}}\right)+\lambda_1 GRO+\lambda_2 GRO_{xt}+\lambda_3 EXP+\lambda_4 EXP_{xt}+\lambda_5 ABD+\lambda_6 ABD_{xt}+\varepsilon_{i,t}$$

$MVE_{i,t}$: Market value; ***$BVE_{i,t}$***: Book value; ***$RI_{i,t}$***: Residual income

GRO: growth option; ***EXP***: option to expand; ***ABD***: Option to abandon or default - months before exercise

GRO_{xt}, EXP_{xt}, ABD_{xt} - months before expiry unexercised

Period	1991	1992	1993	1994	1995	1996	1997	1998	1999	Pooled
Intercept	1.692*** *7.924*	1.187*** *5.345*	0.809*** *4.052*	1.178*** *6.761*	0.82*** *6.728*	0.31** *2.452*	0.93*** *5.653*	1.695*** *8.9*	4.327*** *17.324*	1.597*** *22.258*
$1/BVE_{i,t}$	-0.023 *-0.228*	-0.416 *-1.624*	0.552*** *3.947*	0.674*** *4.063*	1.038*** *8.313*	1.683*** *8.201*	0.32 *0.857*	0.512* *1.929*	4.304*** *3.645*	0.38*** *5.229*
$RI_{i,t}/BVE_{i,t}$	5.518*** *5.062*	0.769 *1.561*	0.532 *1.569*	2.366*** *3.609*	1.518*** *3.675*	0.858*** *3.283*	5.172*** *6.76*	4.751*** *4.232*	1.605 *1.632*	1.153*** *5.472*
GRO			0 *0.003*	-0.231 *-0.146*	0.088 *0.319*	0.275 *1.644*	-0.116 *-0.337*	0.215** *2.104*	0.095 *1.048*	0.265*** *4.286*
GRO_{xt}	0.21 *0.795*		0.006 *0.018*			-0.054 *-0.335*	2.036 *1.285*	0.073 *0.291*	0.19 *0.567*	0.106 *0.78*
EXP		-0.051 *-0.386*			-0.189 *-0.598*	0.056 *0.306*	0.319** *2.459*	-0.077 *-0.385*		0.021 *0.204*
EXP_{xt}		0.28 *1.066*		-0.218 *-0.276*	-0.064 *-0.167*	-0.001 *-0.001*		-0.286 *-0.524*	0.149 *0.728*	0.14 *1.412*
ABD				-0.064 *-0.442*	-0.051 *-0.318*			0.057 *0.252*		-0.097 *-0.749*
ABD_{xt}			0.125 *0.212*		-0.092 *-0.515*	-0.119 *-1.027*		0.176 *0.69*	-0.361 *-1.248*	-0.04 *-0.326*
R-sq	27.07%	15.13%	16.50%	22.78%	33.33%	34.16%	23.65%	15.43%	13.37%	5.71%
R-sq-adj	23.98%	8.84%	12.06%	18.96%	30.02%	31.23%	21.45%	11.49%	9.37%	5.05%
Sample	75	59	100	107	149	165	180	181	137	1150

*Notes: t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively. Restricted sample excludes companies with MV/BV>9.*

Separating Earnings from Shareholder Cash Flows

The inclusion of net cash flows between shareholders and the firm into our model gives a more integrated perspective that takes into account the cash flow that directly affects market value. As a first step in our model, we include net shareholder cash flows *($NSCF_{i,t}$)*, that is the summation of dividends declared less the sum of equity raised for cash and for acquisitions. Initially, we regress net shareholder cash flows, earnings, book value and real option dummy variables against market value, as follows:

$$MVE_{i,t} = \alpha_0 + \alpha_1 BVE_{i,t} + \alpha_2 E_{i,t} + \alpha_3 NSCF_{i,t} + \lambda_1 GRO + \lambda_2 GRO_{xt} + \\ + \lambda_3 EXP + \lambda_4 EXP_{xt} + \lambda_5 ABD + \lambda_6 ABD_{xt} + \varepsilon_{i,t}$$

where $NSCF_{i,t}$ are the net shareholder cash flows and are measured as dividends declared ($D_{i,t}$) less equity raised for cash and for acquisitions($CC_{i,t}$).

In this case, the sample (N=1,435) excludes only these companies that have a negative book value. The pooled results (Table 7.2) lead to an interesting interpretation. First, they indicate that the value of the examined companies is approximately their book value plus 14 times their after tax profits minus 3.8 times corporate outflows to equity-holders. Assuming book value to be a good approximation of replacement value, it is reasonable to say that Greek investors appreciate company replacement value in a way theory expects, since the book value regression coefficient is close to unity (1.006) and it is statistically significant at the 1% level. The coefficient α_3 on cash outflows (α_3=-3.774) is similar to the findings in Shah and Stark (2001) that R&D investment contributes approximately 4 times to company market value.

In addition to the above, the earnings coefficient implies that earnings are a significant forecasting variable of future opportunity and statistically significant at the 1% level. Last, but not least, even though the coefficients of $BVE_{i,t}$, $E_{i,t}$ and $NSCF_{i,t}$ are significant at the 1% level, and the regression fit for the examined period (1991-

1999) is very high (R-sq-adj is 79.99%), we find no evidence that growth options contribute, even marginally, to higher model prediction ability.

There is a possible explanation for the low predictive ability of real options in our model. That is, it is unlikely that real options have a uniform effect on company market value irrespective of company size.

We also run separate regressions for each of the examined years (1991-1999). As indicated in Table 7.2, the regression coefficients vary significantly over time. First, assuming book value is a good approximation of replacement value, it is reasonable to say that Greek investors overestimate company replacement value during "bullish" market periods (1991 and 1999), since the book value regression coefficient is significantly higher than the unity (1.606 and 1.148 respectively) while they underestimate replacement value during the "bearish" market periods 1992 and 1996 (α_1 is -0.148 and -1.27 respectively). Second, cash outflows are associated with smaller market value during "bullish" market periods while they strengthen market value during "bearish" periods. Differentiated investor's attitude to cash outflows is due to increasing significance of dividends during "bearish" periods versus increasing significance of "growth prospects" during "bullish" periods. Especially in "bearish" years 1993, 1994 and 1996, the coefficient of $\boldsymbol{NSCF_{i,t}}$ is 3.511, 3.526 and 4.799, while in bullish years 1991 and 1999 the coefficient is -4.412 and -5.729 respectively. Third, the earnings coefficient is positive and statistically significant (at the 1% level) for all years except 1991. The earnings regression coefficient increases from 1996 onwards, probably due to decreasing interest rates. Similarly, adjusted R-square becomes extremely high from 1996 onwards, giving an indication that our model becomes spurious in the examined period. Again, real option dummies are not stable and their coefficients are statistically insignificant.

Next we exclude high book value observations from our sample. The pooled results are shown in the last column of Panel B of Table 7.2. The coefficient of book value appears higher (1.550 compared to 1.006) while the coefficient of earnings is lower (8.342 compared to 13.991). Both of them are significant at the 1% level. Similarly to the findings shown in Panel A, the net shareholders cash outflows contribute negatively to market value(α_3 =-3.755). Now, the growth options coefficient is positive (1.231) but statistically insignificant.

When we run separate regressions for each of the examined years (1991-1999), the regression coefficients vary significantly over time. In particular, the real option coefficients are not stable and are statistically insignificant. As with the full sample, the results for the restricted sample given in Panel B show that the coefficient of $BVE_{i,t}$ is higher during "bullish" market periods and lower during "bearish" market periods. In addition, cash outflows are associated with smaller market value during "bullish" market periods while they strengthen market value during "bearish" periods. The earnings coefficient is positive and statistically significant (at the 1% level) for the examined years except 1991, and it increases from 1996 onwards. Similarly, adjusted R-square becomes extremely high from 1996 onwards.

To examine whether deflating the regressed factors by the book value reduces size bias, eventually leading to increasing robustness, we compute regression coefficients and t-statistics for the following model:

$$\left(\frac{MVE_{i,t}-BVE_{i,t}}{BVE_{i,t}}\right)=\alpha_0+\alpha_1\left(\frac{1}{BVE_{i,t}}\right)+\alpha_2\left(\frac{E_{i,t}}{BVE_{i,t}}\right)+\alpha_3\left(\frac{NSCF_{i,t}}{BVE_{i,t}}\right)+\lambda_1 GRO+$$
$$+\lambda_2 GRO_{xt}+\lambda_3 EXP+\lambda_4 EXP_{xt}+\lambda_5 ABD+\lambda_6 ABD_{xt}+\varepsilon_{i,t}$$

The results are illustrated in Panel C of Table 7.2 and they indicate that growth options increase company market value. In particular, the presence of growth options for a month increases the company value by 54.2% of the book value. Notably, the coefficients of the options to abandon/default are negative, though statistically insignificant. Surprisingly, net shareholders' cash flows over book value ($NSCF_{i,t}/BVE_{i,t}$) and earnings over book value ($E_{i,t}/BVE_{i,t}$) do not affect the premium of market value over company book value.

The coefficients of real options are not stable over time. In addition, the intercept is positive and significant during the examined years, except in 1994 and in 1997.

To restrict our sample, we exclude companies having negative book value as well as companies having market over book value higher than 9. Panel D of Table 7.2 illustrates that the growth option coefficient is positive and significant in the restricted dataset. The presence of growth options for a month increases the company value by

23.3% of the book value. Again, the abandonment /default option coefficient is negative and insignificant. Pooled data coefficients of earnings over book value ($E_{i,t}/BVE_{i,t}$) become positive and statistically significant, while they are negative and insignificant for $NSCF_{i,t}/BVE_{i,t}$.

Annual regressions are associated with a better regression fit compared to the pooled data, but regression coefficients vary over time. The growth options have made a positive and significant contribution to company value in 1991, 1996 and 1998.

Table 7.2 : Real Options and the components of residual income (book value, earnings and net dividend)

Panel A : Full Sample

$$MVE_{i,t} = \alpha_0 + \alpha_1 BVE_{i,t} + \alpha_2 E_{i,t} + \alpha_3 NSCF_{i,t} + \lambda_1 GRO + \lambda_2 GRO_{xt} + \lambda_3 EXP + \lambda_4 EXP_{xt} + \lambda_5 ABD + \lambda_6 ABD_{xt} + \varepsilon_{i,t}$$

$MVE_{i,t}$: Market value; $BVE_{i,t}$: Book value; $E_{i,t}$: Earnings; $NSCF_{i,t}$: Net Shareholders cash flows: ***GRO*** : growth option; ***EXP*** : option to expand; ***ABD*** : Option to abandon or default - months before exercise GRO_{xt}, EXP_{xt}, ABD_{xt} - months before expiry unexercised

Period	1991	1992	1993	1994	1995	1996	1997	1998	1999	Pooled
Intercept	12.953*** *3.582*	7.242*** *4.192*	6.585*** *3.456*	8.041*** *3.58*	7.531*** *3.909*	3.857 *1.101*	-4.817* *-1.917*	5.455 *0.949*	46.295*** *4.556*	3.265 *1.155*
$BVE_{i,t}$	1.606*** *7.115*	-0.148** *-2.203*	0.115** *2.268*	0.494*** *8.247*	0.06 *0.725*	-1.27*** *-5.014*	0.719*** *7.2*	1.056*** *6.915*	1.148*** *3.313*	1.006*** *10.711*
$E_{i,t}$	-3.326*** *-3.312*	6.425*** *15.861*	4.893*** *9.106*	4.113*** *10.046*	6.637*** *14.719*	15.098*** *16.616*	15.511*** *24.803*	14.391*** *14.312*	19.163*** *10.441*	13.991*** *26.695*
$NSCF_{i,t}$	-4.412*** *-5.049*	1.234** *2.399*	3.511** *2.326*	3.526*** *4.07*	-1.274* *-1.728*	4.799*** *3.07*	-0.263 *-0.207*	-1.093 *-1.188*	-5.729*** *-5.888*	-3.774*** *-9.464*
GRO	-2.263 *-0.352*		-1.529 *-0.793*	8.832 *0.531*	7.316 *1.498*	4.742 *0.88*	0.756 *0.107*	1.832 *0.582*	-8.359 *-1.384*	2.844 *1.104*
GRO_{xt}	-1.112 *-0.218*		-0.626 *-0.176*			-0.941 *-0.185*	3.683 *0.113*	0.125 *0.015*	-1.988 *-0.12*	1.196 *0.206*
EXP		-0.638 *-0.391*			-1.301 *-0.234*	-0.397 *-0.066*	0.664 *0.255*	-4.025 *-0.576*	-2.277 *-0.253*	0.192 *0.051*
EXP_{xt}		-5.272 *-1.379*		-1.907 *-0.163*	-2.611 *-0.387*	-0.62 *-0.229*		-2.539 *-0.132*	-1.724 *-0.136*	-1.286 *-0.29*
ABD				-0.631 *-0.296*	-0.697 *-0.25*			2.927 *0.373*		0.837 *0.139*
ABD_{xt}			-0.098 *-0.016*		0.073 *0.023*	-0.075 *-0.02*		0.164 *0.018*	-4.237 *-0.194*	-0.232 *-0.041*
R-sq	44.91%	82.98%	77.34%	67.89%	76.08%	90.37%	97.95%	94.09%	84.29%	80.11%
R-sq-adj	41.63%	82.11%	75.93%	66.32%	74.83%	89.92%	97.89%	93.83%	83.79%	79.99%
Sample	90	104	104	130	161	180	195	211	260	1435

*Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively.*

Table 7.2: Real Options and the components of residual income (book value, earnings and net dividend)
Panel B : Restricted Sample

$$MVE_{i,t} = \alpha_0 + \alpha_1 BVE_{i,t} + \alpha_2 E_{i,t} + \alpha_3 NSCF_{i,t} + \lambda_1 GRO + \lambda_2 GRO_{xt} + \lambda_3 EXP + \lambda_4 EXP_{xt} + \lambda_5 ABD + \lambda_6 ABD_{xt} + \varepsilon_{i,t}$$

$MVE_{i,t}$: Market value; $BVE_{i,t}$: Book value; $E_{i,t}$: Earnings; $NSCF_{i,t}$: Net Shareholders cash flows: GRO : growth option; EXP : option to expand; ABD : Option to abandon or default - months before exercise GRO_{xt}, EXP_{xt}, ABD_{xt} - months before expiry unexercised

Period	1991	1992	1993	1994	1995	1996	1997	1998	1999	Pooled
Intercept	0.321	2.145	5.765***	7.153***	5.855***	9.373***	-2.622	6.435	20.986**	7.892***
	0.26	*1.296*	*3.024*	*3.257*	*2.903*	*4.516*	*-1.051*	*1.077*	*2.121*	*2.974*
$BVE_{i,t}$	2.567***	2.067***	0.416***	0.851***	0.38*	-0.652***	0.966***	1.272***	2.357***	1.55***
	32.131	*5.925*	*2.854*	*6.436*	*1.679*	*-2.98*	*6.272*	*5.275*	*6.469*	*11.625*
$E_{i,t}$	4.427***	-0.369	3.89***	2.605***	6.071***	8.07***	11.595***	12.616***	21.529***	8.342***
	10.374	*-0.332*	*5.577*	*4.072*	*7.227*	*7.039*	*7.792*	*9.121*	*9.679*	*12.339*
$NSCF_{i,t}$	5.91***	2.528***	2.911*	4.285***	-1.41*	3.884***	1.917	-0.91	-4.639***	-3.755***
	12.616	*5.296*	*1.934*	*4.888*	*-1.931*	*2.889*	*0.872*	*-0.985*	*-4.59*	*-7.115*
GRO	0.149		-0.809	5.372	5.936	5.643*	0.36	1.846	0.346	1.237
	0.073		*-0.421*	*0.332*	*1.24*	*1.83*	*0.053*	*0.589*	*0.062*	*0.53*
GRO_{xt}	0.854		-0.552			-1.44	6.26	0.048	0.249	1.166
	0.527		*-0.159*			*-0.496*	*0.201*	*0.006*	*0.017*	*0.226*
EXP		-0.283			-1.018	-1.068	1.625	-3.859	-0.567	0.454
		-0.205			*-0.189*	*-0.313*	*0.65*	*-0.555*	*-0.069*	*0.136*
EXP_{xt}		9.511**		-2.211	-2.119	-0.776		-2.718	0.387	-0.39
		2.406		*-0.195*	*-0.324*	*-0.502*		*-0.142*	*0.034*	*-0.099*
ABD				-0.598	-0.542			2.21		-0.314
				-0.29	*-0.201*			*0.283*		*-0.058*
ABD_{xt}			-0.205		0.004	-0.824		-0.082	-1.323	-1.086
			-0.035		*0.002*	*-0.393*		*-0.009*	*-0.067*	*-0.216*
R-sq	94.42%	88.05%	78.40%	69.78%	75.21%	73.97%	86.83%	75.98%	64.08%	44.90%
R-sq-adj	94.09%	87.43%	77.05%	68.30%	73.89%	72.74%	86.41%	74.89%	62.93%	44.55%
Sample	89	103	103	129	159	178	193	209	257	1421

*Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively. Restricted sample excludes 1% of High BVE companies.*

Table 7.2 : Real options and the components of residual income (book value, earnings and net dividend)
Panel C : Full Sample

$$\left(\frac{MVE_{i,t}-BVE_{i,t}}{BVE_{i,t}}\right)=\alpha_0+\alpha_1\left(\frac{1}{BVE_{i,t}}\right)+\alpha_2\left(\frac{E_{i,t}}{BVE_{i,t}}\right)+\alpha_3\left(\frac{NSCF_{i,t}}{BVE_{i,t}}\right)+$$
$$+\lambda_1 GRO+\lambda_2 GRO_{xt}+\lambda_3 EXP+\lambda_4 EXP_{xt}+\lambda_5 ABD+\lambda_6 ABD_{xt}+\varepsilon_{i,t}$$

$MVE_{i,t}$: Market value; $BVE_{i,t}$: Book value; $RI_{i,t}$: Residual income $E_{i,t}$:Dividends; $NSCF_{i,t}$: Net Shareholders cash flows: $E_{i,t}$: Earnings;
GRO : growth option; **EXP** : option to expand; **ABD** : Option to abandon or default - months before exercise GRO_{xt}, EXP_{xt}, ABD_{xt} - months before expiry unexercised

Period	1991	1992	1993	1994	1995	1996	1997	1998	1999	Pooled
Intercept	3.711***	1.096*	0.573**	0.754	0.507***	0.257**	0.091	1.027*	6.194***	2.508***
	4.799	*1.884*	*2.309*	*0.929*	*3.399*	*2.186*	*0.56*	*1.798*	*6.53*	*9.926*
1/BVE$_{i,t}$	0.861**	1.052***	0.752***	2.331***	0.993***	1.985***	1.3***	2.309***	14.747***	1.762***
	2.517	*4.397*	*4.629*	*4.678*	*8.601*	*15.582*	*6.862*	*2.99*	*11.363*	*9.218*
E$_{i,t}$/BVE$_{i,t}$	-8.215***	1.755	1.337***	2.67	2.437***	-0.177	5.66***	9.573***	-4.932*	0.368
	-5.511	*1.03*	*3.38*	*0.842*	*4.828*	*-1.398*	*6.851*	*5.558*	*-1.714*	*0.712*
NSCF/BVE$_{i,t}$	-0.767	-4.057*	-3.316**	-1.458	-0.653***	2.447***	0.979	1.774	-1.65	-0.001
	-0.518	*-1.765*	*-2.423*	*-0.396*	*-2.611*	*2.801*	*0.844*	*0.722*	*-0.551*	*-0.001*
GRO	0.205		0.005	-0.422	0.066	0.356**	-0.101	1.001***	-0.095	0.542***
	0.168		*0.024*	*-0.078*	*0.205*	*2.11*	*-0.294*	*3.764*	*-0.211*	*2.622*
GRO$_{xt}$	0.087		0.018			-0.053	1.518	-0.883	0.087	0.022
	0.092		*0.045*			*-0.329*	*0.962*	*-1.22*	*0.068*	*0.048*
EXP		-0.209			-0.122	-0.044	0.209*	-0.156	0.086	0.139
		-0.431			*-0.327*	*-0.232*	*1.664*	*-0.264*	*0.124*	*0.461*
EXP$_{xt}$		0.401		-0.274	-0.065	-0.024		-0.537	-0.194	-0.073
		0.412		*-0.072*	*-0.143*	*-0.279*		*-0.329*	*-0.199*	*-0.203*
ABD				-0.184	-0.047			0.233		-0.307
				-0.265	*-0.248*			*0.35*		*-0.628*
ABD$_{xt}$			0.021		-0.07	-0.1		0.062	-1.058	-0.267
			0.031		*-0.328*	*-0.864*		*0.082*	*-0.63*	*-0.583*
R-sq	39.47%	21.28%	21.20%	17.34%	38.46%	66.77%	35.45%	28.96%	38.38%	6.27%
R-sq-adj	35.87%	17.27%	16.32%	13.31%	35.22%	65.22%	33.39%	25.78%	36.41%	5.68%
Sample	90	104	104	130	161	180	195	211	260	1435

*Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively.*

Table 7.2: Real options and the components of residual income (book value, earnings and net dividend)
Panel D : Restricted Sample

$$\left(\frac{MVE_{i,t} - BVE_{i,t}}{BVE_{i,t}}\right) = \alpha_0 + \alpha_1\left(\frac{1}{BVE_{i,t}}\right) + \alpha_2\left(\frac{E_{i,t}}{BVE_{i,t}}\right) + \alpha_3\left(\frac{NSCF_{i,t}}{BVE_{i,t}}\right) +$$

$$+ \lambda_1 GRO + \lambda_2 GRO_{xt} + \lambda_3 EXP + \lambda_4 EXP_{xt} + \lambda_5 ABD + \lambda_6 ABD_{xt} + \varepsilon_{i,t}$$

