THE EFFICIENCY OF THE SOUTH AFRICAN MARKET FOR RIGHTS ISSUES : AN APPLICATION OF THE BLACK-SCHOLES MODEL

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DECLARATION

I declare that, except where indicated in the dissertation, this research is my own work. It has not been submitted before for any other degree at this or any other University.

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I would like to express my eternal gratitude to my sister for her knowledge of mathematics and programming. Without her input, this piece of research would have remained a mere pipe-dream.

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1 INTRODUCTION

Companies raise funds in three broad ways ; internally generated funds, external debt and external equity funding. An important method of raising external equity funding is by means of a rights issue. A rights issue is an issue to all existing shareholders of the right to buy shares in the company on a pro rata basis at a discount to the current share price [Johannesburg Stock Exchange ("JSE") Listing Requirements, Practice Note viii, 1994].

The South African Companies Act [1973] does not prescribe by which methods a company can raise equity. However, the Johannesburg Stock Exchange requires that listed companies make provision in their articles of association that unissued shares can only be offered to existing shareholders by way of a rights issue [JSE Listing Requirements, Practice Note v., 1994]. As a result of this restriction, most equity issues are by way of a rights issue [Youlds, Firer and Ward, 1993]. The significance of the South African market for rights issues is demonstrated by the amount raised in these issues. For example, R7.263b was raised in 1993, R7.901b in 1992, and R6.530b in 1991 [JSE Handbooks, 1991 - 1993] (these figures represent rights issues of all types of instruments).

Capital market efficiency is an important aspect of modern financial theory. This is because in an efficient capital market, scarce resources are optimally allocated to productive investments in a way that is beneficial to market participants. Yet there appears to be a dearth of research into the market efficiency of rights issues in South Africa, despite the fact that the majority of equity issues on the JSE are via a rights issue. The problem is that if the market is inefficient it is failing in its role of being an efficient allocator of scarce resources.

The objective of this study is to establish whether the South African market for rights issues is efficient.

The format of the study is as follows :

- Chapter 2 presents a review of the main literature pertinent to a study of the efficiency of a rights issue market. This review covers topics such as the efficiency of markets, and the robustness of option valuation models.

- Chapter 3 presents a theoretical background to the research. It places the research in the context of a conceptual base. Topics covered include introductions to options, rights and market efficiency, and the definition of option and rights valuation models.

- Chapter 4 presents the research methodology. It discusses how the research was undertaken; for example, how variables input into the valuation models were measured, how the computer programs were written, and how the results were statistically interpreted.

- Chapter 5 details the criteria for selecting the final sample and also presents the final sample.

- Chapter 6 discusses the results of the empirical study.

- Chapter 7 summarises the findings of the study and draws conclusions on the efficiency of the South African rights market.

2 LITERATURE REVIEW

The literature review presents the main literature pertinent to a study of the efficiency of a rights issue market under appropriate headings. Under each heading the literature is presented in chronological order as many authors make reference to earlier studies. Thus the review has not been presented in order of relevance to the research. The review is presented under the following headings :

- The Robustness of Option-Like Warrant Valuation - since this research uses an option-like warrant valuation method to value rights/Nil Paid Letters ("NPLs"), it is critical to establish the robustness of this method.

- The Robustness of the Black-Scholes ("B-S") Model - the method of valuation used in this research is a dilution adjusted B-S model. Thus it is important to review the literature on this model to establish its robustness.

- Historical Standard Deviation ("HSD") v Implied Standard Deviation ("ISD") - a key input into the B-S model is the standard deviation of the underlying share price. As both measures are used in this research when valuing NPLs, the literature on this subject was reviewed in order to establish the empirical robustness of each measure.

- The Efficiency of the JSE - much has been written about the efficiency of the JSE. The rights market is simply a derivative market of the underlying spot market. Due to the impact of the underlying spot market's efficiency on the rights market efficiency, it is important to be able to classify the spot market as exhibiting the characteristics of one of the forms of market efficiency.

- The Impact of Rights Issue Announcements on Share Prices - since the spot price of the underlying equity is a key input into the B-S model formula, it has an impact on the model NPL value. Thus it is important to understand from the literature on the subject what effect the announcement of a rights issue has on the underlying share price.

- The Efficiency of International Rights Markets - it is important to have an international perspective on rights market efficiency as this gives insight into the efficiency of the South African market. The literature from various other countries on rights market efficiency is thus reviewed.

- Factors Effecting Rights Prices on the JSE - as with any traded instrument, certain factors affect the pricing of NPLs on the JSE. The literature on this subject is thus reviewed to extract these factors.

2.1 The Robustness of Option-Like Warrant Valuation

A warrant is similar to a right - however, the offer period is usually measured in months or years rather than days. Warrants are common in the United States, Japan and Europe. A thorough search of the literature on this subject (by utilising, for example, databases, literature scan, indices, bibliographies) revealed one relevant paper, namely Schulz and Trautmann [1994] who studied two aspects of warrant valuation :

- how the presence of warrants in the capital structure affects the applicability of the B-S formula, where a call option or warrant is valued relative to its underlying stock,

- the robustness of option-like warrant valuation.

In addressing the first aspect they concluded that option-like warrant valuation is very precise if :

- the potential dilution of the equity is anticipated in the current stock price,

- the warrant to be valued is in-the-money (the current market price of the underlying security is greater than the exercise price of the warrant),

- sequential exercise of American-type warrants is not optimal (the warrant cannot be exercised before the expiration date - this makes the warrant European in nature).

They also found that stock volatility is most sensitive to changes in the stock price when the outstanding warrants are near maturity and at-the-money. Another important finding in their study is that the bias from option-like warrant valuation is small even for extreme potential dilution since according to their warrant valuation model potential equity dilution is already anticipated in the current stock price (they also assume that the equity volatility is constant over the life of the warrant). They concluded that to obtain warrant values with acceptable accuracy, adjustments to the B-S formula are not needed except perhaps for deep out-of-the-money warrants; this holds especially true where, in a more realistic scenario, the potential dilution is not severe.

In addressing the second aspect, Schulz and Trautmann [1994] studied 50,960 daily market prices for 37 warrants written on 16 German stocks listed on the Frankfurt Securities Exchange during the period 1 January 1979 to 30 December 1990. They used the American constant variance ("CV") diffusion model instead of the B-S model (in order to allow for large dividends and early exercise). They concluded that their results support the empirical robustness of option-like warrant valuation.

2.2 The Robustness of the Black-Scholes Model

An important problem that has an implication to researchers of the B-S model is that empirical tests of the model are joint tests of market efficiency and the validity of the model. If one is empirically testing the null hypothesis that the B-S theoretical prices exhibit no systematic differences, the null hypothesis can be rejected for any one of three reasons [Copeland & Weston, 1988] :

- inputs to the B-S model have been incorrectly measured, or
- the options market is inefficient, or
- the mathematical structure of the B-S model is incorrect.

Thus the literature presented below will draw conclusions either on the validity of the B-S model or market efficiency or both.

The earliest empirical work on the B-S model was done by Black and Scholes themselves [1972, 1973]. They used price data from the over-the-counter options market for contracts written on 545 securities between 1966 and 1969. They used the option pricing model ("OPM") to generate the expected prices of each option on each trading day. By comparing the model prices with the actual prices, options were classified as "overvalued" or "undervalued". For each option bought (sold) if undervalued (overvalued), a perfectly risk free hedge portfolio was formed by selling (or buying) shares in the underlying stock. The option position was maintained throughout the life of the option. The risk-free hedge was adjusted daily by selling or buying shares of stock in order to maintain the risk free hedge. At the end of each day, the hedged position was assumed to be liquidated so that the daily dollar return could be calculated. The option position was immediately re-established and a new hedge position established. Their results showed that in the absence of transaction costs :

- buying undervalued options and selling overvalued options at model prices produced average profits which were not significant (using *ex post* estimates of actual variances of returns on the underlying stock over the holding period), and

- buying undervalued options and selling overvalued options at model prices produced significant negative excess portfolio returns (using *ex ante* estimates of actual variances of returns on the underlying stock from past stock price histories). When they repeated the procedure using market prices (instead of model prices) substantial positive excess returns were generated. When transaction costs were taken into account, the profit opportunities vanished. Black and Scholes concluded that there is no incentive for market participants to eliminate the discrepancies in the option prices.

Using data from the Chicago Board of Options Exchange ("CBOE") for each option traded between 26 April 1973 and 30 November 1973, Galai [1977] extended the procedure that Black and Scholes had used by adjusting the option position each day. Undervalued options were bought and overvalued options were sold at the end of each day. In addition, the hedged position was maintained by buying or selling the appropriate number of shares of common stock. The significant results of the test were :

- using *ex post* hedge returns (using closing prices to determine whether the option is over- or undervalued), trading strategies (with no transaction costs) that were based on the B-S model earned significant excess returns,

- given 1% transaction costs, the excess returns vanished,

- the results were robust to changes in parameters such as the risk free rate or instantaneous variance,

- the results were sensitive to dividend adjustments,

- adjustments to the model led to worse performance.

Using CBOE daily closing prices from 31 December 1975 to 31 December 1976 for all call options listed for six major companies, Macbeth and Merville [1979] tested the B-S model to see whether or not it over- or underprices options. Using the same set of data, they also tested the B-S model against an alternative constant elasticity of variance ("CEV") model [1980].

In their earlier paper, Macbeth and Merville [1979] estimated the implied standard deviation of the rate of return for the underlying common stock by employing the B-S model. By assuming that the B-S model correctly prices at-the-money options with at least 90 days to expiration, they then estimated the percent deviation of actual observed call prices from B-S model call prices. They concluded that :

- the B-S model predicts prices that are on average less (greater) than market prices for in-the-money (out-of-the-money) options,

- with the exception of out-of-the-money options with less than ninety days to expiration, the extent to which the B-S model underprices (overprices) an in-the-money (out-of-the-money) option increases with the extent to which the option is in-the-money (out-of-the-money), and decreases as the time to expiration decreases,

- the B-S model prices of out-of-the-money options with less than ninety days to expiration, are, on average, greater than market prices; but there does not appear to be any consistent relationship between the extent to which these options are overpriced by the B-S model and the degree to which these options are out-of-the-money or the time to expiration.

The second Macbeth and Merville paper [1980] compared the B-S model against the CEV model. The primary difference between the two models is that the B-S assumes that the variance of returns on the underlying asset remains constant, whereas the CEV model assumes the variance changes when the stock price changes. The CEV model thus includes the B-S model as a special case. They concluded that the CEV model, for most options tested, more accurately approximates market prices that the B-S model. However, the CEV is mathematically more complex and requires the estimation of two variables, rather than the one required by the B-S model (the variance of the underlying stock returns).

Le Plastrier, Thomas and Affleck-Graves [1986] studied the share and gilt options market in South Africa and tested the applicability of the B-S model to selected warrants and gilts. The following options were selected by the authors for testing the applicability of the B-S model to value warrants : AMIC, East Daggafontein, ERPM and Western Deep. The study showed that for all the warrants except the Western Deep Levels options the error between the actual and calculated value was significantly different from zero. Le Plastrier et al [1986] drew the following conclusions from the study :

- the uncertainty of the calculated value of any particular option is high even though the model may on average give good results,

- the correction for dilution is usually small and has a relatively small effect on the valuation of the option - this is due to the fact that in the sample tested the number of warrants was small relative to the number of shares in issue,

- for warrants on shares paying dividends it is essential to include a dividend correction, otherwise the warrant will be considerably overvalued by the B-S model,

- the most reliable volatility measurement to use for warrants was based on 26 weeks of weekly share price data.

The authors' overall conclusion is that the B-S model can be used to value both warrants and gilt options, provided the necessary adjustments are made for dividends and the dilution effect.

Kremer and Roenfeldt [1993] tested the robustness of the B-S model for pricing warrants. They also used another option pricing model, the jump-diffusion ("J-D") model, to test the pricing of warrants. The data used comprised 75 warrants from 71 companies during the period January 1981 to August 1985. Their findings were as follows :

- the J-D model was the most efficient model only for a subset of warrants (for warrants with less than one year maturity),

- large reductions in bias accompanied by relatively minor losses in efficiency indicate that the J-D model probably should be considered when valuing out-of-the-money, noncallable warrants with maturities in excess of one year, or warrants with underlying stocks exhibiting an historically large jump impact,

- empirical results indicate that the B-S model almost uniformly provides more efficient estimates of market value.

The literature review presented above supports the use of the B-S model in predicting market values for both options and warrants. The Black and Scholes [1972, 1973], Galai [1977], Le Plastrier et al [1986], and Kremer and Roenfeldt [1993] studies outlined above indicate the robustness of the B-S model as an accurate predictor of option value. This conclusion is extremely important and relevant to the research as it establishes a theoretical base for the use of the B-S model in this paper.

2.3 Historical Standard Deviation v Implied Standard Deviation

A thorough search of the literature on this subject (utilising the same sources as discussed in section 2.1) revealed one relevant paper, namely Chiras and Manaster [1978]. In this paper the authors tested 23 monthly observations of option prices on the CBOE for the period June 1973 to April 1975. Their null hypothesis tested was that the standard deviations inferred from option prices have been better predictors of standard deviations of future stock returns than standard deviations obtained from historic stock returns. They used a dividend adjusted B-S model to calculate the ISD. Their findings were that during the first nine months of the study, the ISD's and HSD's were both relatively poor estimates of future standard deviations ("FSD"). However, during the last fourteen months of the study, the ISD's were the superior predictors of FSD's.

The authors concluded that ISD's are substantially better predictors of FSD's than HSD's. However, for this research, both HSD's and ISD's are used as the evidence is not sufficiently substantial to exclude the HSD in favour of the ISD.