$MVE_{i,t}$: Market value; $BVE_{i,t}$: Book value; $RI_{i,t}$: Residual income $D_{i,t}$:Dividends; $E_{i,t}$: Earnings;***GRO*** : growth option;
EXP : option to expand; ***ABD*** : Option to abandon or default - months before exercise GRO_{xt}, EXP_{xt}, ABD_{xt} - months before expiry unexercised

Period	1991	1992	1993	1994	1995	1996	1997	1998	1999	Pooled
Intercept	1.412*** *5.303*	1.068*** *5.652*	0.366** *2.242*	0.852*** *4.725*	0.52*** *3.952*	0.29** *2.405*	0.248 *1.335*	0.99*** *5.065*	3.559*** *14.241*	1.455*** *20.994*
1/BVE_i,t	-0.147 *-1.36*	-0.036 *-0.377*	0.543*** *5.02*	0.834*** *5.233*	0.93*** *7.624*	1.586*** *8.221*	0.893** *2.512*	0.747*** *3.13*	4.219*** *4.899*	0.329*** *5.504*
E_i,t/BVE_i,t	3.809*** *3.145*	0.313 *0.544*	0.781*** *2.968*	2.561*** *3.604*	1.941*** *4.243*	0.733*** *2.945*	5.085*** *6.273*	4.492*** *4.508*	1.256 *1.37*	1.173*** *5.906*
NSCF/BVE_i,t	1.771 *1.543*	4.04*** *3.671*	3.753*** *3.352*	-0.159 *-0.199*	-0.586*** *-2.888*	2.319*** *2.761*	0.907 *0.811*	-1.179 *-1.326*	-0.275 *-0.267*	-0.188 *-0.778*
GRO	1.282*** *3.675*		-0.04 *-0.281*	-0.357 *-0.317*	0.083 *0.315*	0.328** *2.055*	-0.088 *-0.263*	0.2** *2.179*	0.088 *1.047*	0.233*** *4.126*
GRO_xt	0.346 *1.288*		0.034 *0.129*			-0.057 *-0.376*	1.538 *1.01*	0.051 *0.233*	0.183 *0.54*	0.1 *0.779*
EXP		-0.09 *-0.571*			-0.109 *-0.358*	-0.031 *-0.174*	0.205* *1.689*	-0.084 *-0.469*		-0.029 *-0.291*
EXP_xt		0.137 *0.436*		-0.25 *-0.316*	-0.014 *-0.038*	-0.028 *-0.345*		-0.406 *-0.818*	0.144 *0.699*	0.145 *1.534*
ABD				-0.106 *-0.734*	-0.036 *-0.235*			0.101 *0.492*		-0.105 *-0.853*
ABD_xt			0.103 *0.23*		-0.071 *-0.413*	-0.09 *-0.811*		0.242 *1.05*	-0.3 *-1.023*	-0.026 *-0.220*
R-sq	31.83%	17.17%	30.32%	28.52%	32.34%	37.73%	23.87%	19.26%	14.67%	5.51%
R-sq-adj	27.46%	12.81%	25.92%	24.89%	28.73%	34.78%	21.41%	15.29%	11.05%	4.86%
Sample	84	101	102	125	159	178	193	193	173	1308

*Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively. Restricted sample excludes companies with MV/BV>9*

Allowing for Dividends as a Separate Factor

Next, we examine whether replacing $NSCF_{i,t}$ by dividends leads to an improvement in model predictive ability. Panel A of Table 7.3 indicates that the replacement of $NSCF_{i,t}$ by dividends leads to similar conclusions. First, the results for the full sample indicate that the value of the examined companies is approximately their book value plus 15.5 times their after tax profits minus 5.8 times dividend outflows. Second, it also gives us the impression that the textbook equation 'market value = replacement value + future opportunities' is in line with market valuation in the Athens Stock Exchange. Third, assuming the book value is a good approximation of replacement value, it is reasonable to say that Greek investors appreciate company replacement value in a way theory expects, since the book value regression coefficient is close to unity (1.138) and it is statistically significant at the 1% level. Fourth, the earnings coefficient implies that earnings is a significant forecasting variable of future opportunity and statistically significant at the 1% level. Last, but not least, even though the coefficients of $BVE_{i,t}$, $E_{i,t}$ and $D_{i,t}$ are significant at the 1% level, and the regression fit for the examined period (1991-1999) is very high (adjusted R-sq is 78.97%), we find no evidence that the growth options contribute to higher model prediction ability. As before, a possible explanation is that real options are unlikely to have uniform effect on company market value due to size bias that is evident in this model.

The regression coefficients vary significantly over time when we run separate regressions for each of the examined years (1991-1999). In 1992, 1995 and 1996, the coefficient of book value is negative. With regard to the dividend effect on market value, this is positive, except in 1997 and in 1999. Like Table 7.2, the earnings coefficient is positive and statistically significant (at the 1% level) except in 1991. The earnings regression coefficient also increases from 1996 onwards, probably due to decreasing interest rates. Also, adjusted R-sq becomes extremely high from 1996 onwards, making us suspicious that the examined model is spurious. Finally, the coefficients of real options are statistically insignificant.

Next we exclude extreme observations from our sample. The pooled results are shown in the last column of Panel B of Table 7.3. The coefficient of book value appears higher (1.415 compared to 1.138) while the coefficient of earnings is lower (8.744 compared to 15.480). Both of them are significant at the 1% level. Unlike to the findings shown in Panel A, the coefficient of dividends is insignificant. As with the full sample, the growth options coefficient is insignificant.

Again, as a second step, it is investigated whether the low predictive ability of real options is due to the fact that we regress absolute values (market value, book value, earnings) instead of deflated ones by examining the following model:

$$(\frac{MVE_{i,t}-BVE_{i,t}}{BVE_{i,t}})=\alpha_0+\alpha_1(\frac{1}{BVE_{i,t}})+\alpha_2(\frac{E_{i,t}}{BVE_{i,t}})+\alpha_3(\frac{D_{i,t}}{BVE_{i,t}})+$$
$$+\lambda_1 GRO+\lambda_2 GRO_{xt}+\lambda_3 EXP+\lambda_4 EXP_{xt}+\lambda_5 ABD+\lambda_6 ABD_{xt}+\varepsilon_{i,t}$$

Table 7.3 (Panel C and Panel D) shows that the premium of market values over company book value is affected by dividends over book value ($D_{i,t}/BVE_{i,t}$) and by earnings over book value ($E_{i,t}/BVE_{i,t}$).

Both regression coefficients are statistically significant, at 1% and 5% significance level, respectively. In addition, The Panel C confirms that the growth options significantly increase company market value (the regression coefficient of growth options is 0.532, and significant at the 1% level). In line with previous findings, the coefficients of options to abandon/default are found to be negative. The intercept is found to be positive during the examined years, except in 1994 and in 1997.

If we exclude extreme $MVE_{i,t}/BVE_{i,t}$ observations, the adjusted R-sq increases and the statistical significance of growth options remains intact. However, Panel D shows that the magnitude of the growth option coefficient decreases from 0.532 to 0.227. The market value is also affected by dividends over book value ($D_{i,t}/BVE_{i,t}$) and by earnings over book value ($E_{i,t}/BVE_{i,t}$), statistically significant, at 1% and 5% level, respectively.

Table 7.3: Akbar and Stark specifications: (1) earnings and dividend payments.

Panel A: Full Sample

$$MVE_{i,t} = \alpha_0 + \alpha_1 BVE_{i,t} + \alpha_2 E_{i,t} + \alpha_3 D_{i,t} + \lambda_1 GRO + \lambda_2 GRO_{xt} + \lambda_3 EXP + \lambda_4 EXP_{xt} + \lambda_5 ABD + \lambda_6 ABD_{xt} + \varepsilon_{i,t}$$

$MVE_{i,t}$: Market value; $BVE_{i,t}$: Book value; $RI_{i,t}$: Residual income; $D_{i,t}$:Dividends; $E_{i,t}$: Earnings; ***GRO*** : growth option; ***EXP*** : option to expand; ***ABD*** : Option to abandon or default - months before exercise GRO_{xt}, EXP_{xt}, ABD_{xt} - months before expiry unexercised

Period	1991	1992	1993	1994	1995	1996	1997	1998	1999	Pooled
Intercept	16.312***	5.312***	5.4***	8.018***	7.868***	2.947	-4.792*	4.698	51.844***	3.233
	3.998	*3.705*	*2.915*	*3.572*	*4.105*	*0.862*	*-1.918*	*0.819*	*5.066*	*1.116*
$BVE_{i,t}$	0.686	-0.37***	0.106**	0.361***	-0.094	-1.371***	0.72***	1.047***	1.746***	1.138***
	1.577	*-5.848*	*2.154*	*5.607*	*-0.989*	*-5.22*	*7.058*	*6.649*	*4.189*	*10.619*
$E_{i,t}$	-2.184*	3.796***	3.954***	2.82***	6.363***	15.127***	15.521***	14.594***	21.356***	15.48***
	-1.86	*8.875*	*6.323*	*5.143*	*12.664*	*16.733*	*23.636*	*11.497*	*11.576*	*24.821*
$D_{i,t}$	2.199	11.568***	7.391***	6.769***	2.181	5.787***	-0.292	0.764	-16.42***	-5.779***
	0.649	*7.599*	*3.603*	*4.096*	*1.584*	*3.373*	*-0.206*	*0.348*	*-4.992*	*-4.602*
GRO	-2.924		-2.371	11.245	7.145	3.644	0.756	1.862	-7.906	1.705
	-0.4		*-1.258*	*0.677*	*1.462*	*0.682*	*0.107*	*0.59*	*-1.283*	*0.648*
GRO_{xt}	-1.278		-0.385			-0.759	3.646	0.086	-0.624	1.798
	-0.22		*-0.112*			*-0.15*	*0.112*	*0.01*	*-0.037*	*0.303*
EXP		-0.445			-1.383	-0.241	0.662	-4.038	-2.649	-0.06
		-0.334			*-0.248*	*-0.041*	*0.254*	*-0.576*	*-0.289*	*-0.015*
EXP_{xt}		- 10.527***		-1.426	-2.877	-0.559		-2.179	-2.625	-1.455
		-3.402		*-0.122*	*-0.426*	*-0.207*		*-0.113*	*-0.204*	*-0.321*
ABD				-0.607	-0.698			3.069***		0.92
				-0.285	*-0.25*			*0.39*		*0.149*
ABD_{xt}			0.262		0.151	0.191		0.2	-5.326	-0.323
			0.046		*0.048*	*0.052*		*0.022*	*-0.24*	*-0.056*
R-sq	53.43%	94.16%	88.82%	82.42%	87.18%	95.12%	98.97%	96.98%	91.51%	88.98%
R-sq-adj	28.55%	88.66%	78.89%	67.94%	76.01%	90.47%	97.95%	94.06%	83.74%	79.17%
Sample	90	104	104	130	161	180	195	211	260	1435

*Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively.*

Table 7.3: Akbar and Stark specifications: (1) earnings and dividend payments.
Panel B: Restricted Sample

$$MVE_{i,t} = \alpha_0 + \alpha_1 BVE_{i,t} + \alpha_2 E_{i,t} + \alpha_3 D_{i,t} + \lambda_1 GRO + \lambda_2 GRO_{xt} + \lambda_3 EXP + \lambda_4 EXP_{xt} + \lambda_5 ABD + \lambda_6 ABD_{xt} + \varepsilon_{i,t}$$

$MVE_{i,t}$: Market value; $BVE_{i,t}$: Book value; $D_{i,t}$:Dividends; $E_{i,t}$: Earnings;*GRO* : growth option; *EXP* : option to expand; *ABD* : Option to abandon or default - months before exercise GRO_{xt}, EXP_{xt}, ABD_{xt} - months before expiry unexercised

Period	1991	1992	1993	1994	1995	1996	1997	1998	1999	Pooled
Intercept	3.668** *2.243*	0.154 *0.137*	4.934*** *2.657*	7.866*** *3.484*	5.972** *2.921*	7.834*** *3.718*	-3.398 *-1.338*	5.691 *0.962*	24.025** *2.390*	8.709*** *3.226*
$BVE_{i,t}$	1.597*** *9.458*	1.845*** *8.318*	0.338** *2.309*	0.455*** *3.266*	0.440* *1.768*	-0.569** *-2.583*	1.097*** *6.001*	1.445*** *5.315*	2.78*** *6.800*	1.415*** *9.070*
$E_{i,t}$	-0.030 *-0.065*	-4.063*** *-4.912*	3.323*** *4.585*	2.507*** *3.652*	6.182*** *6.6*	7.052*** *5.657*	9.45*** *4.284*	13.333*** *9.59*	25.658*** *9.733*	8.744*** *11.940*
$D_{i,t}$	9.400** *7.142*	14.639*** *13.245*	6.364*** *2.998*	6.495*** *3.833*	-1.283 *-0.671*	5.966*** *3.513*	5.680 *1.574*	-3.269 *-1.166*	-16.236*** *-3.285*	-0.789 *-0.501*
GRO	2.233 *0.000*		-1.694 *-0.887*	10.618 *0.637*	5.171 *1.067*	4.704 *1.55*	0.481 *0.071*	1.867 *0.596*	0.325 *0.056*	1.167 *0.491*
GRO_{xt}	0.342 *0.156*		-0.361 *-0.107*			-1.192 *-0.415*	8.216 *0.264*	-0.061 *-0.008*	1.436 *0.093*	1.534 *0.292*
EXP		-0.085 *-0.092*			-1.086 *-0.200*	-0.84 *-0.250*	1.584 *0.636*	-4.354 *-0.626*	-0.839 *-0.101*	0.261 *0.077*
EXP_{xt}	-1.500 *-0.001*	5.929** *2.197*		-1.491 *-0.128*	-2.216 *-0.336*	-0.685 *-0.449*		-2.436 *-0.128*	-0.22 *-0.019*	-0.896 *-0.224*
ABD				-0.606 *-0.285*	-0.573 *-0.21*			2.397 *0.306*		-0.339 *-0.062*
ABD_{xt}			0.131 *0.023*		-0.078 *-0.025*	-0.581 *-0.281*		-0.073 *-0.009*	-1.839 *-0.092*	-1.166 *-0.229*
R-sq	89.97%	94.51%	79.48%	67.75%	74.67%	74.55%	86.95%	76.03%	62.66%	42.94%
R-sq-adj	89.23%	94.23%	78.20%	66.16%	73.32%	73.34%	86.53%	74.94%	61.45%	42.57%
Sample	89	103	103	129	159	178	193	209	257	1421

*Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively.*

Table 7.3: Akbar and Stark specifications: (1) earnings and dividend payments, deflated by book value.
Panel C : Full Sample

$$\left(\frac{MVE_{i,t}-BVE_{i,t}}{BVE_{i,t}}\right) = \alpha_0 + \alpha_1\left(\frac{1}{BVE_{i,t}}\right) + \alpha_2\left(\frac{E_{i,t}}{BVE_{i,t}}\right) + \alpha_3\left(\frac{D_{i,t}}{BVE_{i,t}}\right) + \lambda_1 GRO + \lambda_2 GRO_{xt} + \lambda_3 EXP + \lambda_4 EXP_{xt} + \lambda_5 ABD + \lambda_6 ABD_{xt} + \varepsilon_{i,t}$$

$MVE_{i,t}$: Market value; $BVE_{i,t}$: Book value; $D_{i,t}$:Dividends; $E_{i,t}$: Earnings;**GRO** : growth option; **EXP** : option to expand; **ABD** : Option to abandon or default - months before exercise GRO_{xt}, EXP_{xt}, ABD_{xt} - months before expiry unexercised

Period	1991	1992	1993	1994	1995	1996	1997	1998	1999	Pooled
Intercept	1.243* *1.831*	0.861 *1.22*	0.163 *0.552*	0.989 *1.229*	0.17 *0.963*	-0.213 *-1.413*	-0.357*** *-2.025*	0.921*** *1.685*	4.506*** *4.569*	1.711*** *6.242*
$1/BVE_{i,t}$	0.323 *1.174*	1.13*** *4.737*	0.705*** *4.33*	2.593*** *4.565*	0.935*** *8.196*	1.94*** *15.956*	1.265*** *7.126*	2.278*** *2.993*	13.487*** *10.72*	1.466*** *7.609*
$E_{i,t}/BVE_{i,t}$	5.35 *1.3*	0.714 *0.359*	1.037** *2.579*	3.869 *1.206*	0.627 *1.235*	-0.305** *-2.45*	2.749*** *2.971*	3.755*** *1.117*	- 14.007*** *-4.332*	-1.293** *-2.343*
$D_{i,t}/BVE_{i,t}$	4.843 *0.926*	1.054 *0.182*	7.237** *2.307*	-8.585 *-1.022*	9.436*** *3.936*	9.068*** *5.086*	13.837*** *5.345*	14.239*** *2.109*	49.397*** *4.831*	16.29*** *6.891*
GRO	0.775 *0.814*		-0.067 *-0.308*	-0.373 *-0.069*	0.073 *0.232*	0.335** *2.086*	-0.074*** *-0.231*	1.043*** *3.965*	-0.3*** *-0.696*	0.532*** *2.616*
GRO_{xt}	0.208 *0.284*		0.031 *0.077*			-0.045 *-0.29*	1.845*** *1.248*	-0.778*** *-1.088*	0.428*** *0.351*	0.095 *0.208*
EXP		-0.208 *-0.422*			-0.121 *-0.332*	-0.04 *-0.219*	0.253*** *2.145*	-0.045*** *-0.077*		0.201 *0.676*
EXP_{xt}		0.299 *0.302*		-0.294 *-0.077*	-0.151 *-0.343*	-0.065 *-0.788*		-0.597*** *-0.373*	-0.239*** *-0.257*	-0.125 *-0.354*
ABD				-0.223 *-0.321*	0.028 *0.156*					-0.237 *-0.491*
ABD_{xt}			0.158 *0.229*		-0.028 *-0.132*	-0.035 *-0.312*			-0.874*** *-0.544*	-0.159 *-0.354*
R-sq	40.12%	43.37%	45.58%	42.35%	64.53%	83.56%	65.95%	54.99%	66.07%	30.48%
R-sq-adj	16.10%	18.81%	20.78%	17.93%	41.64%	69.82%	43.49%	30.24%	43.66%	9.29%
Sample	89	104	104	130	161	180	194	211	259	1435

*Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively.*

Table 7.3: Akbar and Stark specifications: (1) earnings and dividend payments, deflated by book value.
Panel D : Restricted Sample

$$\left(\frac{MVE_{i,t}-BVE_{i,t}}{BVE_{i,t}}\right) = \alpha_0 + \alpha_1\left(\frac{1}{BVE_{i,t}}\right) + \alpha_2\left(\frac{E_{i,t}}{BVE_{i,t}}\right) + \alpha_3\left(\frac{D_{i,t}}{BVE_{i,t}}\right) +$$

$$+ \lambda_1 GRO + \lambda_2 GRO_{xt} + \lambda_3 EXP + \lambda_4 EXP_{xt} + \lambda_5 ABD + \lambda_6 ABD_{xt} + \varepsilon_{i,t}$$

$MVE_{i,t}$: Market value; $BVE_{i,t}$: Book value; $RI_{i,t}$: Residual income $D_{i,t}$:Dividends; $E_{i,t}$: Earnings;**GRO** : growth option; **EXP** : option to expand; **ABD** : Option to abandon or default - months before exercise GRO_{xt}, EXP_{xt}, ABD_{xt} - months before expiry unexercised

Period	1991	1992	1993	1994	1995	1996	1997	1998	1999	Pooled
Intercept	1.221*** *4.694*	0.495* *1.746*	-0.107 *-0.595*	0.301 *1.6*	0.12 *0.765*	-0.099 *-0.668*	-0.147*** *-0.775*	0.724*** *3.187*	4.604*** *19.698*	1.11*** *13.991*
$1/BVE_{i,t}$	-0.159 *-1.461*	0.301*** *2.857*	0.545*** *5.508*	0.84*** *5.931*	0.947*** *8.155*	1.523*** *8.169*	0.683*** *2.053*	0.776*** *3.281*	2.624*** *3.632*	0.235*** *3.975*
$E_{i,t}/BVE_{i,t}$	2.801* *1.807*	-1.355* *-1.683*	0.638** *2.612*	0.712 *1.131*	0.386 *0.904*	0.409 *1.598*	2.075*** *2.296*	3.514*** *3.318*	-0.276*** *-0.281*	0.423** *2.05*
$D_{i,t}/BVE_{i,t}$	3.991* *1.696*	9.573*** *4.057*	10.495*** *5.541*	12.621*** *5.538*	9.507*** *4.846*	8.171*** *4.525*	13.973*** *5.607*	8.097*** *2.226*	2.893*** *1.32*	7.282*** *8.337*
GRO	1.325*** *3.793*		-0.05 *-0.385*	-0.455 *-0.454*	0.098 *0.388*	0.312** *2.026*	-0.06*** *-0.193*	0.177*** *1.943*	0.069*** *0.916*	0.227*** *4.125*
GRO_{xt}	0.329 *1.228*		0.081 *0.331*			-0.045 *-0.306*	1.84*** *1.301*	0.098*** *0.444*	0.043*** *0.157*	0.124 *0.995*
EXP		-0.086 *-0.434*			-0.106 *-0.365*	-0.022 *-0.128*	0.246*** *2.182*	-0.048*** *-0.27*		-0.001 *-0.009*
EXP_{xt}		0.182 *0.459*		-0.201 *-0.284*	-0.11 *-0.313*	-0.061 *-0.774*		-0.316*** *-0.649*	0.508*** *2.16*	0.113 *1.225*
ABD				-0.054 *-0.413*	0.037 *0.259*					-0.077 *-0.641*
ABD_{xt}			0.258 *0.626*		-0.02 *-0.122*	-0.026 *-0.24*				0.019 *0.170*
R-sq	56.79%	47.56%	64.11%	65.76%	61.84%	64.77%	58.57%	44.81%	38.46%	32.05%
R-sq-adj	32.25%	22.62%	41.11%	43.25%	38.24%	41.95%	34.30%	20.08%	14.79%	10.27%
Sample	84	102	102	125	159	178	192	193	132	1308

*Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively. Restricted sample excludes companies with MVE/BVE>9.*

Breaking down net cash flows to dividends and capital contributions (Table 7.4) gives the advantage of examining the validity of the Ohlson (1989) system of linear information dynamics. If the Ohlson (1989) system holds, then the coefficient of dividends is positive and statistically different from zero and the coefficient of capital contributions will be negative and statistically different from zero[4].

We run regressions for the period 1991-1999 for all companies having positive book value ($BVE_{i,t}$>0). Pooled data regression coefficients do not support the Ohlson hypothesis. In particular, although the coefficient of capital contributions is negative (-3.53) and significantly different from zero (at the 1% level), the coefficient of dividends is negative (-6.34) and statistically significant (at 1%), in the contrary to theoretical assumptions. The growth options contribute positively to company value, but their coefficient is not statistically significant. Also, adjusted R-sq is extremely high (79.99%).

Annual results give a somewhat different picture. The coefficient of capital contributions is negative and significant during 1991, 1992, 1995 and 1999, whilst positive and significant in 1994. However, the coefficient of dividends is positive for all the examined years, in line with theoretical assumptions, also statistically significant in 1991, 1992, 1993, 1994, 1996 and 1999. The coefficients of the real options are not statistically significant. adjusted R-sq is high (from 54% up to 97%) in the examined regressions.

If we exclude outliers, we have somewhat different results. We run a regression for the period 1991-1999 for a trimmed sample. Unlike previous findings, regression coefficients partly support the Ohlson hypothesis. The coefficient of the capital contributions is negative (-3.82) and significantly different from zero (at the 1% level). The coefficient of the dividends is positive (2.29), in line with the Ohlson theory, though statistically insignificant. Growth options contribute positively to company value, but their coefficient is not statistically significant. In addition, adjusted R-sq is high, whilst lower than previously reported findings (45.55%).

[4] As explained in Chapter 5, pp.147-148.

The coefficient of dividends is positive for all the examined years except 1995, in line with theoretical assumptions. The coefficient is also statistically significant in all years except 1994 and 1995. The coefficient of capital contributions is unstable over time (negative and significant during 1994 and 1998, whilst positive and significant in 1990 and 1993). The coefficients of the real options are not statistically significant. adjusted R-sq is high (from 71% up to 94%) in the examined regressions.

We now regress deflated values, as follows:

$$(\frac{MVE_{i,t}-BVE_{i,t}}{BVE_{i,t}})=\alpha_0+\alpha_1(\frac{1}{BVE_{i,t}})+\alpha_2(\frac{E_{i,t}}{BVE_{i,t}})+\alpha_3(\frac{D_{i,t}}{BVE_{i,t}})+\alpha_4(\frac{CC_{i,t}}{BVE_{i,t}})+$$
$$+\lambda_1 GRO+\lambda_2 GRO_{xt}+\lambda_3 EXP+\lambda_4 EXP_{xt}+\lambda_5 ABD+\lambda_6 ABD_{xt}+\varepsilon_{i,t}$$

Table 7.4 (Panel C) indicates that the presence of growth options for a month increases the market value by 53.9%. Again, the coefficients of options to abandon/default are negative, though statistically insignificant. These results indicate that growth options are value relevant, even if we use dividends and capital contributions as separate forecasting variables instead of using $NSCF_{i,t}$.

Also, Panel C shows that the dividends ($D_{i,t}/BVE_{i,t}$), the capital contributions ($CC_{i,t}/BVE_{i,t}$) and the earnings ($E_{i,t}/BVE_{i,t}$) affect significantly the market value (at 1%, 5% and 5% significance level, respectively).

Similarly, growth options increase significantly company market value in the restricted sample. (the coefficient of growth options is 0.228, and significant at the 1% level). Also, dividends ($D_{i,t}/BVE_{i,t}$), capital contributions ($CC_{i,t}/BVE_{i,t}$) and earnings ($E_{i,t}/BVE_{i,t}$) affect significantly the market value, at the 1% level. Nevertheless, earnings now have a positive effect on market value, and dividends have a smaller regression coefficient. These results indicate that growth options are value relevant, even if we restrict our sample.

Table 7.4: Akbar and Stark specifications: (2) earnings, dividend payments and capital contribution

Panel A : Full Sample

$$MVE = \alpha_0 + \alpha_1 BVE + \alpha_2 E + \alpha_3 D + \alpha_4 CC + \lambda_1 GRO + \lambda_2 GRO_{xt} + \lambda_3 EXP + \lambda_4 EXP_{xt} + \lambda_5 ABD + \lambda_6 ABD_{xt} + \varepsilon_{i,t}$$

$MVE_{i,t}$: Market value; $BVE_{i,t}$: Book value; $RI_{i,t}$: Residual income $D_{i,t}$:Dividends; $CC_{i,t}$: Capital contributions; $E_{i,t}$: Earnings; GRO : growth option; EXP : option to expand; ABD : Option to abandon or default - months before exercise GRO_{xt}, EXP_{xt}, ABD_{xt} - months before expiry unexercised

Period	1991	1992	1993	1994	1995	1996	1997	1998	1999	Pooled
Intercept	13.049***	5.257***	5.472***	7.265***	7.483***	2.943	-4.808*	5.967	44.216***	2.937
	4.071	*3.826*	*2.928*	*3.461*	*3.902*	*0.827*	*-1.902*	*1.029*	*4.477*	*1.039*
$BVE_{i,t}$	0.236	-0.399***	0.105**	0.395***	-0.03	-1.371***	0.72***	1.027***	2.037***	1.114***
	0.687	*-6.44*	*2.147*	*6.482*	*-0.289*	*-5.205*	*7.039*	*6.512*	*5.072*	*10.653*
$E_{i,t}$	-6.055***	2.688***	3.93***	2.677***	6.286***	15.127***	15.52***	13.595***	19.764***	14.744***
	-5.764	*4.658*	*6.243*	*5.202*	*12.54*	*16.684*	*23.562*	*9.283*	*11.057*	*23.991*
$D_{i,t}$	8.627***	13.573***	7.501***	9.854***	0.893	5.787***	-0.29	0.41	-17.919***	-6.487***
	3.108	*8.289*	*3.618*	*5.741*	*0.573*	*3.362*	*-0.204*	*0.186*	*-5.685*	*-5.283*
$CC_{i,t}$	-6.994***	-1.467***	0.636	3.375***	-1.261*	-0.015	-0.143	-1.316	-4.91***	-3.524***
	-7.461	*-2.749*	*0.354*	*4.158*	*-1.718*	*-0.004*	*-0.047*	*-1.359*	*-5.085*	*-8.548*
GRO	-2.251		-2.417	7.774	7.471	3.641	0.757	1.83	-6.038	3.03
	-0.395		*-1.279*	*0.499*	*1.537*	*0.67*	*0.107*	*0.581*	*-1.025*	*1.177*
GRO_{xt}	-0.987		-0.399			-0.758	3.663	0.152	-2.01	1.148
	-0.218		*-0.116*			*-0.149*	*0.112*	*0.018*	*-0.125*	*0.198*
EXP		-0.439			-1.284	-0.241	0.664	-3.739	-2.235	0.154
		-0.342			*-0.232*	*-0.04*	*0.254*	*-0.534*	*-0.256*	*0.041*
EXP_{xt}		-8.871***		-1.728	-2.665	-0.559		-2.669	-1.458	-1.203
		-2.915		*-0.158*	*-0.397*	*-0.207*		*-0.138*	*-0.119*	*-0.272*
ABD				-0.543	-0.661			2.665		0.906
				-0.273	*-0.239*			*0.339*		*0.150*
ABD_{xt}			0.237		0.155	0.192		0.099	-4.512	-0.260
			0.042		*0.050*	*0.052*		*0.011*	*-0.213*	*0.802*
R-sq	57.23%	89.49%	78.96%	71.93%	76.47%	90.47%	97.95%	94.11%	85.26%	80.19%
R-sq-adj	54.14%	88.85%	77.45%	70.34%	75.07%	89.97%	97.88%	93.82%	84.73%	80.05%
Sample	90	105	105	131	161	180	195	211	260	1435

*Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively.*

Table 7.4: Akbar and Stark specifications: (2) earnings, dividend payments and capital contribution

Panel B : Restricted Sample

$$MVE = \alpha_0 + \alpha_1 BVE + \alpha_2 E + \alpha_3 D + \alpha_4 CC + \lambda_1 GRO + \lambda_2 GRO_{xt} + \lambda_3 EXP + \lambda_4 EXP_{xt} + \lambda_5 ABD + \lambda_6 ABD_{xt} + \varepsilon_{i,t}$$

$MVE_{i,t}$: Market value; $BVE_{i,t}$: Book value; $RI_{i,t}$: Residual income $D_{i,t}$:Dividends; $CC_{i,t}$: Capital contributions;: $E_{i,t}$: Earnings; ***GRO*** : growth option; ***EXP*** : option to expand; ***ABD*** : Option to abandon or default - months before exercise GRO_{xt}, EXP_{xt}, ABD_{xt} - months before expiry unexercised

Period	1991	1992	1993	1994	1995	1996	1997	1998	1999	Pooled
Intercept	0.786	5.304***	5.516***	7.315***	5.657***	7.948***	-4.894*	6.125	20.518**	7.991***
	0.637	*3.821*	*2.919*	*3.455*	*2.789*	*3.641*	*-1.914*	*1.022*	*2.088*	*3.013*
$BVE_{i,t}$	2.306***	-0.399***	0.105**	0.394***	0.475*	-0.569**	0.721***	1.398***	2.714***	1.422***
	15.573	*-6.411*	*2.133*	*6.45*	*1.922*	*-2.575*	*7.008*	*4.83*	*6.814*	*9.287*
$E_{i,t}$	3.7***	2.685***	3.927***	2.675***	6.47***	7.053***	15.52***	13.065***	24.417***	7.883***
	6.779	*4.631*	*6.208*	*5.177*	*6.902*	*5.642*	*23.442*	*8.725*	*9.437*	*10.818*
$D_{i,t}$	7.697***	13.57***	7.501***	9.852***	-3.344	5.958***	-0.294	-3.035	-14.756***	-1.305
	7.878	*8.249*	*3.6*	*5.718*	*-1.559*	*3.499*	*-0.206*	*-1.064*	*-3.056*	*-0.843*
$CC_{i,t}$	5.116***	-1.47***	0.644	3.373***	-1.51**	0.458	-0.157	-0.513	-3.999***	-4.031***
	8.557	*-2.741*	*0.356*	*4.14*	*-2.047*	*0.208*	*-0.051*	*-0.486*	*-3.819*	*-7.298*
GRO	0.065		-2.421	7.74	5.648	4.814	0.801	1.853	0.5	1.222
	0.033		*-1.275*	*0.495*	*1.177*	*1.559*	*0.113*	*0.59*	*0.09*	*0.524*
GRO_{xt}	0.804		-0.407			-1.214	3.744	-0.024	0.182	1.19
	0.506		*-0.118*			*-0.421*	*0.114*	*-0.003*	*0.012*	*0.231*
EXP		-0.444			-0.984	-0.858	0.673	-4.208	-0.672	0.488
		-0.344			*-0.182*	*-0.254*	*0.256*	*-0.603*	*-0.083*	*0.147*
EXP_{xt}		-8.861***		-1.751	-2.019	-0.695		-2.609	0.418	-0.499
		-2.898		*-0.159*	*-0.309*	*-0.453*		*-0.136*	*0.037*	*-0.127*
ABD				-0.548	-0.549			2.301		-0.327
				-0.274	*-0.203*			*0.294*		*-0.061*
ABD_{xt}			0.223		-0.044	-0.604		-0.090	-1.355	-1.022
			0.039		*-0.014*	*-0.290*		*-0.010*	*-0.069*	*0.450*
R-sq	94.70%	89.48%	78.92%	71.89%	75.36%	74.55%	97.95%	76.05%	64.74%	45.01%
R-sq-adj	94.31%	88.83%	77.39%	70.27%	73.87%	73.19%	97.87%	74.85%	63.45%	44.62%
Sample	89	104	104	130	159	178	193	209	257	1421

*Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively. Restricted sample excludes 1% of High BVE companies.*

Table 7.4: Real Options and Akbar & Stark specifications. Panel C : Full Sample

$$\left(\frac{MVE_{i,t}-BVE_{i,t}}{BVE_{i,t}}\right) = \alpha_0 + \alpha_1\left(\frac{1}{BVE_{i,t}}\right) + \alpha_2\left(\frac{E_{i,t}}{BVE_{i,t}}\right) + \alpha_3\left(\frac{D_{i,t}}{BVE_{i,t}}\right) + \alpha_4\left(\frac{CC_{i,t}}{BVE_{i,t}}\right) + +\lambda_1 GRO + \lambda_2 GRO_{xt} + \lambda_3 EXP + \lambda_4 EXP_{xt} + \lambda_5 ABD + \lambda_6 ABD_{xt} + \varepsilon_{i,t}$$

Period	1991	1992	1993	1994	1995	1996	1997	1998	1999	Pooled
Intercept	1.73** *2.443*	0.625 *0.89*	-0.142 *-0.508*	0.956 *1.138*	0.116 *0.662*	-0.195 *-1.247*	-0.401** *-2.275*	0.789 *1.365*	3.766*** *3.73*	1.591*** *5.733*
$1/BVE_{i,t}$	0.336 *1.146*	1.015*** *4.221*	0.736*** *4.946*	2.594*** *4.548*	0.902*** *7.973*	1.936*** *15.83*	1.26*** *7.147*	2.287*** *2.987*	13.674*** *10.95*	1.441*** *7.484*
$E_{i,t}/BVE_{i,t}$	-12.11*** *-8.836*	0.595 *0.304*	1.064*** *2.897*	4.062 *1.162*	1.292** *2.272*	-0.305** *-2.442*	2.875*** *3.125*	2.511 *0.663*	-13.613*** *-4.279*	-1.221** *-2.214*
$D_{i,t}/BVE_{i,t}$	22.238*** *5.852*	2.198 *0.384*	8.138*** *2.834*	-8.814 *-1.027*	8.444*** *3.528*	9.034*** *5.05*	13.837*** *5.377*	16.645** *2.212*	50.425*** *4.95*	16.426*** *6.96*
$CC_{i,t}/BVE_{i,t}$	-3.576*** *-2.759*	-5.575** *-2.125*	-6.506*** *-4.501*	-0.544 *-0.143*	-0.589** *-2.454*	0.405 *0.419*	-1.76 *-1.48*	-2.68 *-0.828*	-7.01** *-2.323*	-2.108** *-2.562*
GRO	0.864 *0.851*		-0.027 *-0.135*	-0.363 *-0.067*	0.084 *0.271*	0.339** *2.101*	-0.12 *-0.376*	1.056*** *3.984*	-0.267 *-0.622*	0.539*** *2.655*
GRO_{xt}	0.181 *0.232*		0.083 *0.221*			-0.047 *-0.303*	1.861 *1.266*	-0.741 *-1.027*	-0.076 *-0.061*	0.055 *0.12*
EXP		-0.173 *-0.357*			-0.104 *-0.29*	-0.042 *-0.229*	0.257** *2.19*	-0.012 *-0.019*	0.232 *0.352*	0.203 *0.684*
EXP_{xt}		0.302 *0.31*		-0.284 *-0.074*	-0.155 *-0.357*	-0.066 *-0.798*		-0.78 *-0.48*	-0.157 *-0.169*	-0.118 *-0.334*
ABD				-0.22 *-0.316*	0.027 *0.152*			-0.062 *-0.091*		-0.221 *-0.460*
ABD_{xt}			0.256 *0.408*		-0.016 *-0.077*	-0.037 *-0.326*		0.030 *0.041*	-0.770 *-0.482*	-0.139 *0.097*
R-sq	59.44%	22.42%	34.58%	17.95%	43.88%	69.85%	44.45%	30.47%	44.65%	9.71%
R-sq-adj	56.51%	17.62%	29.81%	13.24%	40.54%	68.25%	42.37%	27.00%	42.66%	9.07%
Sample	90	104	104	130	161	180	195	211	260	1435

Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively. Restricted sample excludes companies with ***MVE/BVE>9***. ***$MVE_{i,t}$***: Market value; ***$BVE_{i,t}$***: Book value; ***$RI_{i,t}$***: Residual income; ***$E_{i,t}$***:Earnings; ***$D_{i,t}$***: Dividends; ***$CC_{i,t}$***: Capital contributions; ***$NSCF_{i,t}$***: Net shareholders cash flows; ***GRO*** : growth option; ***EXP*** : option to expand; ***ABD*** : Option to abandon or default - months before exercise ***GRO_{xt}, EXP_{xt}, ABD_{xt}*** - months before expiry unexercised

Table 7.4: Real Options and Akbar & Stark specifications Panel D : Restricted Sample

$$\left(\frac{MVE_{i,t}-BVE_{i,t}}{BVE_{i,t}}\right)=\alpha_0+\alpha_1\left(\frac{1}{BVE_{i,t}}\right)+\alpha_2\left(\frac{E_{i,t}}{BVE_{i,t}}\right)+\alpha_3\left(\frac{D_{i,t}}{BVE_{i,t}}\right)+\alpha_4\left(\frac{CC_{i,t}}{BVE_{i,t}}\right)++\lambda_1 GRO+\lambda_2 GRO_{xt}+\lambda_3 EXP+\lambda_4 EXP_{xt}+\lambda_5 ABD+\lambda_6 ABD_{xt}+\varepsilon_{i,t}$$

Period	1991	1992	1993	1994	1995	1996	1997	1998	1999	Pooled
Intercept	1.312***	0.519**	-0.078	0.267	0.067	-0.068	-0.189	0.561**	3.498***	1.067***
	4.679	*2.458*	*-0.42*	*1.395*	*0.436*	*-0.436*	*-1.01*	*2.416*	*13.083*	*13.3*
$1/BVE_{i,t}$	-0.172	-0.045	0.539***	0.829***	0.922***	1.508***	0.652**	0.793***	4.224***	0.232***
	-1.561	*-0.525*	*5.403*	*5.837*	*8.084*	*8.034*	*1.974*	*3.403*	*4.896*	*3.934*
$E_{i,t}/BVE_{i,t}$	2.717*	-0.842	0.628**	0.985	0.994**	0.416	2.21**	2.3*	0.903	0.501**
	1.748	*-1.442*	*2.559*	*1.422*	*2.11*	*1.624*	*2.467*	*1.942*	*0.844*	*2.419*
$D_{i,t}/BVE_{i,t}$	4.076*	10.259***	10.477***	12.225***	8.645***	8.111***	14.002***	10.647***	1.174	7.275***
	1.728	*6.011*	*5.515*	*5.274*	*4.447*	*4.481*	*5.659*	*2.835*	*0.473*	*8.357*
$CC_{i,t}/BVE_{i,t}$	1.126	0.459	0.847	-0.677	-0.53***	0.69	-1.895*	-2.765***	-0.561	-0.76***
	0.878	*0.359*	*0.683*	*-0.945*	*-2.787*	*0.742*	*-1.665*	*-2.775*	*-0.499*	*-3.138*
GRO	1.32***		-0.054	-0.445	0.108	0.318**	-0.108	0.183**	0.083	0.228***
	3.773		*-0.418*	*-0.443*	*0.437*	*2.059*	*-0.354*	*2.036*	*0.982*	*4.149*
GRO_{xt}	0.342		0.076			-0.049	1.854	0.145	0.19	0.126
	1.274		*0.31*			*-0.331*	*1.32*	*0.663*	*0.558*	*1.012*
EXP		-0.049			-0.091	-0.025	0.25**	-0.013		0.003
		-0.343			*-0.32*	*-0.145*	*2.234*	*-0.07*		*0.034*
EXP_{xt}		0.057		-0.19	-0.115	-0.063		-0.503	0.146	0.114
		0.2		*-0.269*	*-0.334*	*-0.793*		*-1.038*	*0.704*	*1.241*
ABD				-0.05	0.036			0.03		-0.072
				-0.387	*0.258*			*0.15*		*-0.595*
ABD_{xt}			0.249		-0.010	-0.029		0.196	-0.295	0.023
			0.602		*-0.056*	*-0.263*		*0.869*	*-1.005*	*0.110*
R-sq	32.92%	31.87%	41.40%	43.68%	41.30%	42.14%	35.66%	23.66%	14.88%	10.95%
R-sq-adj	27.69%	27.52%	37.03%	40.31%	37.76%	39.04%	33.22%	19.46%	10.73%	10.26%
Sample	84	101	102	125	159	178	193	193	173	1308

Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively. Restricted sample excludes companies with ***MVE/BVE>9***. ***$MVE_{i,t}$***: Market value; ***$BVE_{i,t}$***: Book value; ***$RI_{i,t}$***: Residual income; ***$E_{i,t}$***:Earnings; ***$D_{i,t}$***: Dividends; ***$CC_{i,t}$***: Capital contributions; ***$NSCF_{i,t}$***: Net shareholders cash flows; ***GRO*** : growth option; ***EXP*** : option to expand; ***ABD*** : Option to abandon or default - months before exercise ***GRO_{xt}, EXP_{xt}, ABD_{xt}*** - months before expiry unexercised

Now all the results are presented in two tables. In Table 7.5 (Panel A), we present all the regression statistics in those regressions where we do not use deflators. Growth options have a positive regression coefficient, though statistically insignificant.