2.4 The Efficiency of the Johannesburg Stock Exchange

Several research studies have examined and tested the efficiency of the JSE. Gilbertson and Roux [1977] found that for the period 30 June 1973 to 30 September 1976, the South African mutual funds earned on average 1.6% per annum (compounded continuously) less than they should have earned given their level of systematic risk. In addition, they found that no individual fund was able to consistently outperform another or to significantly outperform the market. They concluded that these findings were consistent with the Efficient Market Hypothesis ("EMH"). Their overall conclusion was that there is persuasive support for the view that the JSE is an efficient capital market.

Strebel [1977] argued that the tests for market efficiency are only applicable to highly traded shares. The trading volume of many shares on the JSE are so low that their market risk becomes volume dependent and the ex-post Capital Asset Pricing Model ("CAPM") loses its validity as a framework of market equilibrium; consequently, the usual tests of market efficiency are rendered useless. The evidence of longer runs, higher returns and marketability, at low volumes suggests that the competitive market assumption, required for the EMH, cannot be supported. He found that there is evidence of efficiency in the highly traded shares on the JSE. Strebel concluded that at best, the EMH only applies to half of the shares traded on the JSE, namely those with average annual trading volumes exceeding at least 250,000.

Knight and Affleck-Graves [1983] empirically tested the JSE's reaction to a change in the accounting policy of companies from accounting for stock on a FIFO (first-in-first-out) basis to a LIFO (last-in-first out) basis. The LIFO basis has the effect of depressing the value of end-period inventory and understating earnings in inflationary times. This is the converse of the FIFO approach. The authors tested the semi-strong form of the EMH by examining the length of time it takes the JSE to adjust to the information content implied by the change from FIFO to LIFO. The study tested 21 quoted companies which employed LIFO at 14 November 1980, for the period 18 July 1969 to 14 November 1980. The results showed that the market reacted sluggishly to the accounting numbers rather than the economic message inherent to a change to LIFO. The conclusions of the study are as follows :

- the efficient market hypothesis is not valid for the JSE,
- the evidence is that a change to LIFO has a negative impact on share returns directly proportional to the negative impact on earnings [Knight & Affleck-Graves, 1983].

Knight, Affleck-Graves and Hamman [1985] extended the Knight & Affleck-Graves [1983] study to include 19 "flip-flop" companies as a control group in their cumulative abnormal return ("CAR") procedures. Since companies in South Africa are taxed at a company rather than at a group level, subsidiaries could report on a LIFO basis while the holding company reported on a FIFO basis. If the holding company was a listed company then the subsidiaries could enjoy the tax benefits of LIFO while the holding company, by reversing the LIFO effect on consolidation, reported the higher earning figure. This practice is called "flip-flopping". The use of the LIFO basis is no longer allowed for tax purposes [1984 amendment to section 22(5) of the Income Tax Act No. 58 of 1962] or for accounting purposes [Exposure Draft 94, "Inventories", The South African Institute of Chartered Accountants, 1994]. The results of the research confirmed the earlier findings that the change to LIFO has a negative impact on share price in the short term. The authors provide three possible explanations for this observation :

- the market may be inefficient in an information absorption sense in that, given a signal of economic benefit, it reacts in the direction of the accounting number which has little or no economic meaning and which is counter to the true economic benefit,

- the market may be efficient and the downward reaction may be due to a self-selection bias (in other words, the "flip-flop" companies may represent a completely different subset of companies to the LIFO companies and, hence, the negative reaction in the LIFO change companies might be due to some other unknown factor),

- the changes in accounting policy (although merely book entries) may provide new information to the market on management's expectations.

Bhana [1989] performed an empirical analysis on price adjustments on the JSE for unexpected and dramatic news events for the period 1970 to 1984. The evidence suggests that in the short-term the JSE's reaction to extreme unexpected financial events is determined by whether the event is positive or negative. Bhana [1989] found that :

- for negative events, the overreaction resulting in extreme movements in share prices is followed by the JSE generating significant corrections up to one year following the event and then adjusting prices in a random manner, and

- the JSE does not show a long term tendency to overreact to news of a favourable nature. He concluded that the market inefficiency associated with the overreaction to company-specific negative news suggests that the market can be outperformed by an astute investor following appropriate investment strategies.

Bhana [1990] studied the performance of secondary share recommendations published in the news media and the effects on the efficiency of the JSE. A secondary share recommendation is the release to the general public (for example, publication in popular newspapers) of the share recommendations that were earlier released to the clients of investment advisory services (for example, stockbrokers). The hypothesis tested was that the publication of analysts' recommendations in newspapers was expected to increase market efficiency by making new information available to a larger group of investors. It was found that share prices do adjust to analysts' recommendations. However, buy or sell recommendations released to a small group of investors are not immediately and fully reflected in the share price. Instead it was found that the subsequent dissemination of the information in newspapers has a significant impact on the market price. Bhana's conclusion is that the findings are not necessarily a contradiction of an efficient market. Indeed the publication of analysts' recommendations in newspapers make the market more efficient by passing on new information to a large group of investors.

Bhana [1993] tested the efficiency of the JSE by examining the effects of selected trading strategies on the value of closed-end investment trusts. He found that the buy-and-sell points strategy (the method used for testing market efficiency) produced returns substantially in excess of those obtainable either by holding the market portfolio (JSE overall index) or by following a buy-and-hold strategy with closed-end investment funds. An investor could have achieved superior performance by concentrating on specialized funds. The author's conclusion is that the results of the study generally fail to support the semi-strong form of the EMH.

Philpott and Firer [1994] studied share price anomalies and the efficiency of the JSE. Two hypothesis were tested :

- the JSE is efficient in the semi-strong form for all listed shares, and

- the JSE is efficient in the semi-strong form for many, but not all listed shares.

A share price anomaly occurs where there is a significant deviation from the theoretical relationship between two related shares. The extent and magnitude of these share price anomalies were used in the study to test for market efficiency. The findings were that share price anomalies of a magnitude larger than the direct transaction cost of switching from one share to another were detected in 56 out of 60 pairs of closely related shares tested. Non-isolated anomalies (in other words, where inefficiencies are not limited to shares with particular characteristics) were detected for 49 of these pairs. The authors find that the results of the research conclusively prove that the occurrence of share price anomalies between related shares on the JSE is widespread. Their conclusion is that the JSE is not an efficient market, although there may well be "pockets of efficiency", since no price anomalies were found for certain pairs of shares.

Bhana [1995] studied the efficiency of the JSE to determine whether companies listed on the JSE overreacted to the arrival of unanticipated information during the period 1975 to 1992. In the paper, Bhana [1995] tested a modified version of the EMH called the Uncertain Information Hypothesis ("UIH") in order to explain the response of rational, risk averse investors to financially dramatic news. The UIH is based on the assumption that, because of the increased uncertainty and thus greater risk associated with unanticipated events, investors immediately discount the value of the company below the expected value of the company's shares. This discount on the shares then gradually disappears, along with the uncertainty that gave rise to it. Bhana [1995] found that the short term behaviour on the JSE for unexpected news events indicated rational judgement by investors. He concluded that the JSE appears to react to uncertain information in an efficient, if not instantaneous manner.

The literature review presented above shows the wide ranging views on the JSE as an efficient market. Certain authors support the JSE as an efficient market in the semi-strong form, others limit the efficiency according to certain criteria (for example, highly traded shares) and others reject the JSE as an efficient market and assert that the EMH is not valid for the JSE.

2.5 The Impact of Rights Issue Announcements on Share Prices

White and Lusztig [1980] performed an empirical analysis on the price effects of rights offerings in the USA by testing a sample of 90 suitable rights for which the offer announcement was made between the period 2 July 1962 and 29 December 1972. The technique used to test the effect of the rights offer announcement on share price was to study the significance of the effect of market-wide and other firm-specific events on, or near to, the announcement date on market prices. The empirical results support the hypothesis that there is a significant drop in the share price associated with the announcement of a rights offering. The following possible reasons for the drop in price are offered by the authors :

- dilution in earnings per share. This would, however, constitute a market imperfection,
- the drop in share price represents the present value of the significant flotation costs associated with rights offerings,
- rights offerings made by firms are often subject to regulations which might effect the functioning of the offering (see section 3.4 below for the regulations regarding rights issues).

Lambrechts and Mostert [1980] analyzed the behaviour of market prices on the JSE during rights issues. The authors analyzed the rights issued by about one hundred listed companies during the period 1969 and 1974. The authors found that there is no definite evidence that the announcement of a rights issue *per se* has a favourable influence on market prices of shares; furthermore, no important difference between the results obtained during the upward and downward phases of the business cycle were obtained. In the study, a classification was made per rights issue of the difference between the changes in the market prices of existing shares during the ex rights period (period during which NPLs are listed and traded on the stock exchange) and the changes in the market prices of NPLs during the same period (expressed as a percentage of the market prices of the NPL just after the last date to register ("LDR")). If positive results were obtained it would indicate that only part of the changes in the market prices of the existing shares is reflected in the market prices of the NPLs. In the case of a negative result, the change in the market price of the NPL is higher than the change in the market price of the existing share and it could be concluded that other factors influence the market prices of NPLs. In the majority of cases, negative results were obtained; during upward phases of the business cycle about 55% of the cases yielded negative results while in downward phases this figure amounted to about 73%, giving a weighted average of 62%. This result, however, is not according to expectations as theoretically the change in share prices should result in a greater change in the prices of the NPLs, i.e. a leverage effect. Possible reasons offered by the authors for the confusing results include problems with averaging across companies which have different trends, time lags, and seasonal and accidental factors.

Youds, Firer and Ward [1993] used the event study method of analysis to examine the impact of rights issue announcements on share prices of companies listed under the Financial and Industrial sectors of the JSE for the period 1986 to 1992. Three theories on expected price reaction to the announcement of equity issues are detailed in the paper :

- the capital structure hypotheses are based on the net effect of the issue on the firm's debt : equity ratio. According to Modigliani and Miller's theories, a new equity issue will be unfavourably received by the market as it lowers the firms debt : equity ratio and consequently lowers the value of the firm. However, if a firms's debt level is currently so high that it starts to reduce the value of the firm then an equity issue should have a positive effect [Modigliani & Miller, 1958],

- the information theories explain the share price reaction as being related to the asymmetry of information which exists between the management of and investors in a company. The decision by management to issue equity can be seen as a negative signal regarding the future cashflows of the company, or can be seen as a negative signal that management regard the shares as being overpriced. Thus in both cases, the share price would be expected to fall on the announcement of an equity issue (the negative impact could be reduced if management have large equity holdings in the company),

- the application of funds theory states that the price effects of an equity issue announcement will be moderated or exaggerated by the intended use to which the funds raised will be put (for example, it could be expected that raising equity for recapitalization of a business could have a greater negative price effect than for those companies which use the funds to finance investments).

The authors also draw inferences on the efficiency of the market by stating that in an efficient market (semi-strong form) any price reaction to the announcement of a rights issue should take place immediately the issue is first announced. From the results obtained in the study the authors conclude that :

- there is a statistically significant price drop of approximately 2% on average upon the announcement of a rights issue (the price effect was measured as the difference between the risk adjusted return on the shares and the return on the Financial and Industrial Index),

- the negative price effect was observed on the day immediately prior to the first announcement of the rights issue, thus supporting evidence of an efficient market,

- none of the tests conducted on the three theories outlined above gave results which were statistically significant. Thus it is not possible to use any of these theories to explain the effect on share price of a rights issue announcement.

The theory and empirical evidence presented above indicates that a negative price reaction may be expected on the announcement of an equity issue. Certain possible reasons are offered by the authors for this negative reaction. The negative reaction is not prolonged and takes place on and immediately around the announcement date. Thus there should be little impact of the announcement on share prices during the listing period of the NPLs. This conclusion is important as the share price is a key input variable into the B-S model.

2.6 The Efficiency of International Rights Markets

Marsh [1979] performed an empirical study on equity rights issues and the efficiency of the United Kingdom ("UK") stock market. At the time when the study was done, quoted companies in the UK and most other European countries raised virtually all their new equity capital via the rights issue method [Marsh, 1979] - the reason is due to the stock exchange regulations similar to those currently enforced by the JSE. Two hypotheses were used to test the semi-strong form of market efficiency with respect to the announcement of rights issues :

- price pressure hypothesis : a rights issue, because it increases the supply of a company's shares, will have a depressing effect on the company's share price. This hypothesis implies market inefficiency as the increase in the number of shares is represented by an increase in the value of the company (cash paid by shareholders for their new shares). Since most issues of new shares take place at a slight discount to the existing shares, there should only be a negligible effect on the value (and thus price) per share,

- substitution hypothesis : unless the company's rights issue is large relative to the total supply of risky assets, its effect on the share price should be negligible as the demand curve for a company's shares is perfectly elastic (thus increases in the supply of company shares alone will not lead to a fall in the share price). This hypothesis implies market efficiency.

Marsh [1979] studied 254 rights issues made by companies listed on the London Stock Exchange ("LSE") for the period July 1962 to December 1975. The author came to the following conclusions :

- the results do not indicate evidence of significant market inefficiencies associated with rights issues,

- the hypothesis that the UK market is efficient with respect to rights issue announcements cannot be rejected,

- the LSE appears to be a highly liquid market.

Berglund and Wahlroos [1985] studied the efficiency of the Finnish market for rights issues by applying the B-S model. The study used weekly data from the Helsinki Stock Exchange ("HSE") to analyze 32 rights issues during the period 1 September 1977 to 1 October 1981. The authors use two methodologies to study market efficiency :

- buy-and-hold strategy : investment strategy whereby rights and underlying shares are either bought long or sold short (depending on the actual value of the rights relative to the B-S model price) in the opening week of the rights issue, and that position is maintained through to maturity. The number of shares held long or short against the rights could, however, be adjusted as market conditions changed. At maturity the position was closed by either selling or exercising the option,

- buy-and-sell strategy : investment strategy whereby rights and underlying shares are either bought long or sold short on a regular weekly basis (depending on the actual value of the rights relative to the B-S model price) - i.e. arbitrage positions taken. Weekly positions are regarded as arbitrage positions as on the HSE there are long lags in the execution of buy and sell orders.