Table 7.5: Real options and residual income: Summary of results
Panel A: Without deflators

Sample requirements/ coefficient	Full sample	Restricted sample	Full sample	Restricted sample	Full sample	Restricted sample
Intercept	3.265 *1.155*	7.892*** *2.974*	3.233 *1.116*	8.709*** *3.227*	2.937 *1.039*	7.991*** *3.013*
$NSCF_{i,t}$	-3.774*** *-9.464*	-3.755*** *-7.115*				
$BVE_{i,t}$	1.006*** *10.711*	1.55*** *11.625*	1.138*** *10.619*	1.415*** *9.071*	1.114*** *10.653*	1.422*** *9.287*
$E_{i,t}$	13.991*** *26.695*	8.342*** *12.339*	15.48*** *24.821*	8.744*** *11.940*	14.744*** *23.991*	7.883*** *10.818*
$D_{i,t}$			-5.779*** *-4.602*	-0.789 *-0.501*	-6.487*** *-5.283*	-1.305 *-0.843*
$CC_{i,t}$					-3.524*** *-8.548*	-4.031*** *-7.298*
GRO	2.844 *1.104*	1.237 *0.530*	1.705 *0.648*	1.167 *0.492*	3.03 *1.177*	1.222 *0.524*
GRO_{xt}	1.196 *0.206*	1.166 *0.226*	1.798 *0.303*	1.534 *0.293*	1.148 *0.198*	1.19 *0.231*
EXP	0.192 *0.051*	0.454 *0.136*	-0.06 *-0.015*	0.261 *0.077*	0.154 *0.041*	0.488 *0.147*
EXP_{xt}	-1.286 *-0.290*	-0.39 *-0.099*	-1.455 *-0.321*	-0.896 *-0.224*	-1.203 *-0.272*	-0.499 *-0.127*
ABD	0.837 *0.139*	-0.314 *-0.058*	0.92 *0.149*	-0.339 *-0.062*	0.906 *0.150*	-0.327 *-0.061*
ABD_{xt}	-0.232 *-0.041*	-1.086 *-0.216*	-0.323 *-0.056*	-1.166 *-0.228*	-0.26 *-0.046*	-1.022 *-0.204*
R-sq	80.11%	44.90%	79.17%	65.53%	80.19%	45.01%
R-sq-adj	79.99%	44.55%	79.04%	42.94%	80.05%	44.62%
Sample	1435	1421	1435	1421	1435	1421

Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively. Restricted sample excludes companies with *MVE/BVE>9*. $MVE_{i,t}$: Market value; $BVE_{i,t}$: Book value; $RI_{i,t}$: Residual income; $E_{i,t}$:Earnings; $D_{i,t}$: Dividends; $CC_{i,t}$: Capital contributions; $NSCF_{i,t}$: Net shareholders cash flows; **GRO** : growth option; **EXP** : option to expand; **ABD** : Option to abandon or default - months before exercise GRO_{xt}, EXP_{xt}, ABD_{xt} - months before expiry unexercised

In Panel B of Table 7.5, we illustrate all the regression statistics in those regressions where we use deflators. Growth options have a positive and statistically significant regression coefficient in all but two regressions. Besides, growth options are always positive and significant if we exclude companies having high market value over book value.

Table 7.5: Real options and residual income: Summary of results
Panel B: Deflated data

Sample Requirements/ Coefficient	Full sample	Restricted sample	Full sample	Restricted sample	Full sample	Restricted sample	Full sample	Restricted sample
$1/BVE_{i,t}$	2.321*** *7.866*	0.38*** *5.229*	1.006*** *10.711*	0.329*** *5.504*	1.466*** *7.609*	0.235*** *3.975*	1.441*** *7.484*	0.232*** *3.934*
$RI_{i,t}/BVE_{i,t}$	-0.577 *-0.810*	1.153*** *5.472*						
$NSCF_{i,t}/BVE_{i,t}$			-3.774*** *-9.464*	-0.188 *-0.778*				
$BVE_{i,t}/BVE_{i,t}$	2.961*** *8.777*	1.597*** *22.258*	3.265 *1.155*	1.455*** *20.994*	1.711*** *6.242*	1.11*** *13.991*	1.591*** *5.733*	1.067*** *13.300*
$E_{i,t}/BVE_{i,t}$			13.991*** *26.695*	1.173*** *5.906*	-1.293** *-2.343*	0.423** *2.050*	-1.221** *-2.214*	0.501** *2.419*
$D_{i,t}/BVE_{i,t}$					16.29*** *6.891*	7.282*** *8.337*	16.426*** *6.960*	7.275*** *8.357*
$CC_{i,t}/BVE_{i,t}$							-2.108** *-2.562*	-0.76*** *-3.138*
GRO	0.112 *0.386*	0.265*** *4.286*	2.844 *1.104*	0.233*** *4.126*	0.532*** *2.616*	0.227*** *4.125*	0.539*** *2.655*	0.228*** *4.149*
GRO_{xt}	0.132 *0.214*	0.106 *0.780*	1.196 *0.206*	0.1 *0.779*	0.095 *0.208*	0.124 *0.995*	0.055 *0.120*	0.126 *1.012*
EXP	0.243 *0.606*	0.021 *0.204*	0.192 *0.051*	-0.029 *-0.291*	0.201 *0.676*	-0.001 *-0.009*	0.203 *0.684*	0.003 *0.034*
EXP_{xt}	-0.13 *-0.275*	0.14 *1.412*	-1.286 *-0.290*	0.145 *1.534*	-0.125 *-0.354*	0.113 *1.225*	-0.118 *-0.334*	0.114 *1.241*
ABD	-0.387 *-0.600*	-0.097 *-0.749*	0.837 *0.139*	-0.105 *-0.853*	-0.237 *-0.491*	-0.077 *-0.641*	-0.221 *-0.460*	-0.072 *-0.595*
ABD_{xt}	-0.347 *-0.576*	-0.04 *-0.326*	-0.232 *-0.041*	-0.026 *-0.220*	-0.159 *-0.354*	0.019 *0.170*	-0.139 *-0.310*	0.023 *0.213*
R-sq	5.64%	5.71%	80.11%	5.51%	30.48%	32.05%	9.71%	10.95%
R-sq-adj	5.05%	5.05%	79.99%	4.86%	9.29%	10.27%	9.07%	10.26%
Sample	1285	1150	1435	1308	1435	1308	1435	1308

*Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively. Restricted sample excludes companies with* **MVE/BVE>9. MVE**: *Market value;* **BV E**: *Book value;* **RI** *: Residual income* **GRO** *: growth option;* **EXP** *: option to expand;* **ABD** *: Option to abandon or default - months before exercise GRO_{xt}, EXP_{xt}, ABD_{xt} - months before expiry unexercised*

7.3 Comparison with previous studies

Since this part of the study investigates whether real options are value relevant in the context of residual income valuation, the findings can be compared to other studies in the area. Growth options are found to be a significant factor in explaining market returns in the context of residual income valuation. Excluding extreme $MVE_{i,t}/BVE_{i,t}$ observations as well as companies that have negative closing book value, the existence of the growth options for a month increases, on average, the company's market value by 11.2% of the book value, in the examined nine-year period (1991-1999), though statistically insignificant. Restricting further our sample by excluding extreme $MVE_{i,t}/BVE_{i,t}$ observations indicates that the presence of the growth options for a month increases the company's market value significantly (by 26.5% of the book value, at the 1% level of isignificance) but the options to expand are insignificant. The residual income model has lower predictive ability compared to the predictive ability of the models examined in Sougiannis (1994) and Green, Stark and Thomas (1996). In the full sample, the coefficient of residual income ($RI_{i,t}/BVE_{i,t}$) is found to be insignificant and negative. Excluding extreme $MVE_{i,t}/BVE_{i,t}$ observations leads to higher than the unity (1.153) coefficient of residual income at the 1% level of statistical significance, though still lower to those found in other studies (in Sougiannis study the coefficient of $RI_{i,t}/BVE_{i,t}$ is 2.75 and in the GST study it is 4.65 and 4.77). Maybe the inclusion of the real options captures an important part of residual income value.

Nevertheless, the intercept, the closing book value and the residual income are found statistically significant and positive as in the Green, Stark and Thomas (1996) study. The regression coefficient of the book value is found higher in our study (1.597 versus 0.860 and 0.910 found in the Green, Stark and Thomas (1996) study).

Table 7.6: Real Options and Residual Income: Comparison with findings in Green, Stark, Thomas (1996) and Sougiannis (1994)

	BVE/BVE	*1/BVE*	*RI/BVE*	*RD/BVE*	*GRO*	*GRO$_{xt}$*	*EXP*	*EXP$_{xt}$*	*ABD*	*ABD$_{xt}$*	λ_1	λ_2	λ_3	λ_4	λ_5	λ_6	*RD$_{(t-1)}$/BVE*	β_2-β_1	Sample	R^2
Current study, full sample	2.961***	2.321***	-0.576		0.112	0.132	0.243	-0.129	-0.386	-0.346									1285	5.6%
	8.777	*7.866*	*-0.81*		*0.385*	*0.213*	*0.606*	*-0.275*	*-0.6*	*-0.575*										
Current study, restricted	1.597***	0.380***	1.153***		0.265***	0.106	0.021	0.14	-0.096	-0.039									1150	5.7%
	22.257	*5.228*	*5.471*		*4.285*	*0.78*	*0.204*	*1.412*	*-0.749*	*-0.325*										
Green, Stark, Thomas (1996) -a	0.91	4971.3	4.77	4.84							-1.09	0.1	1.99	-0.44	0.85	-0.02				91.7%
	1.79	*2.59*	*15.47*	*82.67*							*-1.39*	*0.23*	*4.56*	*-0.57*	*1.64*	*-1.76*				
	[2.36]	[1.67]	[9.42]	[48.50]							[-1.72]	[0.26]	[3.77]	[-0.62]	[2.01]	[-2.03]				
Green, Stark, Thomas (1996) -b	0.86	4301.1	4.65	4.86																91.4%
	8.63	*2.51*	*15.07*	*82.01*																
	[9.95]	[1.54]	[8.03]	[47.85]																
Sougiannis (1994)	-0.055	0.222	2.757***	3.321***													-0.092	0.564		32.0%
	-0.659	*0.366*	*6.453*	*7.539*													*-.185*	*1.227*		

*Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively. Restricted sample excludes companies with **MVE/BVE**>9. **MVE** : Market value; **BVE** : Book value; **RI** : Residual income **GRO** : growth option; **EXP** : option to expand; **ABD** : Option to abandon or default - months before exercise **GRO$_{xt}$**, **EXP$_{xt}$**, **ABD$_{xt}$** - months before expiry unexercised*

Real options are not value-relevant when net dividends are factored in residual income regressions. Besides, in the study made by Akbar and Stark (2001) net dividends (***$NSCF_{i,t}$***) are negatively associated with market value, while in our study the effect of net dividends (***$NSCF_{i,t}$***) to the company value is statistically insignificant. However, we find that market value is positively associated with earnings and book value. Besides, the regression coefficients of earnings and book value are found very similar to those in the Akbar and Stark (2001) study. Namely, if we exclude from our sample extreme ***$MV_{i,t}/BV_{i,t}$*** observations, the regression coefficient of earnings is 1.173, while in Akbar and Stark (2001), it is found to be 1.400. Similarly, the regression coefficient of book value in our study is 1.566, while in Akbar and Stark (2001) it is 1.920 (Table 7.7, Panel A).

Table 7.7: Real options and the components of residual income: Comparison with findings in Akbar, Stark (2001). Panel A

	1/BVE	*BVE/BVE*	*E/BVE*	*RD/BVE*	*NSCF/BVE*	*GRO*	*GRO_{xt}*	*EXP*	*EXP_{xt}*	*ABD*	*ABD_{xt}*	*Sample*	*R^2*	*R^2-adj*
Current Study, Full sample *t-stat*	1.762*** *9.218*	2.508*** *9.926*	0.368 *0.712*		-0.0008 *-0.001*	0.542*** *2.621*	0.022 *0.048*	0.139 *0.46*	-0.072 *-0.202*	-0.306 *-0.627*	-0.266 *-0.583*	1435	6.3%	5.7%
Current Study, Restricted sample *t-stat*	0.329*** *5.503*	1.455*** *20.99*	1.173*** *5.905*		-0.187 *-0.778*	0.233*** *4.126*	0.1002 *0.779*	-0.028 *-0.29*	0.145 *1.534*	-0.104 *-0.853*	-0.025 *-0.219*	1308	5.5%	4.9%
Akbar and Stark (2001) *p-value*	2357.37 *0*	1.92 *0*	1.4 *0*	10 *0*	-1.11 *0*								15.0%	

*Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively. Restricted sample excludes companies with* ***MV/BV>9. MV*** *: Market value;* ***BV*** *: Book value;* ***RI*** *: Residual income* ***GRO*** *: growth option;* ***EXP*** *: option to expand;* ***ABD*** *: Option to abandon or default - months before exercise* ***GRO_{xt}, EXP_{xt}, ABD_{xt}*** *- months before expiry unexercised*

In the opposition to the previous findings, real options are value-relevant when the dividends and the capital contributions (constituents of net dividends) are factored in regressions with earnings and book value (Table 7.7, Panel B). The thesis also indicates that dividends are positively associated with market value, whereas capital contributions are negatively associated with market value, in accordance with Akbar and Stark (2001), indicating that the clean surplus hypothesis is supported by the findings of our study. Similarly, in the same regressions, earnings and book value are associated positively with market value. Moreover, alike in Akbar and Stark (2001), the coefficients of book value and earnings appear consistently lower in that model compared to the model that has $NSCF_{i,t}$ as a separate explanatory variable. The coefficients of growth options appear consistent. There is also a typical increase in explanatory power associated with the partitioning of $NSCF_{i,t}$. This increase is significant from a statistical point of view and is generally substantial in a numerical sense. This indicates that dividends contribute to a higher regression fit when factored as a separate variable. Both the increase of regression fit and the different sign of regression coefficients of dividends and capital contributions lead to the conclusion that it is inappropriate to amalgamate dividends with capital contributions into shareholder cash flows as if the two components have identical effects on explaining market value.

Table 7.7: Real options, dividends and capital contributions: Comparison with findings in Akbar, Stark (2001). Panel B

	1/BVE	*BVE/BVE*	*E/BVE*	*RD/BVE*	*D/BVE*	*CC/BVE*	*GRO*	*GRO_{xt}*	*EXP*	*EXP_{xt}*	*ABD*	*ABD_{xt}*	**Sample**	**R^2**	**R^2-adj**
Current Study, full sample *t-stat*	1.441*** *7.484*	1.591*** *5.733*	-1.220** *-2.213*		16.426*** *6.959*	-2.107** *-2.562*	0.539*** *2.655*	0.055 *0.120*	0.203 *0.683*	-0.117 *-0.333*	-0.220 *-0.459*	-0.138 *-0.309*	1435	9.7%	9.1%
Current Study, restricted sample *t-stat*	0.232*** *3.934*	1.067*** *13.299*	0.501** *2.418*		7.275*** *8.357*	-0.759*** *-3.137*	0.228*** *4.148*	0.126 *1.011*	0.003 *0.034*	0.114 *1.241*	-0.071 *-0.595*	0.023 *0.213*	1308	11.0%	10.3%
Akbar and Stark (2001) *p-value*	2339.01 *0*	0.88 *0*	0.53 *-0.02*	8.98 *0*	17.04 *0*	-1.61 *0*								28.0%	

*Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively. Restricted sample excludes companies with* ***MVE/BVE>9. MVE****: Market value;* ***BVE*** *: Book value;* ***RI*** *: Residual income* ***GRO*** *: growth option;* ***EXP*** *: option to expand;* ***ABD*** *: Option to abandon or default - months before exercise* ***GRO_{xt}, EXP_{xt}, ABD_{xt}*** *- months before expiry unexercised*

Real options are value relevant even if we examine dividends as a separate explanatory variable in the models. Similar to Akbar and Stark (2001), the coefficients of book value and earnings appear consistently lower in that model compared to the model that has $NSCF_{i,t}$ as a separate explanatory variable (Table 7.7, Panel C). The coefficients of growth options appear consistent indicating that it is possible to rely on the results with respect to the signalling effects of growth options because the coefficient of the growth option is uncorrelated with other coefficients. There is also a typical increase in explanatory power associated with the partitioning of $NSCF_{i,t}$. These findings are similar to these in Akbar and Stark (2001).

Table 7.7: Real options and dividends: Comparison with findings in Akbar, Stark (2001). Panel C

	1/BVE	*BVE/BVE*	*E/BVE*	*RD/BVE*	*D/BVE*	*GRO*	*GRO_{xt}*	*EXP*	*EXP_{xt}*	*ABD*	*ABD_{xt}*	*Sample*	*R^2*	*R^2-adj*
Current Study, Full sample *t-stat*	1.466*** *7.609*	1.711*** *6.241*	-1.292** *-2.343*		16.290*** *6.890*	0.532** *2.615*	0.095 *0.207*	0.201 *0.675*	-0.124 *-0.353*	-0.236 *-0.491*	-0.158 *-0.353*	1435	9.3%	8.7%
Current Study, Restricted sample *t-stat*	0.235*** *3.974*	1.110*** *13.990*	0.423* *2.050*		7.282*** *8.336*	0.227*** *4.125*	0.124 *0.994*	-0.0008 *-0.008*	0.113 *1.224*	-0.076 *-0.641*	0.019 *0.169*	1308	10.3%	9.7%
Akbar and Stark (2001) *p-value*	2702.14 *0*	1.05 *0*	0.4 *0.08*	9.73 *0*	17 *0*								24.00%	

*Notes. t-statistics in italics. *, **, *** indicate that the null hypothesis is rejected at 10%, 5% and 1% level respectively. Restricted sample excludes companies with **MVE/BVE**>9. **MVE** : Market value; **BVE** : Book value; **RI** : Residual income **GRO** : growth option; **EXP** : option to expand; **ABD** : Option to abandon or default - months before exercise **GRO_{xt}**, **EXP_{xt}**, **ABD_{xt}** - months before expiry unexercised*

7.4 Summary & Conclusions

We tested the hypothesis that real option announcements are recognised by the ASE market, by examining the abnormal returns over the real option announcement period (or real option-signalling period). The results reject the hypothesis that the real options are not recognised in the market place and indicate that market participants are normally informed one day before the announcement. Examined in a different way, the value of the company increases till the third day after real option announcement. In particular, the existence of the real options gives cumulative abnormal returns of 2.45% for the period (-5, 3). Statistically significant cumulative abnormal returns are also reported for different periods; however the premium is smaller for those periods.

We then examined whether the type of option is associated with different premiums. The findings indicate that, on average, the announcement of the growth options is associated with a premium, while companies that possess the option to default trade on a discount before the option initiation. These findings confirm and, in a way, extend findings in Kester (1984), Paddock, Siegel and Smith (1988), Panayi and Trigeorgis (1999), Benaroch and Kauffman (1999), Kellog, Charmes and Demirer (1999). However, the existence of an option to increase capacity does not have any effect on company value probably because analysts have already accounted for it well before the announcement.

Our interest is also extended to the effect of option exercising. We investigate whether companies that exercised their options had a premium over the companies that let them expire. To examine whether the real options contribute during their lifetime to the company's value in the share market, we also compute the difference between the stock return and the index performance over the examined periods, called in our study 'excess return'.

Investors give on average a small discount to companies that let their real options expire while they give an enormous premium (19.19%) to companies that exercised their options. To examine whether there is any "information content" in the market place over the possibility of a real option to be exercised in the future, we split cumulative abnormal returns and cumulative excessive returns over the index in two periods. Our results indicate that there is "information content" in the share market about the possibility to exercise the real options. Companies who possess options that expired had, on average, low and statistically insignificant abnormal returns during the "option announcement" period.

On the other hand, companies who possess options that expired had on average high abnormal returns during the "option announcement" period. Nearly 28% of excessive returns are realised on average around the signalling period, in the case of exercised real options. The latter is in line with real option theory. We assume that there is information content during the signalling period, because market participants assess during the early stages the possibility for company managers to exercise real options.

In addition, both theoretical DCF values and theoretical growth option values are initially regressed against cumulative abnormal stock returns, and then they are regressed over excess abnormal stock returns. We conclude that real options are associated with better regression fit, compared to DCF values. We also find that, in the case of option to expand theoretical values are generally higher than observed market valuations. Since theoretical option values provide better predictions of market values than DCF values, our results coincide with the findings of Howell, Jagle (1997) and Paddock, Siegel, Smith (1988). In the current study, there is also an evidence that the capital market tends to overvalue growth options. These findings are in line with the conclusions in Kellog, Charnes and Demirer (1999) and in Schwartz, Moon (2000).

In addition, the study develops models that explain the corporate valuations that the capital markets place on firms and, in particular, the role of accounting information in these models. To achieve this target, we try to investigate whether the real options are significant explanatory variable in the context of 'clean surplus' hypothesis. We run several regressions to examine this relationship. The models employed in these cross-sectional regressions assume that the value of the assets in place (market value of company equity) can be modeled as the sum of book value plus the discounted value of residual income stream. In other words, the market value of a company is modeled as a linear function of earnings, closing book value, net dividends while a less restricted form of the 'clean surplus equation', allows for other control variables that capture the value not controlled by earnings, book value and net dividends. Assuming the real options may account for part of future residual income stream, our study investigates the predictive ability of the real options by inducing the real options as dummy variables. To control for size, fundamental factors (earnings, closing book value, and net dividends) are also deflated by book value.

We provide some evidence that the real options contribute positively to company market value in the context of residual income. In particular, market value is found to be affected positively and significantly by the real options. The existence of the growth options for a month increases, on average, the company's market value by 0.261 times the book value during the 1991-1999 period.

Similarly, the existence of the options to expand for a month increases, on average, the company's market value but not in a statistically significant way. The study provides evidence that growth option dummy variable has statistically significant effect on company's market value in most regressions.

Our conclusions have further importance and validity since they are partly in line with the findings of other researchers that investigate the 'clean surplus hypothesis' (Green Stark and Thomas, 1996). In particular, intercept, as well as the coefficients of the explanatory variables $\boldsymbol{1/BVE_{i,t}}$ and $\boldsymbol{RI_{i,t}/BVE_{i,t}}$, respectively[5] are positive and significantly different from zero (the null hypothesis is rejected at 1%, 1% and 10% respectively for 1991-1999 period as well as for most of the examined years). However, Regression fit, as measured by R-sq, is found to be between 9%-64% in our annual regressions whilst in the study made by Green Stark and Thomas (1996), R-sq is 91.4%. Also the study indicates that restricting the sample to companies having low market over book value ($\boldsymbol{MVE_{i,t}/BVE_{i,t}>9}$) leads to increasingly significant coefficients for the period, whilst the coefficient is positive

[5] in the regression
$$\left(\frac{MVE_{i,t}-BVE_{i,t}}{BVE_{i,t}}\right) = \alpha_0 + \alpha_1\left(\frac{1}{BVE_{i,t}}\right) + \beta\left(\frac{RI_{i,t}}{BVE_{i,t}}\right) + \lambda_1 GRO + \lambda_2 GRO_{xt} + \lambda_3 EXP + \lambda_4 EXP_{xt} + \lambda_5 ABD + \lambda_6 ABD_{xt} + \varepsilon_{i,t}$$

and significant for most of the years. We note that the comparable studies use similar restrictions in the examined samples.

Regression coefficients for earnings, book value, dividends and capital contributions are significant and have the same magnitude as in the study of Akbar and Stark (2001). These findings also support the clean surplus hypothesis.

Overall, our study leads to interesting conclusions.

First, there is some support for the hypothesis that the growth options are value relevant even in the context of residual income valuation, since they contribute to the predictive ability of our models when we deflate our variables. There is also weak support over the hypothesis that options to invest are value relevant.

Second the results do not provide any support for the hypothesis that options to abandon and options to default are value relevant. The magnitudes of coefficients of abandonment options/ options to default are statistically insignificant.

Third, there is some support for the predictive ability of the residual income model; our findings over the predictive ability of residual income model are generally in line with findings from UK and USA researchers.

Also, regression statistics indicate that the market seems to compensate the growth options that were finally exercised.

Besides, the findings from cross-sectional models match the findings from the part of our study that examines the effect of option announcements to companies' value. In particular, our event study finds that exercised growth options compensate for company market value. These findings are, in a way, similar to findings concerning the effect of R&D announcements in other markets. In that respect, our study should provide a link between the real option theory and market valuation.

In contrast to other studies in real option valuation (Otto, 2000) that use market over book value as proxy of the growth options, our study indicates that excessive market over book value multiples are only partly explained by real option value. Maybe excessive market over book value multiples are partly also due to interest rates moves and market liquidity reason (excessive fund inflow in stock markets during specific years). Nevertheless, our study provides evidence that the real options proxied by a dummy variable are value relevant and can explain a significant appreciation of market value over book value.

Furthermore, the appreciation of company market value due to the real options is found analogous to real option duration.

Besides, the joint indications that (a) growth options contribute to company value if they are exercised and (b) the longer the duration of growth options, the higher the appreciation of company market value, lead to the conclusion that the results of this study are in line with observed practices of market value appreciation of companies having growth options that are exercised and have long duration, like Internet companies. Therefore our findings may partly explain the continuous appreciation of Internet companies.

Last, but not least, the way our study confirms, and in a way extends, previous findings in the area of economic determination of market rationality may give incentives to other researchers to investigate whether real options are also value relevant in other capital markets in the context of residual income models.

CHAPTER EIGHT

SUMMARY AND CONCLUSIONS

This thesis demonstrates how real options that arise from the strategic opportunities facing a company can play an important part in the company's valuation. In addressing this issue, the thesis examines four main research questions.

First, the study examines whether real option announcement are recognised by the marketplace. To answer this question, abnormal returns were examined over the real option announcement period. The results reject the hypothesis that real options are not recognized. They also indicate that market participants are normally informed on the day before real option announcements, and also that the value of the company continues to increase until the third day after the real option announcement. In spite of this apparent inefficiency in pricing the announcement, the evidence shows that the existence of the real option is duly recognized when the underlying corporate plans are made public.

Second, the study examines the extent to which real options contribute to a firm's value and whether the type of real option is associated with different premiums in the market. It was found that, on average, firms announcing growth options are associated with a significant premium throughout the announcement period. On the contrary, firms which possess the option to default trade at a significant discount, although only before the announcement, whilst the option to expand has a small but statistically insignificant premium at the time of announcement. With regard to the effect of option exercising, the study assesses whether shares in companies that exercised their options are at a premium over these that let them expire. On average there is small discount for companies that let options expire, but this is statistically insignificant. On the other hand, there is a large significant premium for companies that exercised their options. This implies that there had been information in market pricing regarding the possibility of future exercising of a real option, as companies which let real options expire have low, statistically insignificant abnormal returns during the real option announcement period, whilst companies possessing options that were exercised had high, statistically significant abnormal returns.

Third, the study examines the extent to which excess market value can be attributed to a theoretical real option value or to a theoretical DCF value. For this purpose, theoretical DCF and theoretical Growth Option values were regressed against both cumulative abnormal and excess stock returns. The conclusion is reached that the theoretical real option model generates estimated values that provide the better regression fit. It is also found that, in the case of the option to expand, that theoretical option values are generally higher than the observed appreciation in market values.

Finally, the study develops models that explain the contribution made by real options to a company value using the residual income valuation model. For this purpose, the regression analysis is based on empirical specifications of Ohlson's theoretical residual income model to determine whether different real options are significant explanatory variables within the context of additional information under the 'clean surplus' hypothesis. In its restricted form, the market value of company equity is modelled as a linear function of earnings, closing book value and net dividends, whilst a less restricted form of the clean surplus equation allows for other control variables to capture that part of value not captured by the above. Assuming real options may account for part of future residual income, the predictive ability of real options is introduced by dummy variables. Size is controlled by deflating using book value. The study provides evidence that real options contribute positively to a company's market value in the context of residual income, results that are in line with the findings of Green, Stark and Thomas (1996). In this thesis, however, where different types of real option are considered and their duration is allowed for, market value is estimated as the sum of 1.597 x book value and 1.153 x residual income, plus a further 0.265 x book value for each month of real growth option existence.[1]

An important assumption made in arriving at these results is that the semi-strong form of market efficiency exists. It is assumed that the volatility of stock prices is stable over time and that investors have the information needed to help them predict future price movements and consequently to form optimum portfolios in terms of risk and return, as expressed by expected standard deviations and expected returns. If

[1] Whilst the impact of options to expand is also positive and that of options to abandon or default is negative, they are not statistically significant. The results given here are for the restricted sample, as reported in Table 7.5.

market efficiency is not evident, investors do not form their expectations in terms of risk and return or at least they do not form these expectations with uniform criteria. If this is evident, our model simply breaks down. If, also, the assumption of constant volatility does not exist, there is no correspondence between expected and actual volatility, resulting in miscalculation of abnormal returns. If this is evident, then we cannot be sure whether abnormal returns are due to the existence of the real options or to casual changes in volatility. The available evidence (see Appendix E) shows that the ASE is semi-strong efficient, and it should also be noted that the sample of 161 real option cases investigated here is relatively large given the size of the ASE. Large samples are likely to be free from the potential biases mentioned above, because casual factors are cancelled out.

A further limitation relates to other available market information that could lead an investor to predict future share prices in a way that reflects a wider information set than a past series of share prices. It is true that, over the course of the years, share market participants have used a variety of methods in their attempts to predict the likely direction in which the market trend may go. Interest rate movements, GDP growth indices, inflation rates and other indices, ~~including technical analysis of past share price series,~~ may improve forecasting ability. For example, it could be argued that we do not account for the role of information costs or first-mover advantages.[2] However, the introduction of such factors increases model complexity, something that partly explains why other researchers in the area of real options avoid it. The possible inclusion of additional control variables in cross-sectional regressions is also a limitation. However, R&D expenditure, which is the single most important factor included in other studies, were particularly small and made by less than 5% of the companies.

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[2] According to Bellalah (2003), there are sunk costs incurred during the phase of gathering information about the project and the opportunity to invest. Bellalah (2003) proposes some models that provide some insights into the importance of these costs and may explain why companies that let their growth options expire do not have market premium. In Tsekrekos (2003), first-mover advantages are found to have an asymmetric effect on rival firms' values. The more volatile industries should experience more separated firm entries over time the more substantial the first-mover privileges. Paxson and Pinto (2003) who model the leader and follower value functions for a duopoly environment find that the follower's value function is less sensitive than the leader's value function to market share until the expected revenue exceeds the follower's trigger investment level.

A final potential limitation to consider is that of not analysing the data in different sub-groups that may reflect group-specific characteristics.[3]. Although statistics are reported in this thesis for subgroups, the investigation is not taken further since the benefits of breaking down the sample are more than cancelled-out by the deficiencies of using small sub-samples. Besides, as the research design includes all sectors, it leads to the generalisation of conclusions.

In conclusion, this thesis provides evidence concerning the value relevance of growth options. It also provides weak support for the value relevance of options to expand, whilst no support is found for options to abandon or to default. Importantly, the appreciation of market values due to real options is shown to be a function of their duration. That is to say, growth options contribute to a company's value and the longer their duration the higher the appreciation of a company's value, which is consistent with the finance theory underlying option valuation.

[3] The findings of Moreira and Pope (2001) in the area of residual valuation provide evidence that industries are not homogenous groups of firms; rather, they contain in themselves sub-groups with specific characteristics having specific valuation of their assets. This is also the conclusion of Shah and Stark (2001) who examined the effect of advertising expenditures and R&D expenditures on companies' market value. In their study, advertising expenditure data is only value-relevant for the large firm sub-sample. This is probably due to the different tangible and intangible asset intensity between manufacturing and non-manufacturing firms.

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APPENDIX A

PRIOR STUDIES OF REAL OPTION VALUATION

Authors / (year of study)	Country / examined period	Type(s) of examined real options	Sector /area of interest	Valuation methods	Sample size	Conclusion
Kester (1984)	USA/1984	Growth options	Electronics	EP ratio	3/15	60%-76% of total value of the companies is attributed to growth options
			Food processing		3/15	12%-47% of total value of the companies is attributed to growth options
			Chemicals		3/15	47%-68% of total value of the companies is attributed to growth options
			Tire and rubber		3/15	30%-58% of total value of the companies is attributed to growth options
			Computers		3/15	61%-77% of total value of the companies is attributed to growth options
Paddock, Siegel and Smith (1988)	USA/1984	Growth options	Offshore petroleum leases	Regression analysis	21	There is some evidence that the option pricing theory is useful to value the offshore petroleum leases. However, both option pricing and DCF measures provide particularly low valuations compared to actual bids.
Chung and Charoen wong (1991)	USA/1979-1988	Growth options	All sectors	Regression analysis (EP ratio and P/BV are used as proxies)	482	The growth options are associated with higher systematic risk. The results are statistically significant at 5% level.

Authors / (year of study)	Country / examined period	Type(s) of examined real options	Sector /area of interest	Valuation methods	Sample size	Conclusion
Quigg (1993)	Seattle, USA / 1976-1979	Option to wait	Land values	Regression analysis	2,700	There is a mean option premium of 6% of the theoretical land value. The study provides some support that the option to wait has value.
Busby and Pitts (1997)	UK firms included in the FTSE 100/1997	Growth options	All sectors	Exploratory Survey	44	Growth options occur in more than 60% of the capital investments
		Postponement options				Postponement options occur in more than 40% of the capital investments
		Option to Abandon for Salvage Value				Abandonment options occur in more than 20% of capital investments
		Time to build Option				Time to build options occur in more than 20% of capital investments
		Switch Options				Switch options occur in more than 20% of capital investments
		Time to wait option				20% of the respondents had developed procedures to value the time to wait options
		Postponement options				14% of the respondents had developed procedures to value the postponement options
		Rescaling options (Option to expand etc.)				43% of the respondents had developed procedures to value rescaling options
Howell and Jagle (1997)	UK practicing managers/1997	Option to Expand and Growth option	Oil, aerospace, telecommunications, pharmaceuticals and Brewing industry	Survey / Hypothetical decisions	82 financial managers	25% of the respondents had developed procedures to value growth options On average, the respondents overvalue the cases by 78% of the theoretical option value. This might appear to suggest that respondents' intuition is compatible with the real option theory, under the particular conditions of the experiment, but there is only a weak and approximate correspondence between the management intuition and theory. Oil managers report a higher level of agreement than others with the assumptions required by the real options framework. These managers also show less over-valuation.

Authors / (year of study)	Country / examined period	Type(s) of examined real options	Sector /area of interest	Valuation methods	Sample size	Conclusion
Pennings and Lint (1997)	Philips Corporate research /1997	Option to defer Growth Option	R&D expenditure in multimedia (computers & electronics)	Case study analysis using jump processes		The results of theory application are in line with corporate practice in the field of multimedia at Philips Corporate Research.
Benaroch and Kauffman (1999)	USA	Growth option Option to defer	POS debit services (Information Technology investments)	Case study analysis using B-S model		The results are in line with managerial practice to defer entry into the POS debit market for three years, which was later recognised to have been just about optimal.
Moel and Tufano (1999)	North America/ 1988-1997	Option to abandon for salvage value, option to default	Gold mines	Regression analysis	285	The decisions to shut or to open a mine are in accordance to real option theory but depend also on the profitability of other mines in the firms' portfolio and on the firms' other businesses.
Kellogg, Charnes and Demirer (1999)	USA/ 1994-1996	Growth Option	Pharmaceuticals	Case study analysis using binomial pricing		Theoretical methods valued relatively well when all the projects were in early phase of development
Schwartz and Moon (2000)	USA/1999	Growth Option. Option to default	Internet Companies	Case study analysis using Monte Carlo simulation		Company Market value is significantly higher than theoretical company value.
Ottoo (2000)	USA/2000	Growth options	Internet	P/BV ratio	3/18	97%-99% of total value of the companies is attributed to growth options
			Computer		3/18	77%-91% of total value of the companies is attributed to growth options
			Pharmaceu-tical		3/18	83%-92% of total value of the companies is attributed to growth options
			Biotechno-logy		3/18	81%-85% of total value of the companies is attributed to growth options
			Automotive		3/18	0%-65% of total value of the companies is attributed to growth options
			Rubber & Tire		3/18	9%-59% of total value of the companies is attributed to growth options

APPENDIX B

REAL OPTION CASES OBSERVED

Company Name	*Type of option*	*Case Description*	*Further Comments*	*Date*
SHEET STEEL	*Growth*	The company may increase its production capacity		*20/10/1991*
AB VASSILOPOULOS	*Expand*	The company may become an acquisition target	The Belgian group Lion-Delhaise S.A. is interested in acquiring a majority stake on AB Vassilopoulos, something that will strengthen the company's resources	*20/10/1991*
SHEET STEEL	*Expand*	The company may acquire a majority stake (51%) in AEPAL S.A.	AEPAL S.A., is a state-owned Bronze Profile Producer that has a production capacity of 200 tons/year, and is likely to become privatised.	*9/1/1992*
BANK OF ATHENS-EUROBANK	*Default*	The company may become privatised.	Hanwa Bank S.A., a Korean bank, is interested in acquiring Bank of Athens. The acquisition is a solution to the bank's liquidity problems.	*12/4/1992*
ATHENIAN HOLDINGS-DIMITRIADIS	*Default*	Dimitriadis S.A. may proceed with capital increase so as to relieve its liquidity problems.	Since the early 90's Greek dress making factories have faced enormous financial problems due to both increasing competition from Asian producers and the shift of customers to branded products.	*19/4/1992*
SAINT GEORGE MILLS	*Expand*	The company may acquire a company in the food sector	The company that is likely to be acquired by Saint George Mills is active in Food packaging and has a private port near Saint George's factory.	*8/5/1992*
AB VASSILOPOULOS	*Expand*	The company may become an acquisition target	The Belgian group Lion-Delhaise S.A. is interested in acquiring a majority stake on AB Vassilopoulos, something that will strengthen the company's resources	*17/5/1992*
SHEET STEEL	*Growth*	The company may acquire a majority stake (51%) in AEPAL S.A.	AEPAL S.A., is a state-owned Bronze Profile Producer that has a production capacity of 200 tons/year, and is likely to become privatised.	*27/8/1992*
ERGOBANK	*Growth*	The bank may increase its branch network considerably within the following three years	The increase of the branch network eventually leads to increasing operations and increasing profitability.	*20/1/1993*
ERGOBANK	*Growth*	The bank may increase its branch network considerably within the following three years	The increase of the branch network eventually leads to increasing operations and increasing profitability.	*20/2/1993*
ALPHA	*Growth*	The bank may increase its branch network considerably within the following years	The increase of the branch network eventually leads to increasing operations and increasing profitability.	*26/2/1993*
ALLATINI mills	*Default*	Levendis group, the group that owns the Coca-Cola Hellas-HBC S.A. a large Coca-Cola bottler who holds 40 factories and points of Sales in 14 countries, may acquire the company.	Allatini group is a financially distressed company. Possible acquisition of the company from Levendis group (Coca-Cola Hellas) means a considerable cash inflow that extends the company's life.	*14/5/1993*

Company Name	Type of option	Case Description	Further Comments	Date
KAMBAS	*Abandon*	The company may sell an extensive land area, so as to solve its financial problems.	The land area is situated near Spata, the place where the new Athens airport will be constructed.	*4/9/1993*
SELECTED TEXTILES	*Growth*	The company may proceed with an investment to increase production capacity.	The investment in the area is 40% subsidised by the state.	*1/10/1993*
RILKEN	*Expand*	Rilken may enter the highly promising Russian market.	Entering Russian market is a growth option to enter other nearby markets.	*15/10/1993*
SHEET STEEL	*Growth*	The company may invest in the development of a drilling tube production unit		*30/10/1993*
ALPHA	*Expand*	The bank may increase its branch network considerably within the following years	The increase in the branch network eventually leads to increasing operations and increasing profitability.	*15/1/1994*
AB VASSILOPOULOS	*Expand*	The company may proceed with an extensive investment plan so as to expand its points of sale.	The investment plan aims to expand its distribution network from 17 stores to 50 stores within the following five years	*22/1/1994*
AB VASSILOPOULOS	*Expand*	The company may proceed with an extensive investment plan so as to expand its distribution network.	The investment plan is the first part of the company's expansion plans	*24/1/1994*
AB VASSILOPOULOS	*Expand*	The company may proceed with an extensive investment plan so as to expand its distribution network.	The investment plan to expand its distribution network from 17 stores to 50 stores within the following five years	*12/2/1994*
AB VASSILOPOULOS	*Expand*	The company may proceed with an extensive investment plan so as to expand its distribution network.	The investment plan is the first part of the company's expansion plans	*26/2/1994*
TITAN	*Expand*	The company may open distribution centres in Spain (Valencia port) and France (Rouen)	The company's expansion plan gives the ability to penetrate new large markets (France and Spain).	*28/3/1994*
LAMBROPOULOS	*Expand*	The company may launch an extensive advertisement campaign, as part of its expansion strategy.		*12/4/1994*
LAMBROPOULOS	*Abandon*	The company may sell two loss-making stores.		*9/8/1994*
SAINT GEORGE MILLS	*Expand*	The company may expand into Bulgaria.	Bulgaria is a Balkan country that has several problems in developing factories in the food industry since the collapse of the socialist government. Bulgarian per capita consumption in flour is expected to be relatively high, so an investment in the country should to be successful if the distribution network is well designed.	*15/9/1994*
SAINT GEORGE MILLS	*Expand*	The company may expand into Bulgaria.	Bulgaria is a Balkan country that has several problems in developing factories in the food industry since the collapse of the socialist government. Bulgarian per capita consumption in flour is expected to be relatively high, so an investment in the country should to be successful if the distribution network is well designed.	*5/10/1994*