For the buy-and-hold strategy, significant positive excess returns were recorded, before transactions costs. When transaction costs were deducted, no significant excess returns could be attained. For the buy-and-sell strategy, negative excess returns were recorded which were not significant, before transactions costs. When transaction costs were deducted, significant negative excess returns could be attained. Berglund and Wahlroos [1985] could not detect any evidence of significant departures from market efficiency.

In a recent analysis of the efficiency of the Finnish market for rights issues, Hietala [1994] studied 34 rights issues and 36 stock splits by companies listed on the HSE for the period 1977 to 1981. Securities on the HSE can be divided into three categories : debts issues, stocks, and rights. No options market exists in Finland for individual shares. The rights market on the HSE is similar to that of the JSE - for example, Finnish companies and South African companies raise the majority of their new capital by rights issues, the rights are publicly traded on the HSE and JSE during their valid period, and Finnish and South African rights are issued in-the-money. Hietala [1994] used the boundary conditions methodology to test for market efficiency - this approach sets up theoretical pricing boundary conditions and tests to see how often the actual observed prices pierce these boundaries. Using *ex post* tests, Hietala [1994] tested whether the right and stock market on the HSE are synchronous and informationally efficient. He rejected this joint hypothesis as more than half the observations of rights and stock splits violated the boundary conditions; the violations also persisted for long periods. Using *ex ante* tests, Hietala [1994] showed that "normal" investors cannot exploit the inefficiencies in the market. This is due to transaction costs and the fact that short selling is not permitted on the HSE. The potential also exists for stockbrokers, due to their ability to trade in instruments and avoid transaction costs, to earn arbitrage profits; however, it could not be established whether stockbrokers could earn arbitrage profits as the market is thinly traded. Hietala concluded that the market for Finnish rights was not informationally efficient during the years 1977 to 1981.

2.7 Factors Effecting Rights Prices on the JSE

Bhana [1988] tested a sample of rights traded on the JSE to establish whether shareholders should sell rights early, and to establish what factors affect the prices of rights. The traditional view described by Bhana [1988] is that rights will reach their maximum price shortly after the start of trading and will then decrease until the end of the subscription period. The reason is that shareholders hold onto their rights immediately after listing in order see how the market reacts to the rights issue. This creates a shortage of rights which increases the rights price relative to its theoretical value. As the listing period draws to a close, shareholders flood the market with rights they do not intend to exercise. The argument against this is that arbitrage will not persist and that, in an efficient market, the actual price of the rights will return to its theoretical value.

Bhana [1988] studied 50 companies whose rights were traded on the JSE during the 36 month period 1 July 1984 to 30 June 1987. The listing period was divided into three equal periods : the first, middle and final periods. The study showed that 32% of rights peaked in price in the first period, 16% in the second period, 34% in the third period, and 18% peaked in more than one period. The author concluded that the traditional view of selling rights early due to higher prices was not supported by the evidence on the JSE.

Bhana [1988] further regressed the sample of rights prices changes (dependent variable) against changes in the JSE overall actuaries index, changes in the industry index, and changes in the underlying share price (independent variables). The results showed that all three independent variables could be chosen to predict the market price of NPLs due to high coefficients of determination (r^2). The order of preference of independent variables for explaining the dependent variable (due to a higher r^2) is :

(1) movements in the underlying share price,

(2) movements in the industry index, and

(3) movements in the overall index.

2.8 Conclusion

The literature reviewed a number of issues pertinent to a study of the efficiency of a rights issue market. Certain significant aspects were highlighted in the review as having an impact on the research presented in the paper. These are summarised below :

- stock volatility is most sensitive to changes in stock price when the outstanding warrants are near maturity and at-the-money.

- the use of an option-like warrant valuation model is empirically robust.

- the extent to which the B-S model underprices an in-the-money option increases with the extent to which the option is in-the-money and decreases as the time to expiration decreases.

- the B-S model can be used to provide efficient estimates of market values of warrants provided the necessary adjustments for dilution and dividends are made.

- implied standard deviations are substantially better predictors of future standard deviations than historical standard deviations.

- there are wide ranging views on the JSE as an efficient market. Certain authors support the JSE as an efficient market in the semi-strong form, others limit the efficiency according to certain criteria (for example, highly traded shares) and others reject the JSE as an efficient market and assert that the EMH is not valid for the JSE.

- the general view of the literature is that there is a negative share price reaction to the announcement of a rights issue on the JSE. Reasons given for the negative price reaction include the effect of flotation costs, regulations, and a dilution in earnings per share.

- rights price changes are highly correlated to changes in the underlying share price, the industry index, and the overall index.

The significant aspects highlighted above have an impact on the research presented below. Certain of the key issues will be drawn on during the research.

3 THEORETICAL BACKGROUND

This chapter places the research in the context of a theoretical framework and conceptual base. The research methodology and interpretation of the results is dependent on a sound conceptual understanding of market efficiency and rights and option pricing. The discussion is presented under the following headings :

- Market Efficiency - since the research sets the objective of studying the efficiency of the rights market, it is important to detail the theory behind market efficiency.

- Market Performance - the level of efficiency of a financial market is determined by its performance. The criteria for measuring the performance of a financial market are thus presented.

- Introduction to Options - the B-S model was formulated to value options. Rights are essentially European call options (with certain adjustments) on the equity of a company. Therefore the theory of options forms the basis of the theory of rights.

- Introduction to Rights/NPLs - this section leads on from the theory of options section above. It presents the theory, statutory and regulatory framework of rights.

- Warrants - a warrant is a similar instrument to a right. Certain of the literature presented above studies warrants. Thus the theory of warrants is presented.

- Option and Rights Pricing - this section follows on from the theory of options and rights above. It details the determinants of option and NPL value.

- The Black-Scholes Option Pricing Model - this section details the B-S option pricing model and formula using the determinants of options discussed in the previous section.

- The Adjusted Black-Scholes Model - the adjusted B-S model, which is used in the research to calculate theoretical NPL prices, is derived from the previous section.

- Boundary Conditions of the Value of a Call Option - call options should trade within certain pricing boundaries for efficiency to exist. These conditions, and proof of the conditions, are presented in this section.

- Boundary Conditions of the Value of an NPL - boundary conditions of NPLs are used in the research to test for market efficiency. Therefore it is important that the theory and formulae are presented.

3.1 Market Efficiency

The purpose of capital markets is to transfer funds between lenders (savers) and borrowers (producers) efficiently [Copeland & Weston, 1988]. Both borrowers and lenders are better off if efficient capital markets are used to facilitate fund transfers.

In order to describe efficient capital markets it is useful to contrast them with perfect capital markets. The following conditions are necessary for perfect capital markets to exist :

- markets are frictionless; i.e. there are no transaction costs or taxes and there are no constraining regulations,
- there is perfect competition in products and security markets,
- markets are informationally efficient; i.e. information is costless and is received simultaneously by all individuals,
- all individuals are rational expected utility maximizers.

Given these conditions, both product and securities markets will be both allocationally and operationally efficient. A market is said to be allocationally efficient when scarce savings are optimally allocated to productive investments in a way that benefits everyone. In an operationally efficient market, transaction costs are assumed to be zero (unless the transfer of funds involves risk bearing).

The conditions for capital market efficiency are not as restrictive as those for perfect capital markets outlined above. In an efficient capital market, prices fully and instantaneously reflect all available relevant information. This implies that when assets are traded, prices are accurate signals for capital allocation. Efficient capital markets can still exist if markets are not frictionless. Prices will still reflect all available information if, for example, securities traders have to pay brokerage fees.

Efficient capital markets can still exist if there is imperfect competition. Thus, for example, an efficient capital market will determine a security price for a monopoly that fully reflects the present value of the anticipated stream of monopoly profits. Finally, it is not necessary to have costless information in efficient capital markets [Copeland & Weston, 1988].

Efficient capital markets imply operational efficiency as well as asset prices that are allocationally efficient. Asset prices are correct signals when they fully and instantaneously reflect all available relevant information and are useful for directing funds from savings to investment projects that yield the highest return. Capital markets are operationally efficient if intermediaries, who channelling these funds from savers to investors, do so at the minimum cost that provides them a fair return for their services.

Capital market efficiency has been separated into three different types [Copeland & Weston, 1988] :

- weak form efficiency - the capital market fully incorporates the information in past stock prices. Thus no investor can consistently earn excess returns by developing trading strategies based on historical price or return information,

- semi-strong form efficiency - the capital market reflects all publicly available information (for example, company annual reports, investment advisory data, etc.). Thus no investor can consistently earn excess returns from using publicly available information,

- strong form efficiency - the capital market reflects all information, public or private. Thus no investor can consistently earn excess returns using any information, whether publicly available or not.

An efficient market has certain important implications for corporate finance [Ross et al, 1993]. Implications include the fact that the price of a company's stock cannot be affected by a change in accounting policy, and that finance managers cannot time issues of stocks and bonds using publicly available information.

3.2 Market Performance

A requirement for the successful utilization of the features of rights is the presence of a suitably liquid and efficient spot and derivative/rights market. In such circumstances participants are able to enter and exit both markets as their trading strategies dictate. This should ideally be achievable without incurring substantial penalties.

The performance of a security market can be judged by several factors. These include [Cox & Rubenstein,1985] :

- size and profitability - this can be measured by contract trading volume, listings and memberships,

- liquidity - the difference (spread) between the quoted buy and sell prices of the instrument and the reaction of the spread to purchases and/or sales of the instrument,

- transaction speed - the speed of the execution of orders,

- fairness - the absence of manipulation thus allowing prices to be determined by market forces,

- effects on other financial markets.

The level of efficiency of a financial market is essentially determined by the latter three criteria [Nowitz, 1989].

3.3 Introduction to Options

The theory of options is presented under this section as rights are essentially European call options (with certain adjustments) on new equity of a company. Therefore the theory of options forms the basis of the theory of rights.

A call option is a contract giving its owner the right to buy a fixed number of shares of a specified common stock at a fixed price any time on or before a given date. A put option is a contract giving its owner the right to sell a fixed number of shares of a specified common stock at a fixed price any time on or before a given date [Cox and Rubenstein, 1985]. An option that can be exercised any time up until the expiration date is termed an *American* option. An option that can only be exercised at maturity is termed a *European* option.

The act of utilizing the right and buying the stock is called *exercising* the option. The fixed price is termed the *exercise price* or *strike price*. The given date is called the *maturity date* or *expiration date*. The individual who creates or issues a call is termed the *writer*, and the individual who purchases the call is termed the *buyer*. The market price of the call is termed the *premium* or *call price*.

For European options there is a fixed relationship between the price of put and call options with the same maturity date that are written on an underlying stock. This relationship is called *put-call parity*. It implies that if the price of a European call on an asset is known, the price of a European put on the same asset can be determined.

Let S = the current market price of the underlying security

S^* = the underlying security share price at expiration

C = the current value of an associated call

P = the current value of an associated put

X = the exercise price

e = the positive real number such that ln e = 1

r = the risk free interest rate

t = the time to maturity of option in years.

The following relationship holds [Copeland & Weston, 1988] :

Equation 1 Put-Call Parity

$$\boxed{S + P = Xe^{-rt} + C}$$

In other words, buying a share of stock and buying a put written on that share yield the same payoff as holding the equivalent of the discounted exercise price and buying a call.

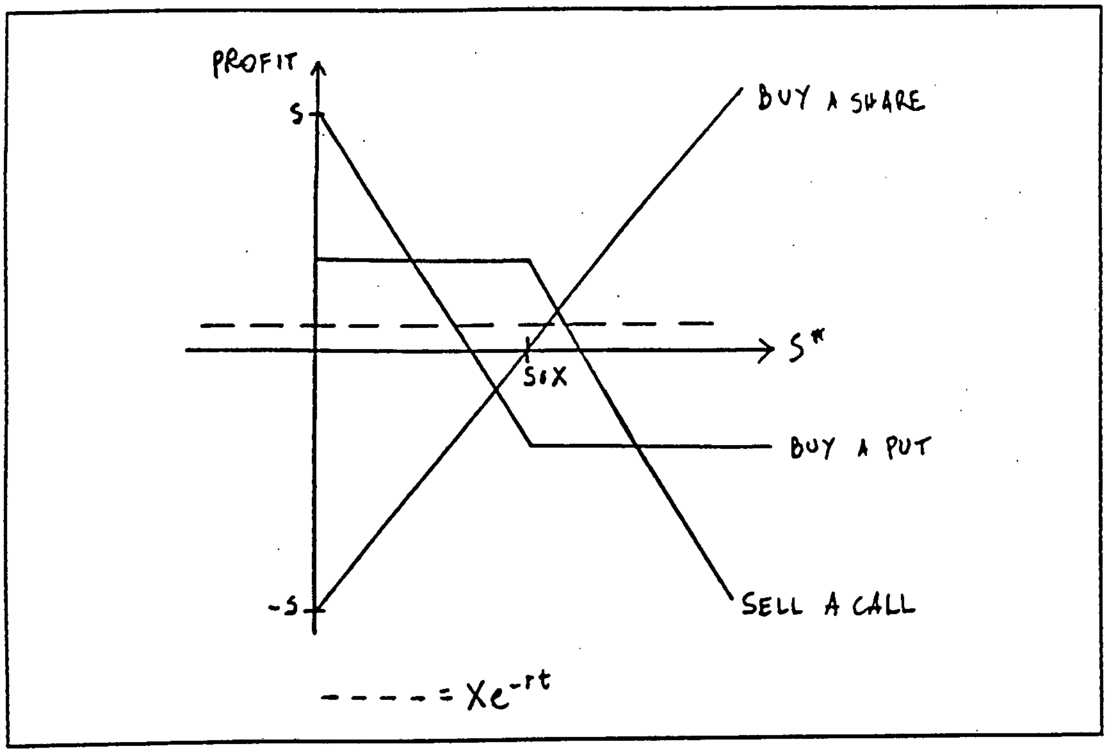
If S > X (in other words, the spot price of the share is greater than the exercise price of the option), a call is *in-the-money*; if S = X, it is *at-the-money*; if S < X, it is *out-of-the-money*. If S is much greater than X, then a call is said to be *deep-in-the-money*. If S is much less than X, then a call is said to be *deep-out-of-the-money*.