Company Name	*Type of option*	*Case Description*	*Further Comments*	*Date*
RADIO ATHINA	*Growth*	Radio Athina S.A. may proceed with the development of two more super-stores	The development of super stores outside Athens is regarded as a growth option, since the company has been active till now in the development of stores only in Athens, the capital city of Greece.	*21/11/1994*
ELMEC	*Growth*	The company may acquire Smash S.A.	Smash S.A. is the exclusive representative of Harley Davidson accessories in Greece.	*22/11/1994*
ASTIR INSURANCE	*Default*	A German Group that operates in the Financial sector may acquire the company.	Astir Insurance is close to bankruptcy due to past mismanagement. The privatisation of Astir insurance or the entry of new strategic investors will extend the company's life.	*23/3/1995*
TERNA	*Expand*	Terna S.A. may proceed in capital increase to finance a project in the real estate sector		*12/4/1995*
BANK OF ATTICA	*Growth*	The bank may proceed with a capital increase to finance its branch expansion plan	The Commercial Bank of Greece- the second largest state owned bank- holds a majority stake in the bank. Many deficiencies regarding the bank's portfolio and its old-fashioned strategy are expected to weaken its position in the sector. Possible capital increases will extent the bank's life.	*27/4/1995*
TERNA	*Expand*	Terna S.A. may proceed with capital increase to finance a project in the real estate sector		*11/5/1995*
BANK OF ATTICA	*Default*	The bank may become an acquisition target, since a French depository Fund is interested to.	The Commercial Bank of Greece- the second largest state owned bank- holds a majority stake in the bank. Many deficiencies regarding the bank's portfolio and its old-fashioned strategy are expected to weaken its position in the sector. Possible acquisition will induce certain economies of scope.	*28/5/1995*
TITAN	*Growth*	The company may proceed with an investment in Roanoke plant, USA and may also implement two new distribution centres.	The planed investments are expected to increase Titan's sales by 10%	*2/6/1995*
ATTIKAT	*Growth*	The company plans to proceed with capital increase.	The capital increase gives the company the opportunity to proceed for the undertaking of new projects.	*4/6/1995*
TITAN	*Growth*	The company may acquire 50% of Chalkis Cement	Chalkis Cement S.A. ranks third in terms of production among Greek cement producers. If Titan acquires 50% of the Chalkis cement, it will increase the group's production capacity and pricing. Pricing will improve, because Chalkis Cement is the main participant of price war among Greek cement producers.	*25/6/1995*

Company Name	*Type of option*	*Case Description*	*Further Comments*	*Date*
ALLATINI mills	*Default*	Levendis group, the group that owns the Coca-Cola Hellas-HBC S.A. a large Coca-Cola bottler who has 40 factories and points of Sales in 14 countries, may acquire the company.	Allatini group is a financially distressed company. Possible acquisition of the company by the Levendis group (Coca-Cola Hellas) means a considerable cash inflow that extends the company's life.	*30/6/1995*
PAPOUTSANIS	*Default*	The company may proceed with capital increase to solve its financial problems		*23/7/1995*
ERGAS	*Growth*	The company plans to proceed with capital increase.	The capital increase gives the company the opportunity to proceed for the undertaking of new projects.	*10/8/1995*
BITROS	*Default*	The company may sell a piece of land in Elefsina, a city near Athens.	The company's extensive investment plan in the past resulted in financial problems. The sell-off of the land area (60,000 m2) will partly solve the company's liquidity problem. The piece of land is situated in a commercial area where Veropoulos, a super market chain, is interested in buildinga super market and warehouses.	*19/9/1995*
GOODYS	*Expand*	The company may extend its network to Cyprus	The expansion plan is likely to be part of sequential investments.	*26/10/1995*
BANK OF ATTICA	*Default*	The bank may become an acquisition target, since the management is considering selling its majority stake.	The Commercial Bank of Greece- the second largest state owned Bank- holds a majority stake in the Bank. Many deficiencies regarding the Bank's portfolio and its old-fashioned strategy are expected to weaken its position in the sector. Possible acquisition will induce certain economies of scope.	*2/11/1995*
GIRAKIAN	*Growth*	The company plans to extend current production facilities.	The investment plan includes the increase of current capacity utilisation by 15%.	*2/11/1995*
KAMBAS	*Default*	The company may proceed with a capital increase, so as to solve its financial problems.	The land area is situated nearby Spata, the place where the new Athens airport will be constructed.	*15/11/1995*
TITAN	*Expand*	The company may enter the French market.Titan S.A. plans to develop a port in South France to transfer cement .	The EU commission asked from the French government to lower entry barriers for cement companies. Till now the French government has protected local producers from competition by inducing artificially high standards in the construction of cement ports for non-French companies.	*1/1/1996*
ELMEC	*Growth*	The company may acquire Ergon-Sissoreftes S.A.	Ergon-Sissoreftes is a small retailer.	*25/1/1996*
SATO	*Growth*	The company is planning to extend production capacity considerably.	The considerable increase of production capacity requires an entirely new factory, since the area of current production facilities is subject to limitations. The development of a new factory requires considerable money resources and time.	*26/1/1996*
AVAX	*Growth*	The company may merge with J&P S.A.	J&P S.A. is a large construction company.	*22/2/1996*

Company Name	*Type of option*	*Case Description*	*Further Comments*	*Date*
KAMBAS	*Default*	The company may proceed with a private placement, so as to solve its financial problems.	According to the press, three businessmen are interested in acquiring a majority stake on the company.	*31/3/1996*
GOODYS	*Expand*	The company may proceed with a considerable network expansion.	The expansion plan is likely to be part of sequential investments. The company's strategic plan includes the development of 40 new restaurants within the following 4 years.	*31/3/1996*
KAMBAS	*Default*	The company may proceed with a private placement, so as to solve its financial problems.	According to the press, five construction companies are interested in acquiring a majority stake on Kambas S.A.	*30/4/1996*
RIDENCO	*Growth*	The company may develop three new stores	The investment is likely to be part of sequential investments. The second phase of the investment is expected to be five times larger than the initial investment and can potentially result in the development of ten more stores.	*10/5/1996*
ERGOBANK	*Growth*	The Bank may increase its branch network considerably within the following three years	The increase of the branch network eventually leads to increasing operations and increasing profitability.	*3/6/1996*
ALLATINI mills	*Default*	The company may sell old factory facilities.	The area where the old factory is situated is near Salonica (10 km away) , the second largest city in Greece. A hotel chain may buy the area.Since Allatini group is a financially distressed company, the sale proceeds can extend the company's life.	*23/6/1996*
ATTICA ENTERPRISES	*Expand*	The company may proceed with an investment to increase its fleet.	To order two new ferries.	*30/6/1996*
ROKAS	*Expand*	The company may develop new windmill power stations to proceed to the second phase of expansion. Subsequent investments largely depend on the success of the second phase of expansion.	The EU's programme for the development of alternative power stations in Greece has particular benefits for the companies involved in the construction of these stations. Both the development and the operation of these stations is subsidised by both the EU and the Greek authorities.	*13/7/1996*
PAVLIDES	*Abandon*	the company plans to sell its croissant production unit.	Whereas Jacobs-Suchard Pavlides S.A. is a leading company in the confectionery sector, its croissant production unit has not been highly profitable due to increasing competition from specialised companies in the niche croissant sector. We believe that Pavlides is likely to find a buyer for the croissant unit, since it will not only sell the unit, but also the trademark.	*6/9/1996*
ATTICA ENTERPRISES	*Growth*	The company may proceed with an investment to increase its fleet.	To order two new ferries.	*12/9/1996*

Company Name	*Type of option*	*Case Description*	*Further Comments*	*Date*
PAVLIDES	*Expand*	The company may merge with Craft Hellas S.A.	Probable merger with Craft Hellas is likely to strengthen Pavlides' competitive position. Craft Hellas trades the products of the German Craft, and has particularly strong position in products in the food sector, especially in the cheese and the dressing niche markets.	*14/9/1996*
SAINT GEORGE MILLS	*Expand*	The company may acquire a Bulgarian in the mill sector.	The company that is likely to become an acquisition target has a production capacity of 350 tons per day.	*19/9/1996*
ERGOBANK	*Growth*	The Bank may increase its branch network considerably within the following three years	The increase of the branch network eventually leads to increasing operations and increasing profitability.	*13/10/1996*
KREKA	*Growth*	The company may proceed with an investment to increase production capacity	The investment plan includes the increase of current capacity utilisation by 1,000 tons of end products, annually.	*18/10/1996*
ERGOBANK	*Growth*	The Bank may increase its branch network considerably within the following three years	The increase of the branch network eventually leads to increasing operations and increasing profitability.	*20/10/1996*
SARANTOPOULOS FLOUR MILLS	*Growth*	The company plans to increase its production capacity by developing a new flourmill unit.	The flourmill unit will increase the company's production capacity by 250 tonnes per day	*28/10/1996*
KAMBAS	*Default*	The company may proceed with a private placement, so as to solve its financial problems.	According to the press, five construction companies are interested in acquiring a majority stake on Kambas S.A.	*9/11/1996*
ERGOBANK	*Growth*	The Bank may increase its branch network considerably within the following three years	The increase of the branch network eventually leads to increasing operations and increasing profitability.	*22/11/1996*
PAVLIDES	*Abandon*	The company plans to sell its croissant production unit.	Whereas Jacobs-Suchard Pavlides S.A. is a leading company in the confectionery sector, its croissant production unit has not been highly profitable due to increasing competition from specialised companies in the niche croissant sector. We believe that Pavlides is likely to find a buyer for the croissant unit, since it will not only sell the unit, but also the trademark.	*1/12/1996*
RILKEN	*Expand*	Henkel, a multinational group in the healthcare sector, may acquire a majority stake in Rilken S.A.	If Henkel acquires Rilken it will shift its (highly profitable) trading activities to the acquired company.	*19/12/1996*
ATTICA ENTERPRISES	*Expand*	The company may proceed with an investment to increase its fleet.	To order two new ferries.	*1/2/1997*
TITAN	*Expand*	The company may acquire a majority stake (51%) of a cement producer in Bulgaria.	The Bulgarian cement producer has an annual production capacity of 850,000 tons	*24/2/1997*
YALCO	*Expand*	The company may acquire a glass retailer.		*24/5/1997*
BANK OF ATTICA	*Growth*	The Bank may proceed with a capital increase to finance its branch expansion plan.	The Bank plans to increase its branch network. Twenty new branches are planned to open within the next 24 months.	*30/5/1997*

Company Name	*Type of option*	*Case Description*	*Further Comments*	*Date*
BANK OF ATTICA	*Growth*	The Bank may proceed with a capital increase to finance its branch expansion plan	The Commercial Bank of Greece- the 2nd largest state owned Bank- holds a majority stake in the Bank. Many deficiencies regarding the Bank's portfolio and its old-fashioned strategy are expected to weaken its position in the sector. Possible capital increases will extent the Bank's life.	*27/6/1997*
TERNA	*Expand*	The company plans to develop a small (10 MW) windmill power plant.	The EU's programme for the development of alternative power stations in Greece has particular benefits for the companies involved in the construction of these stations. Both the development and the operation of these stations is subsidised by both the EU and the Greek authorities.	*1/9/1997*
PAVLIDES	*Growth*	The company may proceed with a capital increase so as to strengthen its financial position.	The company became recently financially distressed.	*31/10/1997*
PAVLIDES	*Expand*	The company may merge with Craft Hellas S.A.	Probable merger with Craft Hellas is likely to strengthen Pavlides' competitive position. Craft Hellas trades the products of the German Craft, and has particularly strong position in products in the food sector, especially in the cheese and the dressing niche markets.	*19/2/1998*
ALPHA	*Growth*	The Bank may increase its branch network considerably within the following years	The increase of the branch network eventually leads to increasing operations and increasing profitability.	*27/2/1998*
YALCO	*Expand*	The company may acquire a glass retailer.		*28/2/1998*
SATO	*Default*	SATO may enter the home furniture market	There are hundreds of small companies active in the home furniture market. Possible entry of SATO in the market may require a heavy advertisement budget.	*1/3/1998*
RILKEN	*Expand*	Henkel, a multinational group in the healthcare sector, may acquire a majority stake on Rilken S.A.	If Henkel acquires Rilken it will shift its (highly profitable) trading activities to the acquired company.	*5/3/1998*
GOODYS	*Expand*	The company may extend its network to Portugal.	The expansion plan is likely to be part of sequential investments.	*10/3/1998*
EOLIKI	*Growth*	The company may proceed with a capital increase.	The capital increase is expected to induce economies of scale.	*10/3/1998*
ATTICA ENTERPRISES	*Expand*	The company may proceed with an investment to increase its fleet.	To order two new vessels.	*24/3/1998*
ALCO	*Growth*	The company may acquire a majority stake (51%) on GROUPAL S.A.. GROUPAL is one of the ten largest Greek aluminium frame producers. Groupal has developed an extensive network to sell its products, and its brand name is well known in Greece. Its products are regarded as "value for money" products, combining rational pricing with relatively good quality.	Groupal has an annual production capacity of 4,300 tons and its possible acquisition by Alco will expand Alco's network, capacity and product variety.	*2/4/1998*

Company Name	*Type of option*	*Case Description*	*Further Comments*	*Date*
A-FINANCE	*Expand*	The Bank may proceed with a capital increase to finance an acquisition		*9/4/1998*
GOODYS	*Expand*	Goody's S.A. may acquire the exclusive rights to develop fashion restaurants under the trademark "Planet Hollywood"	"Planet Hollywood" is a trademark of fashion restaurants developed by artists and Hollywood stars in the United States. The expansion plan is likely to be part of sequential investments.	*28/4/1998*
MAKEDONIAN-THRACE BANK	*Growth*	The Bank may proceed with a capital increase to finance its branch expansion plan		*1/5/1998*
ALFA ALFA HOLDINGS	*Growth*	The company may proceed with an investment to increase production capacity in aluminium products.	If the investment takes place, production capacity will increase from 90 million m^2 of end products per annum to 250 million m^2 of end products.	*1/5/1998*
ALPHA	*Growth*	The Bank may acquire a majority stake (51%) in Ionian Bank S.A.	The acquisition of the Ionian Bank will double its branch network and will strengthen its position in the sector.	*15/5/1998*
TERNA	*Expand*	The company plans to develop two small (34 MW) windmill power plants.	The EU's program for the development of alternative power stations in Greece has particular benefits for the companies involved in the construction of these stations. Both the development and the operation of these stations is subsidised by both the EU and the Greek authorities.	*28/5/1998*
PAPOUTSANIS	*Expand*	The company may proceed with capital increase to finance its plan to represent new products and in acquiring a small Greek food producer.	Papoutsanis may a) represent the product "Frulite", a light food drink, and b) acquire Olympic Foods, a company that produces and trades dressings	*28/5/1998*
THRACE PLASTICS	*Growth*	The company plans a) increase production capacity by 4,000 tons and b) to acquire a similar company in Romania	The company's annual production capacity will increase from 16,000 tons to 20,000 tons.	*31/5/1998*
ALTEC	*Expand*	The company may acquire 70% of Microland, an electronics retailer.		*3/6/1998*
GOODYS	*Expand*	The company may extend its network to Portugal.	The expansion plan is likely to be part of sequential investments.	*3/6/1998*
MAKEDONIAN-THRACE BANK	*Growth*	The Bank may proceed with a capital increase to finance its branch expansion plan		*7/6/1998*
EPIFANIA-INTERTYP	*Expand*	The company may acquire NEUROSOFT S.A., a company in the digital communications sector	The acquisition of a company specialising in digital communications will be particularly useful for Epifania-Intertyp, since the companies serve common customers.	*23/6/1998*
ERGAS	*Default*	The company plans to proceed with capital increase.	The capital increase gives the company the opportunity to increase liquidity and to decrease its possibility of going bankrupt.	*1/7/1998*
ERGAS	*Default*	The company plans to proceed with capital increase.	The capital increase gives the company the opportunity to increase liquidity and to decrease its possibility of going bankrupt.	*20/7/1998*

Company Name	Type of option	Case Description	Further Comments	Date
KOUMBAS	*Expand*	The company plans to proceed with a capital increase so as to finance possible acquisitions of companies in the financial sector.	The companies to be acquired are the following : 100% of Eurobrokers S.A., 100% of K.Consultants S.A. and 40% of Finco S.A.	*20/7/1998*
ERGAS	*Default*	The company plans to proceed with capital increase.	The capital increase gives the company the opportunity to increase liquidity and to decrease its possibility of becoming bankrupt.	*5/8/1998*
OTE	*Expand*	The company may acquire 35% of Rom telecom, the Romanian state telecommunication company.	Rom Telecom is a monopoly in fixed line telecoms in Romania and holds a licence for a mobile phone company.	*22/9/1998*
SELECTED TEXTILES	*Growth*	The company may proceed with an investment to increase production capacity.	The investment in the area is 40% subsidised by the state.	*3/10/1998*
JUMBO	*Expand*	The company may invest for the development of new stores.	The development of three new super-stores is the main subject of the investment plan.	*12/10/1998*
RILKEN	*Default*	The company may stop production in Russia	The adverse economic conditions that took place in Russia after the rouble collapse, have made operations there highly loss making.	*1/11/1998*
ALTEC	*Expand*	The company is considering in acquiring 86% of AFT S.A. AFT is one of the few Greek companies specialised in IT solutions for the Banking sector.	If the acquisition takes place, ALTEC will have the ability to serve an entirely new, for its activity, sector. Besides, ALTEC, will have the ability to sell its existing products in the Banking industry.	*5/11/1998*
ALTEC	*Expand*	The company may be the exclusive representative (VAR) of Lucent technologies in the Balkan countries (Romania, Bulgaria, Yugoslavia, Albania) and simple representative in Greece.	Possible representation of Lucent products would add considerably (5%) to group's sales.	*5/11/1998*
REMEC	*Default*	The company may sell a building that owns.	If Remec sells the building it will solve its cash flow problems. The building is easy to sell because it is situated in Katechaki street- a demanding area in Athens.	*1/12/1998*
TERNA	*Expand*	The company may proceed with the second phase of development of windmill power plants.	The EU's programme for the development of alternative power stations in Greece has particular benefits for the companies involved in the construction of these stations. Both the development and the operation of these stations is subsidised by both the EU and the Greek authorities.	*1/12/1998*
ALCO	*Growth*	The company may proceed with a capital increase so as to finance possible production capacity increase.	The company's possible investment plan consists of two possible expansion phases. Phase 1 expansion will increase production capacity from 6,000 tons to 18,000 tons of end products annually. Phase 2 expansion plan requires the completion of a recycling unit that will increase the company's profit margin considerably.	*2/12/1998*
LOGIC-DIS	*Expand*	The company plans to buy a majority stake (51%) on InfoServe S.A. a VAR of Lotus	Infoserve S.A. will give Logic-Dis the ability to cross-sell its products in new markets.	*6/12/1998*

Company Name	Type of option	Case Description	Further Comments	Date
KREKA	*Growth*	The company may proceed with an investment to increase production capacity	The investment plan includes the increase of current capacity utilisation by 40%	*7/12/1998*
RILKEN	*Default*	The company may stop production in Russia	The adverse economic conditions that took place in Russia after the rouble collapse, have made operations there highly loss making.	*9/12/1998*
ATTICA ENTERPRISES	*Expand*	The company may expand into the airline industry.	The company may acquire Cronus Airlines S.A., one of the three local airline companies.	*29/12/1998*
LOGIC-DIS	*Expand*	The company plans to buy a majority stake (51%) in Taseis Simvouleftiki S.A., an IT consulting company specialised in integrated Information Technology solutions for stores .	Taseis Simvouleftiki S.A. will provide Logic-Dis wth the ability to enter the IT consulting market.	*8/1/1999*
ALOUMIL-MILONAS	*Growth*	The company may increase its production capacity considerably through its subsidiary Alucom. S.A.	Alucom S.A. is expected to increase production capacity by 5.000 tons.	*15/1/1999*
HELLENIC INVESTMENTS	*Growth*	The company may proceed with a capital increase.	The capital increase is expected to induce economies of scale.	*22/1/1999*
ASPIS INVESTMENTS	*Growth*	The company may proceed with a capital increase.	The capital increase is expected to induce economies of scale.	*23/1/1999*
RIDENCO	*Expand*	The company may expand to Turkey.	The expansion plan to Turkey includes the development of five new stores. The investment is likely to be part of sequential investments.	*2/2/1999*
ATTIKAT	*Growth*	The company plans to acquire 70% of Sigalas S.A.	Sigalas S.A. is a small construction company, listed on the Athens stock exchange.	*14/2/1999*
EKTER	*Growth*	The company may extend windmill construction, through some self-financed projects.	Since only four companies in Greece are involved in the construction and operation of windmills, a highly profitable operation since it is partly subsidised by the state, the company's plans are an excellent option to expand operations.	*10/3/1999*
PIRAEUS LEASING	*Expand*	The company may acquire BEST LEASING S.A.	Best Leasing S.A. is one out of the five largest car-leasing companies. The acquisition of Best Leasing from Piraeus Leasing gives an option to the acquirer to enter the highly promising car leasing market.	*10/3/1999*
ALLATINI mills	*Default*	The company may sell old factory facilities.	The area where the old factory is situated is near Salonica (10 km away) , the second largest city in Greece. The hotel chain Intercontinental may buy the area to build a hotel.Since Allatini group is a financially distressed company, the sale proceeds can extend the company's life.	*20/3/1999*

Company Name	Type of option	Case Description	Further Comments	Date
ALOUMIL-MILONAS	Expand	The company may increase its production capacity considerably.	The company may proceed with the development of a new aluminium frame production unit. The new unit will increase production capacity by 40%. The investment is 60% state-funded.	23/3/1999
ELMEC	Expand	The Bank may increase its branch network considerably within the following three years	Elmek may acquire 45% of Concept S.A.. Concept S.A. owns 5 large stores in Greece, 51% of Factory Outlet S.A.- the largest discount centre in Greece- and the exclusive representation of Nike in Romania.	24/3/1999
JUMBO	Growth	The company plans to expand to Former Yugoslavian Republic Of Macedonia.	An investment in FYROM gives an option to enter other nearby Balkan countries	31/3/1999
GOODYS	Expand	The company may extend its network by 25 new points of sale.	The expansion plan is likely to be part of sequential investments. The company's strategic plan includes the development of 210 more restaurants within the following 3.5 years	17/4/1999
SARANTIS	Growth	It is likely to buy a majority stake (70%) in Pharmacare S.A. a company active in the Pharmaceutical market.	Sarantis S.A. is already active in the trading of pharmaceutical products, so possible acquisition of Pharmacare will extend its portfolio of products available in the market. The end markets of Pharmaceutical products in Greece is characterised by low profit margins because it is highly regulated and 40% of the market consists of hospitals. Hospitals buy drugs on credit and the average payment period is 2 yrs.	17/4/1999
GOODYS	Expand	The company may extend its network considerably.	The expansion plan is likely to be part of sequential investments. The company's strategic plan includes the development of 91 new restaurants within the following 3 years	17/4/1999
THRACE PLASTICS	Expand	The company may acquire a majority stake on Don & Low S.A., a company that is ten times larger than Thrace Plastics S.A.	Possible acquisition of Don & Low by Thrace Plastics will multiply the acquirer's Sales and Profits and will led to considerable transfer of skills and know-how from the Scottish company to the acquirer.	1/5/1999
KREKA	Expand	The company may proceed with an investment to increase production capacity	The investment plan includes the increase of current capacity utilisation by 1.000 tons of end products, annually.	14/5/1999
ALCO	Growth	The company may decide on the expansion, by 50%, of its investment plan. To achieve the expansion of its investment plan the company may proceed with a new capital increase.	The company's possible investment plan consists of two possible expansion phases. Phase 1 expansion will increase production capacity from 6,000 tons to 18,000 tons of end products annually. Phase 2 expansion plan requires the completion of a recycling unit that will increase the company's profit margin considerably.	15/5/1999
EUROBANK	Expand	The Bank may acquire ErgoBank	Acquisition is expected to lead to economies of scale	20/5/1999

Company Name	*Type of option*	*Case Description*	*Further Comments*	*Date*
THRACE PLASTICS	*Expand*	*The company may acquire a majority stake in Don & Low S.A., a company that is ten times larger than Thrace Plastics S.A.*	*Possible acquisition of Don & Low by Thrace Plastics will multiply the acquirer's Sales and Profits and will lead to considerable transfer of skills and know-how from the Scottish company to the acquirer.*	*23/5/1999*
NAFPAKTOS SP.MILLS	*Expand*	*It may acquire a company that produces underwear.*	*The company to be acquired, by 50%, is Helios S.A.. Helios holds 12% market share in Greece.*	*26/5/1999*
GOODYS	*Expand*	The company may extend its network by 25 new points of sales.	The expansion plan is likely to be part of sequential investments. The company's strategic plan includes the development of 210 more restaurants within the following 3.5 years	*30/5/1999*
NAFPAKTOS SP.MILLS	*Growth*	It may acquire a company that produces underwear.	The company to be acquired, by 50%, is Helios S.A.. Helios holds 12% market share in Greece.	*31/5/1999*
THRACE PLASTICS	*Expand*	The company may acquire a majority stake in Don & Low S.A., a company that is ten times larger than Thrace Plastics S.A.	Possible acquisition of Don & Low by Thrace Plastics will multiply the acquirer's Sales and Profits and will led to considerable transfer of skills and know-how from the Scottish company to the acquirer.	*2/6/1999*
ERGOBANK	*Growth*	The Bank may become an acquisition target	Acquisition is expected to lead to economies of scale	*9/6/1999*
LOGIC-DIS	*Expand*	The company plans to buy a majority stake (51%) on Taseis Simvouleftiki S.A., an IT consulting company specialised in integrated Information Technology solutions for stores.	Taseis Simvouleftiki S.A. will provide with Logic-Dis the ability to enter the IT consulting market.	*18/6/1999*
ATTIKAT	*Growth*	The company plans in acquiring a majority (51%) stake on Mesochoritis Bros S.A.	Mesochoritis Bros S.A. is a construction company, listed on the Athens stock exchange.	*28/6/1999*
MESOCHORITIS	*Growth*	The company may become an acquisition target by Attikat S.A., a financially sound road construction company listed on the Athens stock exchange.	Mesochoritis S.A. plans to finance self-financed projects.	*28/6/1999*
ATTIKAT	*Growth*	The company plans in acquiring a majority (51%) stake in Atemke S.A.	ATEMKE S.A. faces serious financial problems.	*28/6/1999*
ATEMKE	*Default*	The company may become an acquisition target for Attikat S.A., a financially sound road construction company listed on the Athens stock exchange.	ATEMKE S.A. faces serious financial problems.	*28/6/1999*
ATTIKAT	*Growth*	The company plans in acquiring a majority (51%) stake on TECHNODOMIKI S.A.	TECHNODOMIKI S.A. is a construction company, listed on the Athens stock exchange.TECHNODOMIKI S.A. faces serious financial problems.	*29/6/1999*
TECHNODOMI	*Default*	The company may become an acquisition target for Attikat S.A., a financially sound road construction company listed on the Athens stock exchange.	ATEMKE S.A. faces serious financial problems.	*29/6/1999*
ALOUMIL-MILONAS	*Expand*	The company may proceed with the development of a production unit in Egypt.	The company may proceed with the development of a new aluminium frame production unit in Egypt, through a Joint Venture where Alumil will hold 51% share.	*29/6/1999*

Company Name	*Type of option*	*Case Description*	*Further Comments*	*Date*
EPIFANIA-INTERTYP	*Expand*	The company may acquire NEUROSOFT S.A., a company in the digital communications sector	The acquisition of a company specialised in digital communications will be particularly useful for Epifania-Intertyp, since the companies serve common customers.	*30/6/1999*
RADIO ATHINA	*Expand*	The company may be acquired by Kotsovolos group, the largest retailer in the sector.	Possible acquisition of radio Athinai by Kotsovolos Group will lead to considerable economies of scale due to the common use of warehouses the Kotsovolos group already has.	*1/7/1999*
SPORTSMAN	*Expand*	The company may proceed with an extensive plan that consists of acquisitions of similar companies, new representations and the development of its network of stores in Eastern and Central European countries.	Possible entry in new Eastern and central European countries, formerly socialist countries, will be an important growth option. Besides, the acquisition of related companies is expected to strengthen the company's weak position in the Greek retail sector.	*4/7/1999*
RIDENCO	*Growth*	The company may develop six new stores and a wholesale centre.	The development of six new stores is the second stage of the company's expansion in the apparel retail sector.	*5/7/1999*
GOODYS	*Expand*	Goody's S.A. may acquire the exclusive rights to develop fashion restaurants under the trademark "Planet Hollywood"	"Planet Hollywood" is a trademark of fashion restaurants developed by artists and Hollywood stars in the United States. The expansion plan is likely to be part of sequential investments.	*14/7/1999*
MAKEDONIAN-THRACE BANK	*Growth*	The Bank may proceed with a capital increase to finance its branch expansion plan		*15/7/1999*
PIRAEUS BANK	*Expand*	The Bank may acquire ErgoBank	Acquisition is expected to lead to economies of scale	*23/7/1999*
LOGIC-DIS	*Expand*	The company plans to buy a majority stake (51%) in Optimum S.A. a, a logistics specialist.	The acquisition of a company specialised in logistics will be particularly useful for Logic-Dis, since its future expansion in the area of e-business requires well-developed logistics operations.	*27/7/1999*
ATHENIAN HOLDINGS-DIMITRIADIS	*Expand*	the company may acquire 87% of Maltezos S.A. and 87% of Interclima S.A.	Maltezos S.A. constructs Sun Boilers, while Interclima S.A. constructs and trades Air Conditioning systems	*21/8/1999*
OTE	*Expand*	The company may acquire 90% of Armentel, the Armenian fixed line telecommunication company.	Armentel S.A. is a monopoly in the fixed line sector in Armenia. The acquisition of Armentel gives OTE S.A. an option in acquiring other companies in former socialist countries in East Europe.	*25/8/1999*
PAPOUTSANIS	*Expand*	The company may buy Katselis S.A. a bread producer		*1/9/1999*
KATSELIS	*Growth*	The company may become an acquisition target by Papoutsanis S.A.	Papoutsanis S.A. has an extensive distribution network that will give Katselis the opportunity to increase its sales.	*1/9/1999*

Company Name	*Type of option*	*Case Description*	*Further Comments*	*Date*
SATO	*Expand*	SATO may enter the home furniture market	The company may acquire 75% of Bo-Concept S.A., a company involved successfully in home furniture. The acquisition may be accompanied by considerable investments for the rapid development of 15 more stores for the needs of the expansion.	*8/9/1999*
LAMPSA	*Growth*	The company may become an acquisition target	Management change may be associated with a considerable cash inflow that will extend the company's life.	*17/9/1999*
GOODYS	*Expand*	The company may enter the pizza catering industry.	The company may undertake the representation of Telepizza, a successful pizza restaurant chain	*5/10/1999*

Number of Real Option Cases, by year

Year	*Number of Real Option cases observed*	*Percentage of Total cases observed*
1991	*2*	*1.2%*
1992	*6*	*3.7%*
1993	*8*	*5.0%*
1994	*12*	*7.5%*
1995	*16*	*9.9%*
1996	*24*	*14.9%*
1997	*7*	*4.3%*
1998	*38*	*23.6%*
1999	*48*	*29.8%*
Total	***161***	***100.0%***

APPENDIX C
COMPANIES HOLDING REAL OPTIONS

Banks

1. Alpha Bank S.A. is the largest privately owned Bank in Greece, holding nearly 15% market share. The Bank holds a majority stake in many leading companies in the brokerage, leasing and investment sector. Alpha Bank may increase its branch network considerably and plans in acquiring Ionian Bank S.A.

2. Bank of Athens S.A. is a small state-owned Bank that may become privatised. Hanwa Bank S.A., a Korean Bank, is interested in acquiring Bank of Athens. The acquisition is a solution to Bank of Athens' liquidity problems.

3. Bank of Attica S.A. is a small size Bank that plans to proceed with a capital increase to finance its branch expansion plan. Many deficiencies regarding the Bank's portfolio and its old-fashioned strategy are expected to weaken its position in the sector. The Bank may become an acquisition target. Possible acquisition will induce certain economies of scope. Possible capital increase will improve the Bank's liquidity position.

4. ErgoBank S.A. is the second, in terms of size, privately owned Bank in Greece and by far the most competitive in the sector. The Bank may increase its branch network and may become an acquisition target. Acquisition is expected to lead to economies of scale.

5. EFG-EuroBank S.A. has an aggressive expansion plan. The Bank may acquire ErgoBank. Acquisition is expected to lead to economies of scale.

6. Macedonian-Thrace Bank S.A. has an extensive branch network and has been recently privatised. It belongs to the Bank of Piraeus group. The Bank may proceed with a capital increase to finance its branch expansion plan.

7. Bank of Piraeus S.A. is a private Bank that has an aggressive expansion plan. The Bank may acquire ErgoBank. Acquisition is expected to lead to economies of scale.

Other Financial Companies

8. Alpha Finance S.A. is involved in Investment Banking. It is a subsidiary of Alpha Bank. The company may proceed with a capital increase. The capital increase is expected to induce economies of scale.

9. Aspis Investment S.A. is a closed-end investment fund. It is a subsidiary of Aspis Bank. The company may proceed with a capital increase that is expected to induce economies of scale.

10. Eoliki S.A. is a closed-end investment fund. The company may proceed with a capital increase that is expected to induce economies of scale.

11. Hellenic Investments S.A. is a closed-end investment fund that belongs to ETVA, the largest Greek investment Bank. Hellenic Investments is the largest company in the sector. The company may proceed with a capital increase that is expected to induce economies of scale.

12. Piraeus Leasing S.A. is a subsidiary of Piraeus Bank in the leasing sector. The company may acquire a car leasing company.

13. Astir Insurance S.A. is a large insurance company that belongs to the National Bank of Greece, the largest state-owned Bank in Greece. Astir Insurance is close to Bankruptcy due to past mismanagement. The privatisation of Astir Insurance or the entry of new strategic investors will reduce the company's liquidity problems. The company may become an acquisition target.

14. Koumbas S.A. is a small insurance company aiming to expand into other financial sub-sectors. The company plans to proceed with a capital increase so as to finance possible acquisitions of companies in the financial sector.

Food & Beverage

15. AB Vassilopoulos S.A. is a large supermarket chain, the only supermarket chain listed in the Athens Stock Exchange. It ranks 5^{th} in the sector, holding approximately 7% market share.

The company faces two types of opportunities. First, it may become a member of a larger group of food retailers, second it may expand its distribution network considerably. In particular, the Belgian group Lion-Delhaise S.A. is interested in acquiring a majority stake in AB Vassilopoulos, something that will strengthen the company's resources. The investment plan aims to expand its distribution network from 17 stores to 50 stores within the following five years. The investment plan is the first part of the company's expansion plans.

16. Allatini Mills S.A. is the second largest wheat mill in Greece. The company is active not only in flour production but also in the production of related products, some of them exported.

The company faces liquidity problems, because of problems in its main export markets, Eastern Europen countries. Allatini Mills has the opportunity to reduce liquidity problems either by selling premises, or by become an acquisition target.

In particular, the company may sell old factory facilities and may be acquired by the Levendis group, the group that owns Coca Cola Hellas-HBC S.A. a large Coca Cola bottler who has 40 factories and points of sales in 14 countries.

17. Goody's S.A. is one of the five leading European fast-food chains, holding 60% market share in the Greek market. The company's only visible competitor in the Greek market is McDonalds restaurants.

Goody's has a detailed expansion plan. The company's strategic plan includes the development of nearly 90 new restaurants. The company may also extend its network to other countries, including Cyprus, Spain and Portugal. Moreover, Goody's S.A. may acquire the exclusive rights to develop fashion restaurants under the trademark "Planet Hollywood". It is also possible the company can enter pizza catering industry.

18. Kampas S.A. is a wine producing company that faces cash flow problems. The company may sell an extensive area of land, so as to solve its financial problems. An alternative solution is to proceed with a capital increase.

19. Katselis S.A. is a leading Greek bread producer. The company may become an acquisition target by Papoutsanis S.A. Papoutsanis S.A. has an extensive distribution network (more than 3.000 points of sale in Greece) that will give Katselis the opportunity to increase its sales.

20. Kreka S.A. is specialised in the production of sausages. Ranked 4th in turnover terms in the sausage sub-sector, the company may proceed with an investment to increase production capacity. The investment plan includes the increase of the current production capacity by 40%.

21. Papoutsanis S.A. is a soap and beverage producing company. The company faces problems since it introduced & unsuccessfully promoted *Lucozade & Ribena* in the Greek market. The company may proceed with capital increase to solve its financial problems.

The company's plans include capital increases in acquiring leading producers in niche markets, including Katselis S.A. a bread producer. Papoutsanis may also represent light food drinks on behalf of HBC, a Coca-Cola bottling company. The company may also acquire Olympic Foods, a company that produces and trades dressings. The implementation of the company's plans will give Katselis the ability to enter new markets.

22. Saint George Mills is the largest flourmill company in Greece, holding 35% market share. The company may acquire a company in the food sector that is active in food packaging and has a private port near an existing factory. The company may also expand into Bulgaria, through acquisitions of similar companies.

23. Jacobs-Suchard Pavlides S.A., formerly named Pavlides S.A., has recently been acquired by Jacobs-Suchard. It holds 40% market share in the Greek confectionery market. The company plans to sell its croissant production unit. Jacobs-Suchard Pavlides may also merge with Craft Hellas S.A. Also, the company aims to proceed with a capital increase so as to strengthen its financial position.

24. Sarantopoulos Flour Mills S.A. is a small company, holding 6% market share that produces high quality flour. The company plans to increase its production capacity by developing a new flourmill unit.

25. Yalco S.A. is active in the trade of glass-made and domestic use materials. The company may acquire a glass retailer.

Metal Processing

26. Alco S.A. is involved in the processing and production of aluminium frames, mainly for the needs of the building construction sector. The company may acquire Greek aluminium frame producers and may decide on the expansion, by 50%, of its production capacity.

27. Aloumil-Milonas S.A. is an aluminium frame producer with an important international presence. The company may increase its production capacity considerably through its subsidiary Alucom. S.A. The company may proceed with the development of new aluminium frame production units in Greece and abroad.

28. Alfa Alfa Holdings S.A., formerly named Aluminium of Attica, is an aluminium rolling company that has some subsidiaries, mainly construction companies. The company may proceed with an investment to increase production capacity in aluminium products. If the investment takes place, production capacity will triple.

29. Bitros S.A, is a metal processing company. The company may sell a piece of land in Elefsina, a city near Athens, to reduce its liquidity problems.

30. Girakian-Profile S. A. is a small industrial company in the niche market of aluminium frames. The company plans to extend production capacity.

31. Sheet Steel S.A. is a small company in the sheet steel industry. The company may increase its production capacity. Sheet Steel S.A. is also considering the acquisition of a state-owned Bronze Profile Producer and the development of a drilling tube production unit.

Construction & Cement producers

32. Atemke S.A. is a company specialising in road construction projects and faces serious liquidity problems. The company may become an acquisition target for Attikat S.A., a financially sound road construction company listed on the Athens Stock Exchange.

33. Attikat S.A. is a construction company specialised in road construction projects. The company plans in acquiring 70% of Sigalas S.A., a majority (51%) stake in Mesochoritis Bros S.A. ,a majority (51%) stake in Atemke S.A. and a majority (51%) stake in Technodomiki S..A.

34. AVAX S.A. is one of the largest construction companies in Greece. The company may merge with J&P S.A., a large construction company that operates in Cyprus.

35. Ekter S.A. is a small construction company that has recently entered the windmill power sector.
The company may extend windmill construction, through some self-financed projects. Since only four companies in Greece are involved in the construction and operation of

windmills, a highly profitable operation since it is partly subsidised by the state, the company's plans are an excellent option to expand operations.

36. Ergas S.A. is a small construction company that faces many financial problems, due to the undertaking of large infrastructure projects without the backup of the necessary liquidity. The company plans to proceed with capital increase. The capital increase gives the company the opportunity to proceed with the undertaking of new projects, and will partly replace bank financing. Also the capital increase gives the company the opportunity to increase liquidity and to decrease its possibility ofBankrupt.

37. Mesochoritis Bros S.A. is a construction company specialising in building construction projects. The company may become an acquisition target for Attikat S.A., a financially sound road construction company listed on the Athens Stock Exchange.

38. Rokas S.A. is the first developer of windmill power stations. The company is likely to take advantage from the EU programme for the development of alternative power stations. The company may develop new windmill power stations to proceed withthe second phase of expansion. Subsequent investments largely depend on the success of the second phase of expansion. The EU's programme for the development of alternative power stations in Greece has particular benefits for the companies involved in the construction of these stations. Both the development and the operation of these stations is subsidised by both the EU and the Greek government.

39. Technodomi S.A. is a construction company specialising in road construction projects. Technodomi S.A. faces serious financial problems. The company may become an acquisition target for Attikat S.A., a financially sound road construction company listed on the Athens Stock Exchange.

40. Terna S.A. is a small construction company. Terna S.A. may proceed with capital increase to finance a project in the real estate sector. The company plans to develop a small (10 MW) windmill power plant. The company may proceed with the second phase of development of windmill power plants.

41. Titan S.A., is the second largest in production capacity, Greek cement producer. Titan exports half of its production to developed and highly competitive markets, including Italy and the US. The company may proceed with an investment in Roanoke plant, USA and may also implement two new distribution centres. The company may acquire 50% of Chalkis Cement. The company may extend to the French market. Titan S.A. plans to develop a port in South France to transfer cement. The company may acquire a majority stake (51%) in a cement producer in Bulgaria.

Electronics, Computers and Telecommunications

42. Altec S.A. is a group involved in the information sector, mainly in software developing, computer hardware assembly and system integration. The company is considering acquiring 86% of AFT S.A. AFT is one of the few Greek companies specialising in IT solutions for the Banking sector. If the acquisition takes place, ALTEC will have the ability to serve an, entirely new, sector. Besides, ALTEC, will have the ability to sell its existing products in the Banking industry. The company may be the exclusive representative (VAR) of Lucent technologies in the Balkan countries (Romania, Bulgaria, Yugoslavia, Albania) and representative in Greece.

43. Epifania -Intertyp S.A. is the second largest company in electronic publishing. The company may acquire NEUROSOFT S.A., a company in the digital communications sector. The acquisition of a company specialising in digital communications will be particularly useful for Epifania-Intertyp, since the companies serve common customers.