The put-call parity formula in equation 1 can be re-written as :

$$S + P - C = Xe^{-rt}$$

This can be graphically represented in the graph 1 (called a "payoff diagram"). The dotted line represents the net effect of buying a share, buying a put and selling a call : the net effect equals Xe^{-rt} (the payoff of the discounted exercise price).

Graph 1 Put-Call Parity



There are three major uses for options [Nowitz, 1989] :

- hedging - this involves the insurance characteristic of options. Hedgers are able to protect their funds from unanticipated movements in either the price or volatility of the underlying instrument. There is an advantage of using options as a hedging instrument in comparison to other hedging instruments (such as futures) in that the cost of the hedge is limited to the size of the premium of the option,

- speculating - speculators are attracted to options due to the advantageous gearing characteristics of options. The initial capital outlay is considerably less than if speculating in the underlying physical asset. The speculators are able to avoid having to deliver physical stock and having to make restitution for any coupons/dividends paid in that time,

- arbitraging - arbitragers attempt to earn relatively risk-free returns from strategies, involving both the options and the underlying instrument, by identifying deviations from theoretical values of either the underlying or the derivative instrument.

3.4 Introduction to Rights/NPLs

Rights are issued to existing shareholders entitling them to acquire new share in a company in proportion to their existing holdings at a predetermined price.

It is clear from the definition of a right outlined above, and that of a call option, that a Nil Paid Letter ("NPL") (see definition of right and NPL below) is almost the same instrument as a European call option. The only difference is that a rights issue involves the issuing of new equity by the company concerned. Thus an NPL can be thought of as a call option on a new equity issue by a company. From the discussion of option uses described, it would appear that the NPLs can be used for hedging (protect the underlying share from unanticipated movements in either its price or volatility), speculating (buying and selling rights to exploit possible mispricing between actual NPL prices and theoretical NPL values), and for arbitraging (earning relatively risk-free returns from strategies, involving both the NPLs and the underlying shares, by identifying deviations from theoretical values of either the NPLs or underlying shares).

The essential features of a rights offer, as defined by s142 of the South African Companies Act [1973] are that :

- it is an offer for subscription,

- it is renounceable, i.e. those to whom it is addressed can renounce it in favour of other persons,

- it is made to the members or debenture-holders of a company,

- it relates to listed shares.

General public issues and private placings of shares are alternative methods for raising equity [Companies Act, 1973]. The Companies Act [1973] is not prescriptive with regard to how a company raises equity. However, the JSE requires (JSE's Listing Requirements, clause 3.2 of section 1, 1994) that listed companies make provision in their articles of association that unissued equity can only be offered to existing shareholders by way of a rights issue. The only exceptions are where the shares are being issued for the acquisition of assets (in which case a private placing is acceptable) or where the issue has been approved by the company's shareholders and the JSE. As a result of these restrictions, the majority of the equity issues on the JSE are by way of a rights issue.

Further requirements relating to rights issues are detailed in the Practice Notes issued by the JSE. Two important requirements of Practice Note viii are :

- the price at which shares are to be issued for the purposes of a rights issue must be at or below the ruling market price on the day of the announcement of the terms of the offer,

- unless circumstances are such as to warrant a concession being granted by the JSE Committee, the JSE requires that a rights issue must be underwritten and the letters of allocation listed.

All shareholders registered on the LDR receive the rights to additional shares in proportion to their current holding in the form of Letters of Allocation ("LOA's"). LOA's are also commonly termed NPL's. Between the date of the announcement of the rights issue and the LDR, the shares and the LOA's are indivisible and are said to trade *cum-rights*. All persons registered as holding LOA's on the Closing Date of the Offer ("CDO") receive shares to which the LOA is entitled. During the listing period when the shares and the rights trade separately (between the LDR and the CDO), the shares are said to trade *ex-rights*. The common period for listing rights is approximately four calender weeks (20 trading days).

It is important to differentiate between the terms *rights* and *NPLs/LOAs*. The former is linked to each share currently in issue. The latter is linked to the new number of shares to be issued on exercise of the rights. Thus, for example, take a company with 5,000,000 shares in issue. The company announces a 1 for 5 rights issue, thus shareholders receive 1,000,000 NPLs/LOAs. These NPLs/LOAs are the instruments quoted and traded on the JSE. If all NPLs are exercised, the number of shares in issue will increase by 1,000,000 to 6,000,000.

3.5 Option and Rights Pricing

The fundamentals discussed below on option pricing apply equally to rights (unless otherwise indicated). Thus for "strike/option/call" read "exercise/NPL/NPL". In addition, when the word "option" is mentioned, this refers only to a call option and not a put option (unless otherwise indicated).

As with any traded item, such as an option, the value of the instrument will be determined by the market forces of supply and demand. Thus, because the value of an option is directly linked to the value of the underlying asset price, an option will be priced in equilibrium as a function of the underlying asset price. An option represents rights owned by the option holder without any attached obligation. Thus an option can never become a liability and can never have a negative value.

The value of a European option has three components :

- the intrinsic value,
- the time value of money on the striking price of the option,
- the insurance value.

The first component is the difference between the price of the underlying asset and the strike or exercise price of the option - it represents the amount that can be "locked in" if one trades in the underlying asset. The second is the gain to the buyers of calls from the exercise price being paid only on the expiration date of the option. Time value is greatest for at-the-money options. The further the option is in-or out-the-money, the less time value effects the option value. This is because it becomes easier to predict whether or not the option will be exercised. The third component is the most important [Brenner & Subrahmanyam, 1994], and the one that primarily distinguishes an option from other financial assets. It measures the value of the potential profit or loss from an option position, with the loss being limited to the price paid for the option. This insurance feature is related to the option's premium (what is paid for the option) versus the deductible (what is given up if the option finishes out-the-money).

An option's current value is the probability-weighted average of all possible intrinsic values of the option at expiration. This value is essentially determined by certain variables. The six most fundamental direct determinants of option value are [Cox & Rubenstein, 1985] :

- current stock price :
  for call options, the higher the stock price, the higher the call value as the probability is higher that the option will be exercised.

- strike price :
  at expiration, only two variables impact on the options value, namely the strike price and the spot price. The higher the strike price, the higher the spot price must move for the call to expire in-the-money and have a positive value. Thus, the higher the strike price, the lower the value of the call.

- time to expiration :
  the longer the time to maturity, the greater the probability that the option will expire in-the-money. Thus, the longer the time to maturity, the higher the value of the call.

- stock volatility :
  this represents the measure of the dispersion of possible future stock prices - it is a measure of the total risk of a stock. An option is valued on the likelihood of the future price movements of the underlying asset. The higher the volatility of the underlying stock, the higher the option value.

- interest rates :
  the higher the interest rate, the lower the present value of the strike price the call buyer has contracted to pay in the event of exercise. Thus high interest rates tend to imply lower call values.

- cash dividends :
  the larger the fraction of the total return made up by cash dividends to be paid with the ex-dividend dates prior to the expiration date, the lower the value of the call.

Table 1 below summarizes the effect that an increase in each factor discussed above will have on the value of a call option.

Table 1 Factors Affecting Call Option Values

	Determining Factors	Effect of increase
1	Current stock price	↑
2	Striking price	↓
3	Time to expiration	↑
4	Stock volatility	↑
5	Interest rates	↑
6	Cash dividends	↓

There are certain other factors that may influence the value of an option in an insignificant way. Examples of these factors include : the expected rate of growth of the stock price, investors' attitudes towards risk, tax rules, transaction costs and market structure.

3.6 The Black-Scholes Option Pricing Model

The option pricing formula for a call option, derived by Black and Scholes [1973], is presented below :

Equation 2 Black-Scholes Model

$$\boxed{C = SN(d_1) - Xe^{-rt}N(d_2)}$$

where

$$d_1 = \frac{\ln(S/X) + (r + \sigma^2/2)t}{\sigma\sqrt{t}}$$

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

and where

e	=	the positive real number such that ln e = 1
C	=	current call option value
S	=	current stock price
X	=	exercise price
r	=	risk free interest rate (the annualized continuously compounded rate on a safe asset with the same maturity as the expiration of the option)
t	=	time to maturity of option in years
σ	=	standard deviation of the annualized continuously compounded rate of return of the stock
N(d)	=	probability that a standardized, normally distributed, random variable will be less than or equal to d. This equals the area under the normal curve up to d.

As with most models, the B-S formula is based on some simplifying assumptions regarding conditions in the stock and option markets. These are [Black and Scholes, 1973] :

- the short term interest rate is known and constant through time,

- the stock price follows a random walk in continuous time with a variance rate proportional to the square of the stock price. Thus the distribution of possible stock prices at the end of any finite interval is log-normal. 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 stock or the option,

- it is possible to borrow any fraction of the price of a security to buy it or to hold it, at the short term interest rate,

- there are no penalties to short selling.

Under these assumptions, the value of the option will depend only on the price of the stock, on time, and on variables that are taken to be known constants.

3.7 The Adjusted Black-Scholes Model

The B-S call option model needs to be modified because rights are not written by other investors; they are supplied by the company. When rights are exercised, the firm receives the exercise price and the size of issued share capital increases. The dilution effect causes an otherwise identical European right to sell for less than the corresponding European call. Just how much less depends on the ratio of the number of outstanding NPL's to the number of outstanding shares prior to exercise. The dilution can be significant in practice (for example, the Rand Leases issue in 1990 had a factor of nine (see table 10)).

When the B-S call option model is adjusted for the dilution that occurs when NPL's are exercised, model rights prices are given by [Black & Scholes, 1973 and Cox & Rubenstein, 1985] :

Equation 3 Adjusted Black-Scholes Model

$$W = \frac{1}{(1+q)} \left[(S - De^{-rt})N(d_1) - Xe^{-rt}N(d_2)\right]$$

where

$$d_1 = \frac{\ln((S - De^{-rt})/X) + (r + \sigma^2/2)t}{\sigma\sqrt{t}}$$

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

and where

e	=	the positive real number such that ln e = 1
W	=	NPL price
S	=	current stock price
X	=	exercise price

r	=	risk free interest rate (the annualized continuously compounded rate on a safe asset with the same maturity as the expiration of the NPL)
q	=	the ratio of the number of new shares to be issued to the number of shares currently outstanding
t	=	time to maturity of NPL's in years
σ	=	standard deviation of the annualized continuously compounded rate of return of the stock per unit time
D	=	the dividend paid (per share) during the life of the NPL
N(d)	=	probability that a standardized, normally distributed, random variable will be less than or equal to d. This equals the area under the normal curve up to d.

It became apparent during the empirical research presented below that no sample companies paid dividends during the listing period of the right.

3.8 Boundary Conditions of the Value of a Call Option

The value of a call is never *less than* the larger of :

- zero,
- the share price minus the exercise price,
- the share price minus the present value of the exercise price minus the present value of the maximum dividends that will be paid during the remaining life of the NPL [Cox & Rubenstein, 1985].

The value of a call is never *greater than* the price of its underlying share. The above conditions are depicted as :

Equation 4 Call Boundary Conditions

$$\boxed{S \geq C \geq \max\left[0,\ S - X,\ S - Xe^{-rt} - D\right]}$$

The proof of the above lower boundary conditions is as follows :

- since a call represents a right and not an obligation, and since a call has limited liability, it should never be worth less than zero,

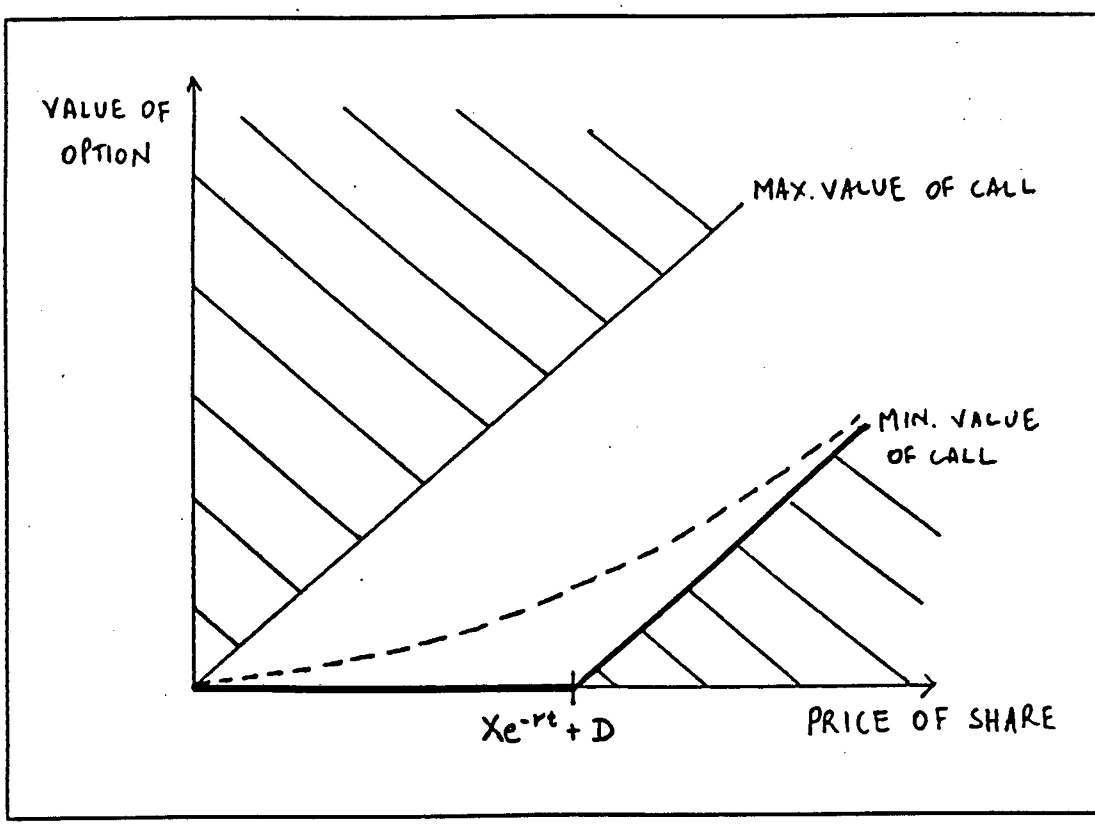
- if $C < S - X$, you can buy the call and exercise it immediately. Note that you could not do this with a European call, so its value could be worth less than $S - X$,

- a contract that must be exercised on the expiration date and cannot be exercised before then should be worth at least $S - Xe^{-rt} - D$. If $C < S - Xe^{-rt} - D$, you can lock in a certain profit by forming the following portfolio : short one share, buy one call, buy D, and place Xe^{-rt} in default-free bonds maturing on the expiration date. This produces the positive amount $S - Xe^{-rt} - D - C$ now. Hold this portfolio to expiration date. Liquidate D as required to cover cash dividends due from the short position in the stock. Since the loan will have grown to $Xe^{-rt} \times e^{rt} = X$ at expiration, the portfolio will at worst be worth zero (if $S^* \geq X$) and at best will return the positive amount $X - S^*$ (if $S^* < X$). S^* represents the share price on the expiration date of the option.

The proof of the upper boundary condition ($S \geq C$) is that if $C > S$, it is logical that an investor would invest directly in the shares and ignore the options.

These boundary conditions of a call option are graphically depicted in graph 2. The unshaded area represents the boundaries within which the price of the option will fall. The curved line represents a typical pattern that the option price can adopt :

Graph 2 Boundary Values of a Call



3.9 Boundary Conditions of the Value of an NPL

The boundary conditions of a call option can be interpolated into boundary conditions for NPLs.

The value of an NPL is never *less than* the larger of :

- zero,

- the share price minus the exercise price. This net amount multiplied by the dilution factor,

- the share price minus the present value of the exercise price minus the present value of the maximum dividends that will be paid during the remaining life of the NPL, multiplied by the dilution factor.

The value of an NPL is never *greater than* the price of its underlying share, multiplied by the dilution factor.

The above conditions are depicted as :

Equation 5 NPL Boundary Conditions

$$\mathbf{S\,(1/(1+q)) \geq W \geq \max\,[0,\,(S - X)\,(1/(1+q)),\,(S - Xe^{-rt} - D)\,(1/(1+q))]}$$

The proof of the above boundary conditions for an NPL is a variation of the proof presented for equation 4 above and can be derived therefrom.

3.10 Conclusion

This chapter has established a theoretical base for the research. This is extremely important as the research methodology and interpretation of the results is dependent on a sound understanding of the theoretical background to market efficiency and rights and option pricing.

4 RESEARCH METHODOLOGY

The research methodology is designed to address the problem and objective of the study as defined in the introduction. The problem that is addressed by this research is that if the market is inefficient then the market is failing in its role of being an efficient allocator of scarce resources.

The objective of the study, which was also defined in the introduction, is to establish whether the South African market for rights issues is efficient. S: Intro

The B-S model was used to test the efficiency of the South African market for rights issues. It was modified to allow for the effect of dilution and dividends. The following null hypothesis was tested :

Ho : the South African market for rights issues is efficient.

Restated in terms of the empirical work done :

$Ho_1 : \mu = 0$

In other words, the mean of the differences between the actual observed NPL prices and those generated by the B-S model approximates zero. S: end

$$Ho_2 : S\,(1/(1+q)) \geq W \geq \max\,[0, (S - X)\,(1/(1+q)), (S - Xe^{-rt} - D)(1/(1+q))]$$

In other words, the value of an NPL falls within the theoretical pricing boundaries described in section 3.9 above.

4.1 Methodology

The methodology used in this research to test for market efficiency is the test for excess returns. This methodology has been widely used in other studies when employing the B-S model to test for market efficiency of options and warrants, or to test for B-S model robustness (for example, Macbeth & Merville [1979 & 1980], Noreen & Wolfson [1981], Kremer & Roenfeldt [1993]). The methodology involves calculating model values for NPLs and calculating differences between model values and observed NPL prices. The differences are then tested for significance by using the t statistic.

The data requirements are as follows :

- daily closing share prices, closing NPL prices and trade volumes are obtained for the final sample. Exercise prices and dilution factors are also obtained for each issue in the final sample. The BA rate is obtained on a daily basis for the entire sample period.

A detailed description of the methodology is presented below :

(1) an HSD value is calculated for each issue by using the daily closing prices for the year preceding the LDR of the issue (see "Measurement of Input Variables" section below for further description).

(2) on each day, for each issue, a test is done to see whether the boundary conditions for C (NPL price using non-diluted adjusted formula) and W (NPL price using diluted adjusted formula) apply, in other words, whether :

$$C \geq \max [0, S - X, S - Xe^{-rt} - D] \qquad \text{and}$$

$$W \geq \max [0, (S - X) ((1/(1+q)), (S - Xe^{-rt} - D) ((1/(1+q))].$$

6

The boundary test is performed for C as, even though the majority of the literature review concludes that the dilution adjustment is required, the Schultz and Trautmann [1994] article concludes that the dilution adjustment is not necessary.

(3) for each day, for each issue, a theoretical NPL price is calculated using :

(a) B-S formula (non-dilution adjusted) with the HSD as a measure of standard deviation (*HSD price*). Non-diluted means that the underlying share price is not adjusted for the dilution effect of the rights issue.

(b) B-S formula (dilution adjusted) with the HSD as a measure of standard deviation (*W-HSD price*).

(c) B-S formula (non-dilution adjusted) with the ISD as a measure of standard deviation (*ISD price*).

(d) B-S formula (dilution adjusted) with the ISD as a measure of standard deviation (*W-ISD price*).

The ISD value used is that calculated from the previous trading day's actual share and NPL prices. This method has been employed in the literature (for example, Sheikh [1993]). On the first trading day of each issue, the HSD value is used as an estimate of the ISD value as there is no prior trading day of the NPL. Note that the above calculations are only performed for those days where both the NPLs and the shares trade.

(4) for each measure of model NPL price, the difference is calculated per issue on a daily trade basis between the actual NPL price and the model NPL price.

(5) for each measure of model NPL price, these differences are placed in a matrix with days on the horizontal axis and NPL issues on the vertical axis.

(6) a statistical significance test is then performed on these differences by using the t statistic, with reference to the null hypothesis formulated above. The t statistic is an important distribution in statistics in problems involving small samples from normal distributions. The t statistic thus assumes the normality of distribution of a population with a random sample size, sample mean and sample variance. In the statistical tests performed, normality of distribution of share prices is assumed as the t statistic is robust (relatively insensitive) to violations of the normality assumption [Pagano, 1981].

(7) the t statistic is calculated per day for each measure of model NPL price, and for each NPL issue for each measure of NPL price. The statistical measure is to test whether the differences between theoretical and actual NPL prices are significantly different from zero.

(8) if number of days/issues for which the t statistic is significant exceeds the probabilities of the binomial distribution, then the null hypothesis is rejected and the conclusion reached that the South African market for rights issues is inefficient. However, if number of days/issues for which the t statistic is significant does not exceed the probabilities of the binomial distribution, then the

null hypothesis cannot be rejected and the conclusion reached that the South African market for rights issues is efficient.

To summarise the method :

(1) calculate a model (theoretical) NPL price;

(2) determine if the actual price differs significantly from the model price,

(3) determine if the number of occurrences of significantly different pricing is significant.

4.2 Measurement of Input Variables

5

4.2.1 Risk free interest rate (r)

The indicator to use for the short-term risk free interest rate is a contentious issue [Cox & Rubenstein, 1985]. The B-S model assumes that there is a constant rate over the period of the option. This imposes restrictions on valuing long termed options or warrants which could have lives measured in months or years. However, where the instrument being valued has a short trading or listing period (for example, a right), the assumption of a constant rate over the period does not impose restrictions.

Cox and Rubenstein [1985] recommend that if the portfolio or investor has a net surplus of funds, then the investment rate should be used for valuation. If the portfolio or investor is a net borrower of funds then the borrowing rate should be used. The investor using the B-S model to value rights would have to use the applicable interest rate depending on the fund position. 5

The short-term risk free rate should ideally be the annualized continuously compounded rate on a safe asset with the same maturity as the expiration of the right. Most rights are listed for average periods of 20 days (one calender month). Difficulties were encountered when attempting to identify a suitably stable risk free interest rate with a maturity date approximating that of the right.

The three month (90 day) B.A. rate was taken as a suitable indicator of the short-term interest rate. The three month B.A. rate was used because it was easily accessible and appears to be a stable indicator of market conditions. The three months B.A. rate has been used in prior research (for example, Nowitz [1989]). A banker's acceptance (B.A.) is a bill of exchange with a stated maturity (usually 90 or 180 days). The borrower (usually a company) accepts a bill from an issuing bank and then discounts it with a discount house. At maturity, (1) the borrower pays the bank the face amount, (2) the bank pays the discount house the face value on presentation of the bill by the discount house (which it guaranteed at inception). B.A.'s can be resold at any time up to maturity.

It was concluded that the three month B.A. rate would be used for valuing all the rights in the sample on a consistent basis. The closing rate is used as intra-day volatility is unlikely.

4.2.2 Standard deviation (σ)

Standard deviation (volatility) is defined as the variability of the annualized continuously compounded rate of return of the share per unit time. Standard deviation is the most difficult of all the input variables to measure [Cox & Rubenstein, 1985]. The volatility input for the calculation of a rights price should be the future expected volatility of the stock (shares plus rights) over the period of the rights. Two alternative estimates have been used in this study - historical standard deviation (HSD) and implied standard deviation (ISD).

- <u>historical standard deviation</u>

The B-S model assumes that stock prices are lognormally distributed. This means that the natural log of the price relative (final stock price divided by initial stock price) over any period has a normal distribution, with mean and variance proportional to the length of the period. The standard deviation was calculated for each share by using the closing daily share prices for the year (approximately 260 trading days) preceding the date of the LDR of the right. The HSD is the used in the B-S formula as an approximation of the future expected volatility of the stock. Daily share prices for one year preceding the issue are used as the calculation is for an estimate of annual volatility, and the larger the sample, the greater the likelihood that the calculated estimate of HSD will be extremely close to its true value [Cox & Rubenstein, 1985].

"Programming Methodology" below describes how the HSD was calculated by the computer program.

- <u>implied standard deviation</u>

The ISD is defined as the standard deviation which, when entered into the B-S model, yields a NPL price equal to market price. Thus, using the actual NPL price on each trading day, the theoretically predicted (implied) volatility was calculated using the B-S model. This required solving for the roots of the equation :

Equation 6 Implied Standard Deviation

$$\boxed{\text{market price} - \text{model price (ISD)} = 0}$$

Equation 6 above is non-linear and cannot be solved by analytical methods. Thus an iterative process using numerical methods was required.

"Programming Methodology" below describes how the ISD was calculated by the computer program.

4.2.3 Cumulative normal distribution (N(d))

The cumulative normal distribution is defined as the probability that a standardized, normally distributed, random variable will be less than or equal to d. This equals the area under the normal curve up to d. Equation 7 was used to approximate N(d) [Cox & Rubenstein, 1985] :

Equation 7 Cumulative Normal Distribution

$$z = 0.39894228 \exp(-d^2 / 2)$$

$$y = 1 / (1 + 0.2316419 \text{ Abs}(d))$$

$$x = 1 - z\,(1.330274429\, y^5 - 1.821255978\, y^4 + 1.781477937\, y^3 - 0.35653782\, y^2 + 0.31938153\, y)$$

$$N(d) = x \text{ for } d > 0$$

$$N(d) = 1 - x \text{ for } d < 0$$

(8) to generate matrices showing the daily differences between actual NPL prices and model values for the HSD, W-HSD and W-ISD measures of volatility. The ISD measure was excluded for reasons given in chapter 6,

(9) to calculate the t statistic for each trading day for each measure of volatility determined in step (8) above,

(10) to calculate the t statistic for each share for each measure of volatility determined in step (8) above.

The input data required were in text delimited form. The data for the BA rate and each share (for each NPL issue) were recorded in separate files showing the daily date and the daily closing price, for the period 1 January 1989 to 31 December 1994. The data for the NPL prices were recorded in separate files for each issue showing the daily date and the daily closing price, for the listing period.

A summary is presented below of how certain variables and values used in, and produced by, the B-S model were calculated :

4.3.1 HSD measure

The method used to calculate the HSD measure is that described by Cox and Rubenstein [1985]. The B-S formula is based on the assumption that stock prices are lognormally distributed. This means that the natural logarithm of the price relative (final stock price divided by initial stock price) over any period has a normal distribution, with mean and variance proportional to the length of the period. Standard statistical techniques are used for estimating the parameters of a normal distribution with unknown mean μ and variance σ^2.