44. Logic-Dis S.A. is a computer company that is active in software production. It also represents Enterprise Resource Planning software applications (developed by J.D.Edwards, SAP etc). The company also plans to buy a majority stake (51%) in InfoServe S.A. a VAR of Lotus. Infoserve S.A. will give Logic-Dis the ability to cross-sell its products in new markets. The company plans to buy a majority stake (51%) in Taseis Simvouleftiki S.A., an IT consulting company specialising in Integrated Information Technology solutions for stores. Taseis Simvouleftiki S.A. will provide Logic-Dis with the ability to enter the IT consulting market. Besides, the company plans to buy a majority stake (51%) in Optimum S.A., a logistics specialist. The acquisition of a company specialising in logistics will be particularly useful for Logic-Dis, since its future expansion in the area of e-business requires well-developed logistics operations.

45. OTE S.A. (Hellenic Telecommunications Company), is the Greek fixed telecom company, a monopoly up to FY2001. The company may acquire 35% of Rom telecom, the Romanian state telecommunication company. Rom Telecom is monopoly in fixed line telecoms in Romania and holds a licence for a mobile phone company. OTE may also acquire 90% of Armentel, the Armenian fixed line telecommunication company. Armentel S.A. is a monopoly in the fixed line sector in Armenia. The acquisition of Armentel gives OTE S.A. an option in acquiring other companies in former socialist countries in East Europe.

46. Radio Athina S.A. is highly profitable retailer in the electronics market. However its branch network expands slowly due to certain diseconomies. Radio Athina S.A. may proceed with the development of two more super-stores. The development of super stores outside Athens is regarded as a growth option, since the company has been active till now with the development of stores only in Athens, the capital city of Greece. the company may be acquired by Kotsovolos group, the largest retailer in the sector. Possible acquisition of Radio Athinai by the Kotsovolos Group will lead to considerable economies of scale due to the common use of warehouses the Kotsovolos group already has.

Clothing

47. Athenian Holdings S.A. is the new name of Dimitriadis S.A. a highly recognised manufacturing company for men's casual dress. Dimitriadis S.A. may proceed with capital increase so as to relief its liquidity problems. The company may acquire 87% of Maltezos S.A. and 87% of Interclima S.A.

48. Elmec S.A. is a wholesaler in the apparel industry that plans to enter the retailing sector. The company may acquire Smash S.A. the exclusive representative of Harley Davidson accessories in Greece. Elmek may acquire 45% of Concept S.A. Concept S.A. owns 5 large stores in Greece, 51% of Factory Outlet S.A.,- the largest discount centre in Greece- and also is the exclusive representation for Nike in Romania.

49. Lambropoulos Bros S.A. is a retail chain having high brand recognition in the apparel retail sector. The company may launch an extensive advertisement campaign, as part of its expansion strategy. The company may sell two loss-making stores.

50. Ridenco S.A. is a wholesaler in the apparel sector. The company plans to enter the retail sector. The company may develop three new stores. The investment is likely to be part of sequential investments. The second phase of the investment is expected to be five times larger than the initial investment and can potentially result in the development of ten more stores. The company may expand into Turkey. The expansion plan to Turkey includes the development of five new stores. The investment is likely to be part of sequential investments. The company may develop six new stores and a wholesale centre. The development of six new stores is the second stage of the company's expansion in the apparel retail sector.

51. Sportsman S.A. is a representative and wholesaler of Chemise Lacoste and other branded products in the apparel industry. The company may proceed in an extensive plan that consists of acquisitions of similar companies, new representations and the development of its network of stores in Eastern and Central European countries. Possible entry in new Eastern and central European countries, formerly socialist countries, will be an important growth option. Besides, the acquisition of related companies is expected to strengthen the company's weak position in the Greek retail sector.

Others

52. Attica Enterprises S.A. owns modern ferries that serve routes in the Adrian Sea. The company may proceed with an investment to increase its fleet and considers expansion in the airline industry through acquisition of a local airline company.

53. Remec S.A. is a small factory in the area of pharmaceutical products. The company may sell a building to solve its liquidity problems.

54. Rilken S.A. is a small Greek company in the healthcare industry with a particular strong presence in the hair colour and mascara niche markets, due to the company's R&D team. Rilken may enter the highly promising Russian market. Also, Henkel, a multinational group in the healthcare sector, is considering acquiring Rilken S.A.

55. Thrace Plastics S.A. is a rapidly growing company in the plastics sector. The company may acquire a majority stake in Don & Low Ltd., a Scottish company that is ten times larger than Thrace Plastics S.A. Possible acquisition of Don & Low by Thrace Plastics will multiply the acquirer's sales and profits and will lead to considerable transfer of skills and know-how from the Scottish company to the acquirer.

56. Sarantis S.A. is leading company in the healthcare industry, holding 30% market share in Greece. Sarantis has an important presence in many other Balkan countries, including Bulgaria and Romania. It is likely in acquiring a company active in the pharmaceutical market. Sarantis S.A. is already active in the trading of pharmaceutical products, so the possible acquisition of Pharmacare will extend Sarantis' portfolio of products available in the market.

57. Lampsa S.A. owns the Hotel Grand Britannia in Athens. The company faces serious liquidity problems, but it may become an acquisition target. New management may be associated with a considerable cash inflow that will extend the company's life.

58. Sato S.A. is market leader in the area of office furniture. SATO's products are widely recognised in Greece for their quality. The company is planning to extend production capacity considerably. The considerable increase in production capacity requires an entirely new factory, since the area of current production facilities is subject to limitations. The development of a new factory requires considerable money resources and time. SATO may enter the home furniture market. There are hundreds of small companies active in the home furniture market. The possible entry of SATO in the market may require a heavy advertisement budget. The company may acquire 75% of Bo-Concept S.A., a company involved successfully in home furniture. The acquisition may be accompanied by considerable investments for the rapid development of 15 more stores for the needs of the expansion.

59. Jumbo S.A. is an importer, wholesaler and retailer of products for children. The company may invest in the development of new stores. The development of three new super-stores is the main subject of the investment plan. The company plans to expand to FYROM. An investment in FYROM gives an option to enter other nearby Balkan countries.

60. Nafpaktos Spinning Mills S.A. is a small company in the textile sector. The company may acquire a company that produces underwear. The company to be acquired, by 50%, is Helios S.A.. Helios holds 12% market share in the domestic market.

61. Selected Textiles S.A. is a medium-size modern textile factory. The company may proceed with an investment to increase production capacity.

APPENDIX D

INTRODUCTION TO THE ATHENS STOCK EXCHANGE

In this Appendix, we introduce Athens Stock Exchange and we examine previous studies in Athens Stock Exchange.

Legal Developments in Early Years

Stock market activities began unofficially in Greece in the latter half of the 19th century from Greek merchants and ship-owners that realised transactions with foreign currency and securities in unofficial markets in Athens.
The Athens Stock Exchange (ASE) is established in 1876 and the first legal framework, based on the French commercial code, is printed. The ASE began operating as an independent statutory public body. The existing regulatory framework is amended in 1909. In 1918 the ASE becomes Public Law Entity (Law 1308). The role and responsibilities of stockbrokers and intermediaries in general are clarified in 1928 (Law 3632). Existing requirements for listing of shares on the Athens Stock Exchange are designated in 1985 (Presidential Decree 350/24.05.1985). Also, during the same year the Presidential Decree 348/85 incorporated the Directive 80/390/EEC of the European Union in Greek Legislation and determined the kind and volume of information that must be included in Prospectuses regarding selling of securities to the broad investing public. In 1988 the legal framework of the Parallel Market and the Central Securities is settled (Law 1806) and Depository (CSD) is defined. In 1989 the legal and financial obligations of ASE members are designated (Ministerial decision 6280/B508).

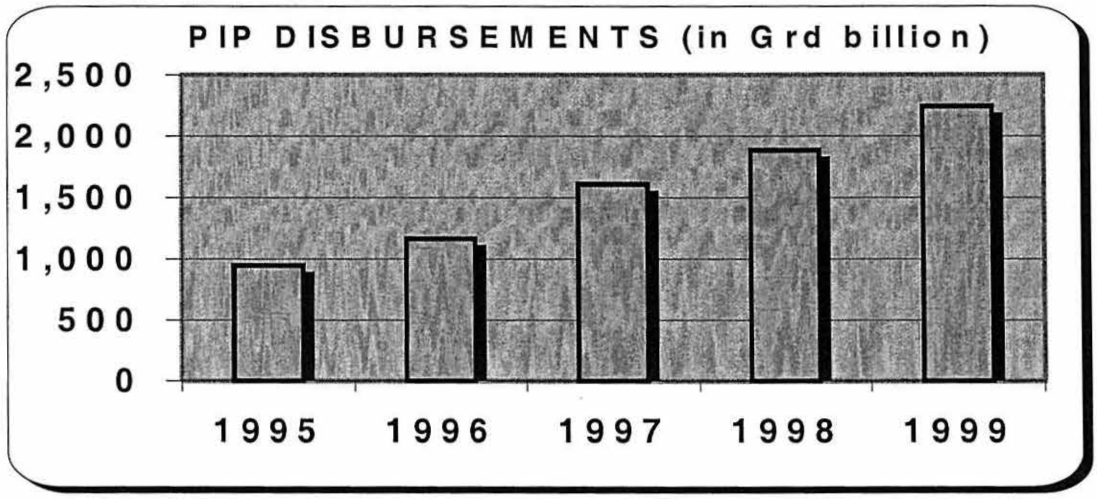
Legal Developments in the examined period (1990-1999)

In 1991 the Capital Market Commission is established as a supervisory authority, and the legal framework of Investment Companies and Mutual Funds Management Companies is set (Law 1969). In 1992, PD 51 defines that information that must be published on acquisition and assignment of significant participation in a company whose shares are listed on the ASE, in conformity with Directive 88/627/EEC. At the end of 1992,the Automatic System of Electronic Trading (ASIS) is put into full operation. In 1996 (Law 2328 (article 15)) all Construction Companies which undertake projects of the public sector exceeding GRD 1 billion, and Holding Companies which include shares of the above-mentioned companies in their portfolio, are under the obligation to register their shares at natural person level. In 1997 (Law 2533), the legal framework of privatisation of the Athens Stock Exchange is set. Three new markets –the Derivatives Market, The Greek Market of the Emerging Capital Markets (EAGAK) and the Market of Fixed Income Securities –are established. The Guarantee Fund of the Members of the ASE was restructured and the policy of shares loan was provided for. In 1998 listing requirements are set stricter, regarding the particulars on the Athens Stock Exchange (Law 2651). Stricter requirements regarding obligations of listed companies, shareholders, high-ranking executives, as well as securities companies, concerning supply of information relevant to issues of transparency are set in 1999 (Law 2744).

Political & Economic Developments in the examined period (1990-1999)

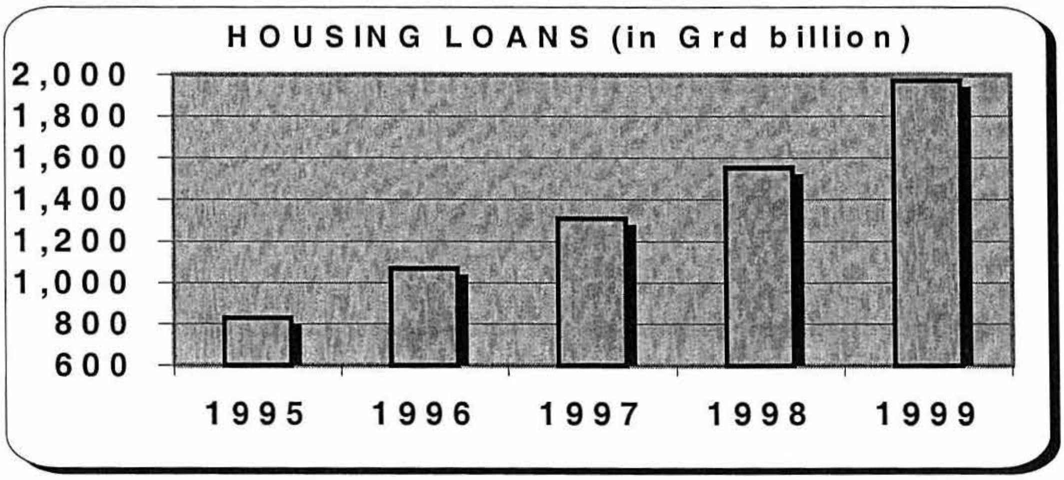
The election of a conservative government in July 1990 resulted in significant appreciation of most shares, due to speculation for privatisation of large state-owned companies. However, the opposition of labour union to government's plans and liquidity factors resulted in a rapid drop of share prices during the following 10 months. The socialists return to power in 1993 lead to an important appreciation of the share prices. The socialists are re-elected in June 1996. The new government follows a cautious deflationary policy. In addition, large EU-financed infrastructure projects were introduced at that time, leading in strong GDP growth. However, the collapse of the Greek textile company "Magrizos", in August 1996, and the related collapse of a brokerage house that was involved in share price manipulation made investors cautious in late 1996.

Public Infrastructure Projects Disbursements in Greece (1995-1999, in Grd billion)



A large restructuring of the banking sector takes place from 1996 to 1999. Bank privatisations, restructuring, repositioning of Greek banks from wholesale to retail banking, emerging of new banks and economic stability and deflationary policy resulted in lower interest rates and rapid growth of retail banking, including growth of housing loans, resulting eventually in high profit growth for the Greek banking sector and rapid appreciation of banking shares.

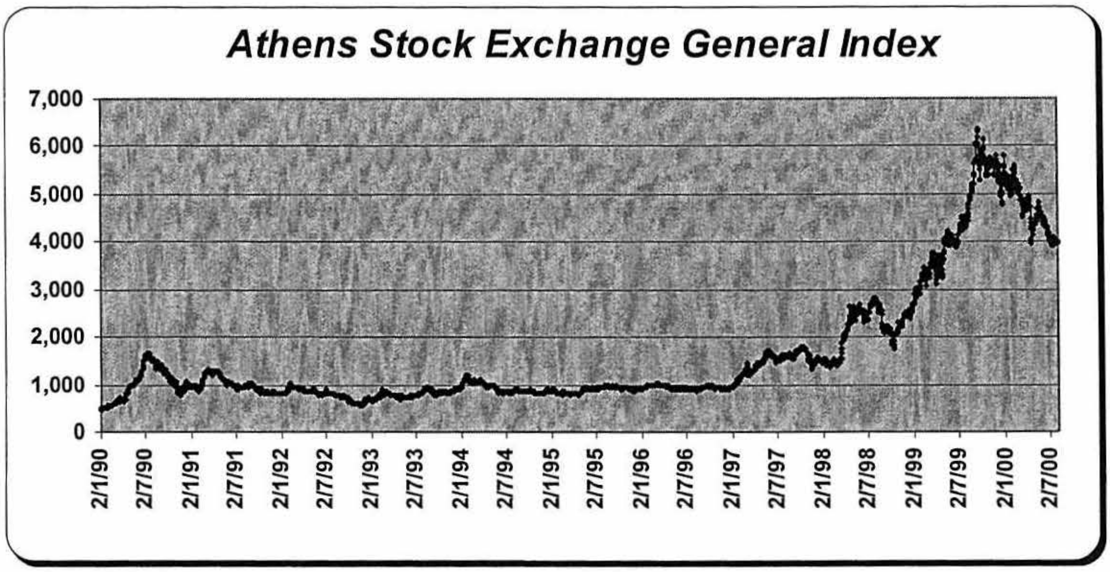
Housing Loans outstanding in Greece (1995-1999, in Grd billion)



The Russian crisis in August 1998 resulted in a general price index fall by eighteen percent in one week with bank shares hardest hit, shedding twenty three percent over the first week of crisis.

Whilst restructuring, economic growth and political stability resulted in the quadrupling of share prices from late 1996 to early 1999, the announcement of important deals gave increasing popularity in the Athens Stock Exchange in the following months.

The Athens Stock Exchange index (1990-2000)



Price appreciation, as well as important listings, including the listing of Hellenic Telecommunication Organisation (OTE) in 1998, resulted in the gradual increase of total market capitalisation of listed on the ASE companies.

A.S.E. Capitalisation & Relative Valuation indices

Year	Capitalisation	Earnings after taxes & minority Interest	Dividends	P/E	D.Y.
1991	2355	236.6	127.5	9.95	5.41%
1992	2044	180	89.1	11.36	4.36%
1993	3117	311.2	120.3	10.02	3.86%
1994	3577	347.2	171.4	10.30	4.79%
1995	4026	365.4	193.6	11.02	4.81%
1996	5944	494.4	249.9	12.02	4.20%
1997	9811	730.8	344.3	13.43	3.51%
1998	22838	899.7	448.5	25.38	1.96%
1999	67306	2081.8	658.1	32.33	0.98%

Source : Hellenic Capital Market Commision, Annual Guide-1999

The capitalisation of the Athens stock exchange reached 170% of GDP in December 1999.

Capitalisation of A.S.E. compared to GDP and M4N

Year	Capitalisation/GDP (%)	Capitalisation/M4N (%)
1991	14.5	17.4
1992	10.9	12.7
1993	14.7	16.8
1994	14.9	16.9
1995	14.9	17.6
1996	20	23.2
1997	31.7	38.9
1998	64.3	93.1
1999	169.4	187.8

Source : Hellenic Capital Market Commision, Annual Guide-1999

Nearly Grd 1,410bn was raised through capital issues and Grd 4.370bn was raised through capital increases during the examined period.

New Listings and Capital Increases in A.S.E. (1995-1999)

Year	Number of new listings	Money raised through capital issues*	Number of capital increases	Money raised through capital increases*
1991	14	54.34	N/A	96.55
1992	5	0.41	N/A	30.82
1993	10	20.78	N/A	80.19
1994	46	98.72	N/A	164.27
1995	20	23.85	N/A	64.44
1996	19	111.63	14	44.46
1997	13	20.09	39	502.72
1998	24	394.33	49	483.47
1999	42	627.77	119	2769.6

**In Grd billion. Source : Hellenic Capital Market Commision, Annual Guide-1999, ASE fact book 2000.*

A comparison of Athens Stock Exchange with other stock exchanges is provided in the following table.

Comparison of Athens Stock Exchange to other financial markets (November 1999)

Stock Exchange	Market Value (in USD billions)	Transaction value (in USD billions)	Capitalisation of Stock Exchange / GDP (%)	Transaction Value / GDP (%)	Number of Listed Companies
Athens	216	21.7	168	19.4	251
LSE	2,774	334	222	26.8	2,788
Frankfurt	1,229	155	62	7.9	8,798
Paris	1,304	277	98	5.7	1,150
Zurich	661	46.3	N/A	N/A	420
Amsterdam	617	48.7	173	13.7	N/A
Milan	610	50.9	56	4.7	270
Madrid	389	62.7	74	12	658
Stockholm	318	36.6	158	18.1	304
Brussels	178	5.45	77	2.3	275
Vienna	31.3	0.77	16	0.4	113
NYSE	10,787	775	147	10.6	2,606
NASDAQ	4,226	942	58	12.8	4,844
Tokyo	4,244	241	131	7.4	1,913
Hong Kong	536	28.4	N/A	N/A	700

Source : Hellenic Capital Market Commission, Annual Guide-1999

Studies in the Athens Stock Exchange

Studies made in the Athens Stock Exchange in different time periods, during the last thirty years, do not provide support for the strong form of EMH. However, these studies provide generally supportive results over the existence of the semi-strong version of the Efficient Market Hypothesis in the Athens Stock Exchange.

Stengos and Panas (1992) provide support for the existence of both weak and semi-strong form of efficiency in the Athens Stock Exchange. Stavrinos and Sitara (1997) provide support for the weak form of EMH for stocks from the banking sector. Similar results were derived by Karathannasis and Patsos (1992) who investigated market efficiency and did not find serial correlation among share prices and partly by Dockery and Kavussanos (1997) who do not reject the random walk hypothesis for stock prices when the examined sample includes up to 30 stocks, while the random walk hypothesis is rejected for larger samples.

Glezakos(1997) and Stavrinos and Sitara (1997) don't provide support for the joint hypothesis of EMH and CAPM. In particular, Glezakos (1997) concludes that systematic risk although significant, is not the only priced factor since firm-specific factors affect also market returns.

To conclude, most studies made in the Athens Stock Exchange seem to support the semi-strong version of the Efficient Market Hypothesis, indicating also that not only BETA but also other fundamental factors affect market returns.

A review of past studies in market efficiency on the ASE is provided in the following table.

Review of efficiency studies on the Athens Stock Exchange

Paper	Examined period	Examined sample	Subject	Conclusion
Stengos and Panas (1992)	January 1985 to October 1988	Four widely traded selected stocks from the banking sector	Efficient market hypothesis in the Athens Stock Exchange	The evidence provides support for the existence of both weak and semi-strong form of efficiency in the Athens Stock Exchange.
Glezakos(1997)	1973-1981		Investigation of joint hypothesis of market efficiency and CAPM validity	Company size seems to affect seriously the returns only within the framework of high earnings yield securities
Karathanassis and Patsos (1997)	1986-1990		Market Efficiency	Serial correlation was not evident. The functional forms derived from Dimpson(1979) type models explain better the behaviour of most stocks than the simple market model.
Stavrinos and Sitara (1997)	January 1989 to September 1993		Efficient Market hypothesis and causality	The study provides support for the weak form of EMH for stocks from the banking sector.
Dockery and Kavussanos (1997)	February 1988 through October 1994	73 out of 150 possible companies quoted on the ASE (only frequently traded securities were included).	Empirical Investigation of stock price efficiency of the Athens Stock Exchange	Statistics reject the random walk hypothesis for stock prices (which is a necessary condition for market efficiency), when the sample includes at least 40 stocks. However, the random walk hypothesis is not rejected for smaller samples.