The HSD measure for each share is calculated by using the daily closing prices for the year preceding the LDR. This usually gives approximately 260 prices for each share. The standard price relatives statistical technique is employed to estimate each shares annual volatility.

4.3.2 ISD and W-ISD measure

Numerical methods were required to calculate the ISD measure, as the equation is non-linear and thus has no analytical solution. As it is not possible to take the first derivative of the function as required by simpler numerical methods such as Newton's method, the Regula Falsi method was used [Rice, 1983]. This method requires estimating two starting points, x_o and x_1, such that $f(x_0)$ and $f(x_1)$ have opposite signs, where x is the volatility and f(x) is the B-S formula. The next iteration produces a point x_2, which is between x_o and x_1, using the formula :

Equation 8 Regula Falsi Iteration Method

$$x_2 = x_1 - [(x_1 - x_0)/(f(x_1) - f(x_0))] * f(x_1)$$

The sign of $f(x_2)$ is compared to the signs of $f(x_0)$ and (fx_1), and the point which gives the opposite sign is used for the next iteration. This process is repeated until convergence to a solution is achieved that falls within the required error margin.

Under certain conditions it is not possible to chose x_0 and x_1 such that $f(x_0)$ and $f(x_1)$ have opposite signs, and no result can be obtained. These conditions occur when $C < (S - Xe^{-rt})$ for ISD, and $W < (1/(1 + q))(S - Xe^{-rt})$ for W-ISD. For instances where a solution is possible, the initial points chosen were $x_0 = 0.001$, and $x_1 = 20$. The small value of x_0 and large value of x_1

chosen help ensure that the $f(x_0)$ and $f(x_1)$ results will have opposite signs and convergence will be possible.

4.3.3 NPL prices

The program required the input (either from the data files, or calculated by other programs) of the following variables into the B-S model :

- share price,
- exercise price,
- time to expiration,
- interest rate (BA rate),
- stock volatility (HSD, W-HSD or W-ISD measure),
- dilution effect (W-HSD, or W-ISD measure).

There are no prices calculated for the last day of each share issue. The reason being that "t" (time to expiration) is zero and division by zero (in the B-S formula) gives an answer of infinity.

4.4 Potential Sources of Error in Data

The accuracy and reliability of a test of the efficiency of a market is dependant on the financial information upon which the test is performed. The data accumulation process, by its nature, exposes the accuracy of the data to vulnerabilities. The possible sources of error include :

- incorrect prices recorded on the UCT database,

- incorrect prices and information recorded in the JSE handbooks,

- incorrect prices and information recorded by the JSE on those shares for which prices were obtained from the JSE database,

- transposition errors resulting from copying information incorrectly from a manual form into a computerized form.

These potential errors were addressed by :

- checking at least three daily prices, for two issues per year, obtained from the UCT database and the JSE to other sources of financial data (for example, daily JSE closing prices recorded in financial supplements to newspapers, JSE handbook high, low and closing prices),

- checking at least three daily prices of each issue transposed to ensure that no errors in the recording thereof occurred.

No errors were found. Consequently, the accuracy of the recorded data was relied upon.

4.5 Expectations of Results

At this point, expectations of which measure of volatility (HSD, W-HSD, or W-ISD) will produce the best approximation of NPL price can be formulated given :

- the findings obtained through the literature review,
- the review of the theoretical background,
- the formulation of the methodology.

In respect of the measure of stock volatility, Chiras and Manaster [1978] concluded that ISDs are substantially better predictors of Future Standard Deviations (FSDs) than HSDs. 5 – concl

In respect of the dilution effect of NPLs, Le Plastrier et al [1986] and Kremer and Roenfeldt [1993] concluded that the empirical accuracy of the B-S model is enhanced by the adjustment of the formula for the dilution effect.

Thus the expectation is that the W-ISD measure will provide the most robust approximation of NPL price.

4.6 Assumptions and Limitations of the Study

5 before concl.

The key assumptions required for this study are as follows :

4.6.1 Assumptions Required to Test for Market Efficiency

The efficiency test used in this research was based on the presence of statistically significant differences of observed rights prices from B-S model calculated prices. If the differences existed and persisted over time, then the market for rights issues was assumed to be inefficient for the period investigated (1990 to 1994 inclusive). Conversely, if significant differences did not exist, then the market was assumed to be efficient.

A favoured approach used by various authors in testing for market efficiency in derivative markets is the excess profits test [Nowitz, 1989]. This approach uses hedging in the asset and derivative instrument in situations where significant differences in the observed and model derivative prices are calculated. Hedging strategies are employed for over- and undervalued derivatives using buy-and-hold or buy-and-trade strategies. It is then established whether significant excess profits can be generated by any of the strategies. If significant excess profits can be generated, then the market is assumed to be inefficient. This procedure was not employed in this dissertation for two important reasons :

- the excess profits approach assumes the efficiency of the underlying asset market (i.e. assumes that the share price, at any point in time, was correctly valued). This is an unacceptably strong assumption to make for the JSE, given the conclusions drawn by certain authors in the literature review, and

- the buy-and-sell strategy of the excess profits approach assumes a highly liquid market for the shares and the rights. This assumption is unjustifiable on the JSE due to the illiquidity of the market.

As discussed previously, the test of efficiency is, in fact, a joint test. If one is empirically testing the null hypothesis that the B-S theoretical prices exhibit no systematic differences from actual traded prices, the null hypothesis can be rejected for any one of three reasons [Copeland & Weston, 1988] :

(1) inputs to the B-S model have been incorrectly measured, or

(2) the rights/options market is inefficient, or

(3) the mathematical structure of the B-S model is incorrect.

The test for efficiency of the rights market assumed that the null hypothesis would not be rejected for reasons (1) and (3). In other words, the study assumed that the inputs into the B-S model have been correctly measured and that the mathematical structure of the B-S model is correct.

4.6.2 Assumptions of the B-S Model

These assumptions have been discussed above [Black and Scholes, 1973]. A summary is provided below :

- the short term interest rate is known and constant through time,
- the stock price follows a random walk in continuous time,
- the stock pays no dividends or other distributions,
- the option is "European",
- there are no transaction costs in buying or selling the instruments,
- it is possible to borrow at the short term interest rate,
- there are no penalties to short selling.

Under these assumptions, the value of the right/option will depend only on the price of the stock and on time, and on variables that are taken to be known constants.

4.6.3 Limitations of the Study

The following limitations of the data and the methodology should be noted :

- the three month B.A. rate may not be an appropriate indicator of the short-term interest rate. However, as discussed in section 5.2.1 above, the exact indicator for the short-term risk free interest rate is a contentious issue. Since a right has a short listing period, the assumption of a constant rate over the period does not impose severe restrictions. Thus the three month B.A. rate can be relied upon as a robust measure of the short-term risk free interest rate,

- the use of the previous traded day's ISD as an estimate of the current trade day's volatility has certain limitations. An alternative could have been to use an average ISD over the life of the right to estimate volatility. However, there is no empirical evidence that this average measure improves the accuracy of the ISD measure. As such, the previous traded day's ISD can be relied upon as an estimate of the current trade day's volatility,

- closing prices were taken as an estimate of the actual trading prices for each traded day. An alternative estimate of actual price could be the daily high, daily low, an average, etc.. The closing price was used as it was assumed to represent the results of the day's trade. In addition, extreme observed daily highs and lows can distort the research.

Thus, it appears that the limitations are unlikely to invalidate the findings of the research.

5 SAMPLE SELECTION AND DESCRIPTION

The data sample selected for the purposes of this research was taken from the records of companies listed on the JSE which issued rights during the period January 1990 to December 1994. The issues and their details (such as name of company, exercise price of rights, days traded in rights, total value of issue) were extracted from the monthly JSE Bulletins.

All rights issues during the period January 1990 to December 1994 which satisfied the following selection criteria were included in the sample :

- only rights issues of ordinary shares were included in the sample. The issue of different types of securities (e.g., convertible debentures) would be expected to have a price effect itself. As it is not the intention of this study to test the efficiency of the rights market for each type of rights issued, the study is restricted to the most commonly issued security, namely ordinary shares. Moreover, if the market is not efficient for rights issues of ordinary shares, it is unlikely to be efficient for rights issues of other securities,

- only rights issues of the company's shares were included, i.e. rights issues of another company's shares (e.g., the holding company or a subsidiary) were excluded. The reason for this is that rights issues by one company on another company's shares introduces complex valuation consequences which are beyond the scope of this study,

- only rights issued on the basis of ordinary shares held were included in the study (thus, for example, rights issues of ordinary shares based on convertible or preference instruments held in the company were excluded). The reason for this is that the B-S model values rights on the basis of the underlying comparable stock price,

- only companies without confounding events (e.g., simultaneous announcement of merger and/or acquisition, simultaneous announcement of issue of another security type) were included in the sample. The exclusions did not apply to those companies which made simultaneous announcements regarding the use to which the rights issue funds would be put as this disclosure is required by the JSE Listing Requirements [1994] (section 2, paragraph 21.1.1),

- only companies for which complete data was available from the either the JSE Bulletins or other sources were included in the sample.

- only those issues where there had been more than 10 days trading in the rights (most rights are listed for approximately 20 days) were included in the sample. The reason for the adjustment was to ensure that a sufficient number of data points were obtained when calculating theoretical rights values as the rights and the underlying shares needed to be traded on the same day. In order for accurate theoretical rights values to be derived from the B-S formula, the rights and the underlying shares need to be frequently traded. The reason for this is that rights and the underlying shares are assumed to trade simultaneously so as to allow for hedging and arbitraging strategies.

The following two sources were used to obtain share and NPL prices :

- for the majority of the issues, daily share prices and NPL prices were obtained from the database maintained by the Department of Statistical Sciences at the University of Cape Town,

- for the 1990 issues, and certain other issues in the final sample not maintained on the University of Cape Town database, daily share prices and NPL prices were obtained from the JSE's Market Information Department.

After filtering all the rights issues during the period January 1990 to December 1994 according to the criteria stated, the final sample was made up of 42 issues of NPLs during this period.

Tables 2 to 5 present the breakdown of the final sample by certain criteria. This has been done to establish whether there is any peculiar bias in the spreads of the final sample.

Table 2 gives a breakdown of the final sample by year of issue (based on the year in which the LDR fell). As can be seen, the rights issues are evenly spread over the years with the exception of 1992 which showed a greater number of issues :

Table 2 Final Sample by Year of Issue

Year	Number of issues	Percentage of total
1990	5	12%
1991	9	22%
1992	14	33%
1993	8	19%
1994	6	14%
Total	42	100%

Table 3 illustrates the distribution of companies in the sample on the basis of the sector in which they are listed. The table indicates that, although the majority of the issues were made by companies in the financial and industrial sectors, the proportion of financial sector issues is higher than that of the mining and industrial sector issues :

Table 3 Final Sample by Company Sector

Sector	Number of issues	Percentage of total	Percentage of sector (approx)
Mining	5	12%	4%
Financial	17	40%	14%
Industrial	20	48%	5%
Total	42	100%	-

Table 4 classifies the events on size of issue (in Rm). The table indicates that the number of the issues is evenly spread over the ranges. The majority of the largest issues (R 501m - R 1,500m) took place in 1992 :

Table 4 Final Sample by Size of Issue

Amount (Rm)	Number of issues	Percentage of total
0 - 10	1	2%
11 - 50	12	29%
51 - 200	12	29%
201 - 500	10	24%
501 - 1 500	7	16%
Total	42	100%

Table 5 indicates the level of tradeability in the rights and the shares in the sample by classifying the events according to the number of days in which there was trading in the NPLs, and number of days during the listing period that there was combined trading in the both the shares and the NPLs. Note that the NPLs in the table only trade for eleven or more days due to the exclusion of rights issues with fewer trading days (as detailed in the sample design above). Table 5 clearly demonstrates the lack of tradeability on the JSE of both shares and NPLs. Of the final sample used in the study, 20 out of the 42 issues (48%) showed 10 or less combined days of trading during the listing period :

Table 5 Final Sample by Days of Trading

Days of trading	NPLs only	NPLs and shares combined
2 - 4	-	2
5 - 7	-	4
8 - 10	-	14
11 - 13	12	7
14 - 16	15	6
17 - 19	14	9
≥ 20	1	-
Total	42	42

The tables presented above, giving the breakdown of the final sample by certain criteria, establish that there is no peculiar bias in the spreads of the final sample.

6 RESULTS AND DISCUSSIONS

An ISD measure could not be calculated using the non dilution adjusted B-S model for the majority of trading days as the lower boundary condition was exceeded. Thus there is no iterative numerical solution to the B-S formula as both estimates of roots for the ISD measure have the same sign. This, however, is according to expectations as NPLs are being traded and not options - thus the dilution effect holds and decreases the actual NPL price in comparison to a non-dilution adjusted NPL model price. The decision was thus taken to exclude this measure from the final research analysis. Therefore, only measures for HSD, W-HSD and W-ISD were considered.

6.1 Boundary Values

In an efficient market the boundaries conditions should never be exceeded. The reasons for this are presented under sections 3.8 and 3.9. The boundary conditions are shown in graph 2.

A test is performed on a daily basis for every NPL issue. In this procedure, boundary conditions are calculated and subsequently tested to determine whether the conditions are exceeded. The test is performed for both the dilution-adjusted ("W") and non dilution-adjusted measures of NPL price ("C").

Table 6 shows the percentage of times the boundary values of NPLs were exceeded; in other words where :

- $S < C < S - Xe^{-rt}$
- $S\ (1/(1+q)) < W < (S - Xe^{-rt})\ (1/(1+q))$

Table 6 Percentage of Times Boundary Values Exceeded

	Value of C	Value of W
Upper Boundary Exceeded	0%	0%
Lower Boundary Exceeded	55.78%♪	14.56%♪

♪ - denotes that binomial distribution probability at 95% level exceeded.

Table 6 indicates the inefficiencies associated with the lower boundary condition. On 55.78% of all days measured the lower boundary was exceeded for the non dilution adjusted measure. It is expected that the lower boundary condition for C could be exceeded as there is no adjustment for dilution, which can have a large impact on the price of C.

Thus we would expect there to be a much lower percentage of inefficiency associated with the measure for W. This is the case; on 14.56% of all days measured the lower boundary was exceeded for the dilution adjusted measure. This indicates inefficiencies in the NPL market as the investor on these days could have generated a higher return per share/NPL by going short on one stock, buying one NPL, and placing Xe^{-rt} in risk free debt instruments; liquidating the above position on expiration.

The findings can be summarised as follows :

- The binomial distribution probability at 95% level is exceeded and thus it can be concluded that the exceeded boundary conditions indicate market inefficiency.

- Using the two-tailed test for significance of difference between proportions, the difference between C and W has a z statistic which is significant at the 95% level. This contradicts the Schultz and Trautmann [1994] study which asserted that the dilution adjustment is not necessary. The findings therefore support the majority of the literature reviewed which held that the dilution adjustment is required.

6.2 Daily Measure of Efficiency

Table 7 below presents a summary of the t statistic for each day for each measure of volatility. The significance of the t statistic is measured at the 5% level (in other words, at the 95% confidence interval). The test performed is that to see whether the differences between the actual NPL price and the theoretical NPL price (using HSD, W-HSD and W-ISD measures) for each day are significantly different from the expected population difference of zero. The t test is thus a two-tailed significance test. The measure is split into significance tests for overpricing (where the actual NPL price is significantly higher than the theoretical NPL price) and underpricing (where the actual NPL price is significantly lower than the theoretical NPL price).

Table 7 t Stat Summary by Day for Each Measure of NPL Price

	HSD	W-HSD	W-ISD
% significantly overpriced	0%	68.4%♪	31.6%♪
% significantly underpriced	15.8%♪	0%	0%
% not significant	84.2%	31.6%	68.4%
total	100%	100%	100%

♪ - denotes that binomial distribution probability at 95% level exceeded.

The table above indicates that there are inefficiencies in the rights market. The measure for HSD indicates that 15.8% of days were significantly underpriced. It can be expected that the HSD measure would result in underpricing as no adjustment has been made for dilution in this measure and thus the model can underprice theoretical NPL prices. The measure for W-HSD indicates that 68.4% of days were significantly overpriced. According to the expectations developed in section 5.5. above, the W-ISD measure should be the most robust. This measure indicates that 31.6% of days were significantly overpriced. Thus although the W-ISD measure is much more robust it nevertheless results in significant inefficiencies.

The binomial distribution probability at 95% level is exceeded for all over and underpricing indicated above. It can thus be concluded that at the 95% confidence level, the null hypothesis is rejected and that the rights market is inefficient.

Using the two-tailed test for significance of difference between proportions, the difference between the percentage days overpriced for the W-HSD and W-ISD prices has a z statistic which is significant at the 95% level.

Table 8 presents the detail of the t statistic by day for each measure of NPL price. This detail is summarised in table 7.

It is interesting to note that for the W-ISD measure, most of the significant t statistics occur in the latter stages of the rights issues. Thus it seems as though, in general terms, the overpricing of NPLs becomes greater as the time to expiration decreases. The reason for this is not clear. This is discussed further under "Recommendations for Future Research".

Table 8 t Stat by Day for Each Measure of NPL Price

Day	HSD	W-HSD	W-ISD
1	-2.3513*	-0.5631	-0.5631
2	-2.6399*	3.6128*	0.4417
3	-1.2283	0.3687	1.1142
4	-1.0558	0.7614	0.7075
5	0.3383	2.5692*	0.6321
6	-1.5131	3.7923*	1.3788
7	-0.2267	2.7527*	-0.7422
8	-2.3417*	4.0601*	2.3706*
9	-0.6084	3.6893*	1.776
10	0.6622	4.4004*	1.854
11	-0.7478	2.4292*	0.1868
12	-0.8237	0.9961	2.9754*
13	0.9518	4.1532*	2.0998*
14	-0.8132	1.0097*	1.5484
15	0.4569	4.9059*	1.6327
16	0.2153	4.3865*	2.4691*
17	0.5301	3.8127*	2.8373*
18	1.3999	1.5572	3.4444*
19	-1.2857	1.5738	1.1778

* - denotes significant at 5% confidence level.

6.3 Measure of Efficiency Per NPL Issue

Table 9 below presents a summary of the t statistic for each share/NPL issue for each measure of volatility. The significance of the t statistic is measured at the 5% level (in other words, at the 95% confidence interval). The test performed is designed to establish whether the differences between the actual NPL price and the theoretical NPL price (using HSD, W-HSD and W-ISD measures) for each share are significantly different from the expected population difference of zero. The t test is thus a two-tailed significance test. The measure is split into significance tests for overpricing (where the actual NPL price is significantly higher than the theoretical NPL price) and underpricing (where the actual NPL price is significantly lower than the theoretical NPL price).

Table 9 t Stat Summary by Share Issue for Each Measure of NPL Price

	HSD	W-HSD	W-ISD
% significantly overpriced	9.5%♪	69.0%♪	16.7%♪
% significantly underpriced	50.0%♪	4.8%♪	0%
% not significant	40.5%	26.2%	81.0%
N/A	0%	0%	2.3%
total	100%	100%	100%

N/A - denotes "not applicable" as insufficient readings for share/s to calculate t stat.

♪ - denotes that binomial distribution probability at 95% level exceeded.

Table 9 above indicates that there are inefficiencies in the rights market. The measure for HSD indicates that 50.0% of shares were significantly underpriced. This underpricing is consistent with the daily measure of significance where 15.8% of days were significantly underpriced. It can be expected that the HSD measure would result in underpricing as no adjustment has been made for dilution in this measure and thus the model can underprice theoretical NPL prices.

The measure for W-HSD indicates that 69.0% of shares/NPL issues were significantly overpriced and 4.8% were significantly underpriced. This overpricing is consistent with the daily measure of significance where 68.4% of days were significantly overpriced. Thus even with the dilution adjustment, the majority of issues are significantly overpriced.

According to the expectations developed in section 5.5 above, the W-ISD measure should be the most robust. This measure indicates that 16.7% of shares/NPL issues were significantly overpriced. This overpricing is consistent with the daily measure of significance where 31.6% of days were significantly overpriced.

Using the two-tailed test for significance of difference between proportions, the difference between the percentage issues overpriced for the W-HSD and W-ISD prices has a z statistic which is significant at the 95% level. The difference between the percentage issues underpriced for the W-HSD and W-ISD prices has a z statistic which is not significant at the 95% level.

Table 10 below presents the detail of the t statistic by share/NPL issue for each measure of NPL price. This detail is summarised in table 9 above.

The results of the statistical measures for both daily and per issue over/under-pricing is consistent. Given the expectations developed in section 5.5 above that the W-ISD measure should best approximate actual NPL prices, the binomial distribution probability at 95% level is exceeded for all significant mispricing indicated above. It can thus be concluded that at the 95% confidence level, the null hypothesis is rejected and that the rights market is inefficient.

Table 10 t Stat by Year by Share for Each Measure of NPL Price

Year	Share	Sector	X (c)	q	HSD Measure	HSD	W-HSD	W-ISD
1990	Middle Wits	Financial	550	0.33	0.701	-6.1616*	2.2861*	-0.2538
	Northam Platinum	Mining	2200	1	0.3906	-0.1475	7.5946*	0.5422
	Rand Leases	Mining	30	9	1.0974	-2.5065*	5.9753*	0.0
	Simmer Jack Mines	Mining	225	1.95	0.7993	-6.3483*	3.2677*	0.1821
	Standard Bank Prop Fund	Financial	125	0.15	0.3626	-6.0579*	-4.4296*	-2.3333
1991	Capital Property Fund	Financial	245	0.4	0.1529	-2.5757*	0.9698	0.3413
	Electronic Media Network	Industrial	575	0.29	0.6145	-5.1806*	21.6997*	1.6441
	Engen	Industrial	2500	0.4	0.2973	-6.485*	22.1488*	3.3699*
	First International Trust	Financial	900	0.3	0.3726	0.8194	9.236*	1.5626
	Metropolitan Life	Financial	850	0.5	0.3238	-1.0347	22.4868*	2.2118*
	Sappi	Industrial	3200	0.35	0.3581	-2.2871*	15.169*	2.5021*
	Syfrets Property Fund	Financial	700	0.2	0.2027	-2.5871*	1.2579	-0.124
	Tamboti Property Fund	Financial	270	0.4	0.1979	-4.092*	-2.1381	-1.0
	Tempora Investments	Financial	1500	0.25	0.4085	-1.2657	-0.8633	-0.20

* - t statistic significant at 5% confidence level.

Table 10 t Stat by Year by Share for Each Measure of NPL Price / Cont...

Year	Share	Sector	X (c)	q	HSD Measure	HSD	W-HSD	W-ISD
1992	Click Stores	Industrial	2000	0.13	0.3655	-0.8872	1.4945	1.1096
	Crusader Life Assurance	Financial	210	0.47	0.4196	-0.2318	1.6566	0.0696
	First National Bank Hold	Financial	5000	0.15	0.2054	3.5178*	9.236*	1.5626
	Gencor	Financial	1000	0.17	0.3576	0.7919	9.3205*	0.4727
	Gencor Beheerend	Financial	900	0.18	0.4125	-1.5197	1.1893	-0.7104
	Metkor Group	Industrial	220	0.11	0.4316	-5.16*	-3.0041*	-0.399
	Northam Platinum	Mining	1475	0.42	0.401	3.8646*	9.0562*	0.5292
	Otis Elevator Company	Industrial	220	0.2	0.5496	1.0514	2.6266*	-0.7322
	Perskor Groep	Industrial	2500	0.29	0.4843	-1.6624	13.3258*	0.9586
	Plateglass & Shatterprufe	Industrial	4300	0.5	0.2079	-3.1228*	5.8453*	0.7853
	Standard Bank Inv Corp	Financial	6000	0.1	0.2777	0.122	10.295*	2.0307
	Sun International (Bop)	Industrial	3200	0.05	0.4141	8.8385*	12.7549*	2.5548*
	Tempora Investments	Financial	1500	0.25	0.5046	0.595	4.8786*	-0.5127
	Tiger Oats	Industrial	3700	0.15	0.3387	0.3641	4.6118*	2.1068

* - t statistic significant at 5% confidence level.

Table 10 t Stat by Year by Share for Each Measure of NPL Price / Cont...

Year	Share	Sector	X (c)	q	HSD Measure	HSD	W-HSD	W-ISD
1993	ABS Holdings	Industrial	120	1	0.637	-5.0952*	-1.4556	-1.372
	Dimension Data Holdings	Industrial	850	0.25	0.4168	2.6821*	7.8351*	2.4427*
	Higate Property Fund	Financial	680	0.3	0.1357	1.0398	5.7155*	-0.3333
	Holdains	Industrial	4000	0.2	0.2147	0.1119	5.683*	3.6495*
	Power Technologies	Industrial	400	0.11	0.3704	1.1404	4.1344*	0.3106*
	Suncrush	Industrial	40000	0.1	0.2104	-2.7648*	-1.1283	N/A
	Tempora Investments	Financial	1800	0.5	0.2944	-3.026*	6.0852*	0.0983
	Waicor	Industrial	70	1.5	0.8344	-2.7521*	1.9907	-1.3333
1994	Amalgamated Retail	Industrial	750	2.25	0.5618	-6.1386*	5.6525*	-0.6972
	Basil Read Holdings	Industrial	105	1	0.8786	-3.7811*	4.5696*	0.937
	Ettington Investments	Financial	400	1	0.4523	-4.1538	0.378	-1.0
	H J Joel Gold Mining Co	Mining	290	1	1.2123	-11.17*	2.3958*	-0.4494
	Laser Transport Holdings	Industrial	450	0.8	0.5098	-3.6922*	4.2692*	-0.3364
	Sentrachem	Industrial	850	0.3	0.2665	-4.3492*	13.0161*	1.553

* - t statistic significant at 5% confidence level.

7 CONCLUSION

7.1 Summary

The problem was defined in the introduction as :

"If the market is inefficient it is failing in its role of being an efficient allocator of scarce resources."

The objective of this research which was defined in the introduction is :

"... to establish whether the South African market for rights issues is efficient."

The following null hypothesis was tested :

Ho : the South African market for rights issues is efficient.

Restated in terms of the empirical work done :

$Ho_1 : \boldsymbol{\mu} = 0$

In other words, the mean of the differences between the actual observed NPL prices and those generated by the B-S model approximates zero.

$$Ho_2 : S\ (1/(1+q)) \geq W \geq \max\ [0, (S - X)\ (1/(1+q)), (S - Xe^{-rt} - D)\ (1/(1+q))]$$

In other words, the price of an NPL falls within the theoretical pricing boundaries described in section 3.9 above.

An empirical test was performed to determine the presence of mispricing of NPLs on the JSE. To accomplish this, an appropriate NPL pricing model was required. The model chosen was the Black-Scholes option valuation model. This model was chosen due to its acceptance in practice in valuing options, and its robustness established with reference to the literature review. The model was adjusted to allow for the dilution effect which occurs when NPL holders exercise their rights and the number of shares in issue increases.

Suitable estimates for the input variables had to be found. Two alternative methods of volatility estimation were considered : Historical Standard Deviation (HSD) and Implied Standard Deviation (ISD). For each NPL issue in the final sample, a daily theoretical NPL price was calculated for each volatility estimate (HSD, W-HSD and W-ISD). Daily differences were calculated between actual NPL prices and theoretical prices for those days when there was trading in both the share and the NPL.

The following empirical tests were performed :

- tests of theoretical NPL boundary conditions,
- two-tailed t statistic significance tests on a daily basis, and
- two-tailed t statistic significance tests on a per issue basis.

The significance tests were performed at the 95% confidence level. Computer programs were written to perform the necessary calculations and data analysis.

Theoretical upper and lower boundary conditions for NPLs should never be exceeded in an efficient market. For the calculation of boundary conditions and the subsequent test to determine whether they were exceeded, the test was performed on a daily basis for every NPL issue. Results showed inefficiencies associated with the lower boundary condition. In 55.78% of all days measured the lower boundary was exceeded for the non dilution adjusted measure. It is expected that the lower boundary condition for C could be exceeded as there is no adjustment for dilution, which can have a significant impact on the value of C. In 14.56% of all days measured the lower boundary was exceeded for the dilution adjusted measure (W). This indicates inefficiencies in the NPL market as the investor on these days could have generated a higher return per share/NPL by going short one share, buying one NPL, buying D, and placing Xe^{-rt} in default-free bonds maturing on the expiration date. This position is then liquidated on maturity.

The t stat significance tests were performed on a daily basis. The measure for HSD indicated that 15.8% of days were significantly underpriced. It can be expected that the HSD measure would result in underpricing as no adjustment has been made for dilution in this measure and thus the model can underprice theoretical NPL prices. The measure for W-HSD indicated that 68.4% of days were significantly overpriced. Thus even with the dilution adjustment, the majority of days are significantly overpriced. The W-ISD measure (according to expectations, the more robust measure) indicated that 31.6% of days were significantly overpriced. The binomial distribution probability at 95% level is exceeded for all significant over and underpricing. It can be concluded that at the 95% confidence level, the null hypothesis is rejected and that the rights market is inefficient.

The t stat significance tests were performed on a per issue basis. The measure for HSD indicated that 50.0% of shares were significantly underpriced. This underpricing, and potential reason for the underpricing, is consistent with the daily measure above. The measure for W-HSD indicated that 69.0% of shares/NPL issues were significantly overpriced and 4.8% were significantly underpriced. This overpricing is consistent with the daily measure above. As per the daily measure, even with the dilution adjustment, the majority of issues are significantly overpriced. The W-ISD measure indicated that 16.7% of shares/NPL issues were significantly overpriced. This overpricing is also consistent with the daily measure of significance above.

The results of the statistical measures for both daily and per issue over/under-pricing is consistent. Given the expectations developed in the research that the W-ISD measure should best approximate actual NPL prices, the binomial distribution probability at 95% level is exceeded for all significant mispricing. It can thus be concluded that at the 95% confidence level, the null hypothesis is rejected and that the rights market is inefficient.

It should be noted that the findings of this research may be due, in part, to the limitations referred to in the methodology. Certain of these limitations are addressed in section 7.2.

7.2 Recommendations for Future Research

For the reasons discussed in the introduction, and elsewhere in this dissertation, the field of rights issues and market efficiency is an interesting and pertinent one. The dissertation has indicated areas which have the potential to be researched and studied further. The following are suggested as areas for further research and study in this area :

- the use of a different model from the B-S model to estimate the price of a right. The model used should allow for all the characteristics of rights detailed in the dissertation above. One model that has been used in empirical testing is the CEV model which has proved robust in option valuations [Macbeth & Merville, 1980].

- the use of different estimators for the standard deviation parameter, and possibly risk-free interest rate parameter, in the B-S model.

- the extension of the study period to cover a longer time period. It is doubtful, however, whether this adjustment will add to the accuracy of the study as the pre-1990 rights issues were not as frequent or as highly traded as the post-1990 issues studied above.

- for the most robust measure, the W-ISD measure, most of the significant t statistics occur in the latter stages of the rights issues. Thus it seems as though, in general terms, the overpricing of NPLs becomes greater as the time to expiration decreases. The reason for this is not clear and could be explored further in future research.

- the B-S and other derivative pricing models could be used to study the efficiency of the South African market for other convertible securities, for example, convertible debentures and preference shares. The results of the study could then be contrasted with the results of this dissertation and relevant conclusions on market efficiency drawn.

- normative theoretical research could be conducted into the inefficiencies in the South African share derivative market highlighted in this and other studies. Input could be obtained from various sources, for example, the JSE, stockbrokers, traders, portfolio managers, and private investors. The research could be extended to offer suggestions on alternative methods for raising equity capital that are not available to South African companies at present, and their potential effects on market efficiencies. Alternative methods of raising equity capital include publicly traded company issued share options, non-selective public and private placings, and different forms of convertible equity instruments. This normative research could provide a theoretical base for future research into South African financial markets.

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9 GLOSSARY OF ABBREVIATIONS

BA Rate	=	Banker's Acceptance Rate
B-S Model	=	Black-Scholes Model
CAPM	=	Capital Asset Pricing Model
CAR	=	Cumulative Abnormal Returns
CBOE	=	Chicago Board of Options Exchange
CDO	=	Closing Date of Offer
CEV Model	=	Constant Elasticity of Variance Model
CV Model	=	Constant Variance Model
EMH	=	Efficient Market Hypothesis
FIFO	=	First-In-First-Out
FSD Measure	=	Future Standard Deviation Measure
HSD Price	=	B-S formula (non-dilution adjusted) with the HSD as a measure of standard deviation
HSD Measure	=	Historical Standard Deviation Measure
HSE	=	Helsinki Stock Exchange
ISD Price	=	B-S formula (non-dilution adjusted) with the ISD as a measure of standard deviation
ISD Measure	=	Implied Standard Deviation Measure
J-D Model	=	Jump-Diffusion Model
JSE	=	Johannesburg Stock Exchange
LOA	=	Letter of Allocation
LDR	=	Last Date to Register
LIFO	=	Last-In-First-Out
LSE	=	London Stock Exchange
NPL	=	Nil Paid Letter
OPM	=	Option Pricing Model
UK	=	United Kingdom
W-HSD Price	=	B-S formula (dilution adjusted) with the HSD as a measure of standard deviation

W-ISD Price	=	B-S formula (dilution adjusted) with the W-ISD as a measure of standard deviation
W-ISD Measure	=	Dilution adjusted Implied Standard Deviation Measure

10 GLOSSARY OF SYMBOLS

r^2	=	coefficient of determination
C	=	current call option value
S	=	current stock price
X, K	=	exercise price
r	=	risk free interest rate (the annualized continuously compounded rate on a safe asset with the same maturity as the expiration of the option/NPL)
t	=	time to maturity of option in years
σ	=	standard deviation of the annualized continuously compounded rate of return of the stock
N(d)	=	probability that a standardized, normally distributed, random variable will be less than or equal to d. This equals the area under the normal curve up to d
W	=	NPL price
q	=	the ratio of the number of new shares to be issued to the number of shares currently outstanding
μ	=	mean of normal distribution
D	=	the dividend paid (per share) during the life of the NPL

APPENDIX A

Computer Programs

```
/************************************************************************/
/* MODULE:        OPTIONS.CPP                                            */
/* DESCRIPTION: Main program module that controls program sequence.      */
/* AUTHOR:        C.E. Alston                                            */
/************************************************************************/
#include <stdlib.h>
#include <stdio.h>
#include <conio.h>
#include <math.h>
#include <iostream.h>
#include <fstream.h>
#include <strstream.h>
#include <iomanip.h>
#include <string.h>
#include <dir.h>

#ifndef _DATECLAS_HPP_
 #include "dateclas.hpp"
#endif

#ifndef _BLCKSHOL_HPP_
 #include "blckshol.hpp"
#endif

#define ROUND(value) ((int)floor(value+0.5))

#define DAYS_IN_YEAR 365
#define MAX_NO_FILES 42
#define MAX_RIGHTS_ENTRIES 21
#define UNITS 1.0 //cents; use 100.0 for Rands
#define INVALID 0xFF
static int file_no = 0;

static double days_in_year = 365.0;

static double hsd_result;
static double hsd_prices[MAX_RIGHTS_ENTRIES];
static double isd_values[MAX_RIGHTS_ENTRIES];
static double isd_prices[MAX_RIGHTS_ENTRIES];
static double W_isd_values[MAX_RIGHTS_ENTRIES];
static double W_isd_prices[MAX_RIGHTS_ENTRIES];
static double W_hsd_prices[MAX_RIGHTS_ENTRIES];
static boolean valid_trading_day[MAX_RIGHTS_ENTRIES];
static boolean shares_traded[MAX_RIGHTS_ENTRIES];
static boolean rights_traded[MAX_RIGHTS_ENTRIES];
static boolean C_valid[MAX_RIGHTS_ENTRIES];
static boolean W_valid[MAX_RIGHTS_ENTRIES];
static double W_guess1;
static double W_guess2;
static double share_C_valid_yes;
static double share_C_valid_no;
static double share_W_valid_yes;
static double share_W_valid_no;
static int total_W_C_valid_yes_no;
static int total_C_valid_yes;
static int total_W_valid_yes;


static double exercise_price[MAX_NO_FILES];
static double M_value[MAX_NO_FILES];
static double n_value[MAX_NO_FILES];
static double fT_value[MAX_NO_FILES];
static double x_factor[MAX_NO_FILES];

typedef char tFileName[100];
static tFileName extra_file = "C:\\OPTIONS\\SHARES\\EXTRA.INI";
static tFileName ba_rate_file = "C:\\OPTIONS\\SHARES\\BA.OUT";
static tFileName results_file = "RESULTS3.LOG";
static tFileName hsd_tstat_file = "HSD.LOG";
static tFileName w_hsd_tstat_file = "W_HSD.LOG";
static tFileName w_isd_tstat_file = "W_ISD.LOG";

typedef struct
{
 char s[MAXPATH];
 char drive[MAXDRIVE];
 char dir[MAXDIR];
 char file[MAXFILE];
 char ext[MAXEXT];
} tFileStruct;

static tFileStruct Rights_Files[MAX_NO_FILES];
static tFileStruct Shares_Files[MAX_NO_FILES];

typedef enum
{
 fRIGHTS = 0,
 fSHARES = 1,
 fBA_RATE = 2,
 fEXTRA = 3
} tInputFiles;
#define MAX_NO_INPUT_FILE_TYPES 4
static ifstream Input_Files[MAX_NO_INPUT_FILE_TYPES];

typedef enum
{
 fRESULTS = 0,
 fHSD_TSTAT = 1,
 fW_HSD_TSTAT = 2,
 fW_ISD_TSTAT = 3
} tOutputFiles;
#define MAX_NO_OUTPUT_FILE_TYPES 4
```

```
static ofstream Output_Files[MAX_NO_OUTPUT_FILE_TYPES];

typedef struct
{
 char share[20];
 int entries;
 char first_day[8];
 char last_day[8];
} sInfo;

typedef struct
{
 char day[8];
 double last;
 long int volume; //values >= 50000
} sData;

static sInfo rights_info;
static sData rights_data[MAX_RIGHTS_ENTRIES];

static sInfo shares_info;
static sData shares_data[MAX_RIGHTS_ENTRIES];

typedef struct
{
 char day[8];
 double rate;
} sBaRateData;
static sBaRateData ba_rate[MAX_RIGHTS_ENTRIES];

static date_class LastHsdDay;
static date_class FirstHsdDay;

static sData hsd_data[DAYS_IN_YEAR];
static double ln_price_relative[DAYS_IN_YEAR];
static int number_hsd_days;


/*=======================================================================*/
/*----------------------------------------------------------------------*/
/* FUNCTION :                                                           */
/* DESCRIPTION : Reset file pointer to beginning of file.               */
/*----------------------------------------------------------------------*/
boolean ResetInputFile(tInputFiles file_type, char* file_name)
{
 Input_Files[file_type].seekg(0, ios::beg);
 return TRUE;
}

/*----------------------------------------------------------------------*/
/* FUNCTION :                                                           */
/* DESCRIPTION : Opens the given type of file and filename.             */
/*----------------------------------------------------------------------*/
boolean OpenInputFile(tInputFiles file_type, char* file_name)
{
 Input_Files[file_type].open(file_name);
 if(Input_Files[file_type].bad())
 {
  cout << "Couldn't Open Input File: " << file_name << endl;
  return FALSE;
 }
 else
 {
  cout << "Input File Opened OK: " << file_name << endl;
  return TRUE;
 }
}

/*----------------------------------------------------------------------*/
/* FUNCTION :                                                           */
/* DESCRIPTION : Closes the given type of file and filename.            */
/*----------------------------------------------------------------------*/
void CloseInputFile(tInputFiles file_type, char* file_name)
{
 Input_Files[file_type].close();
}

/*----------------------------------------------------------------------*/
/* FUNCTION :                                                           */
/* DESCRIPTION : Opens the given type of file and filename.             */
/*----------------------------------------------------------------------*/
boolean OpenOutputFile(tOutputFiles file_type, char* file_name)
{
 Output_Files[file_type].open(file_name);
 if(Output_Files[file_type].bad())
 {
  cout << "Couldn't Open Output File: " << file_name << endl;
  return FALSE;
 }
 else
 {
  cout << "Output File Opened OK: " << file_name << endl;
  return TRUE;
 }
}

/*----------------------------------------------------------------------*/
/* FUNCTION :                                                           */
/* DESCRIPTION : Closes the given type of file and filename.            */
/*----------------------------------------------------------------------*/
void CloseOutputFile(tOutputFiles file_type, char* file_name)
{
```

```
 Output_Files[file_type].close();
}

/*------------------------------------------------------------------------*/
/* FUNCTION :                                                             */
/* DESCRIPTION :                                                          */
/*------------------------------------------------------------------------*/
void InputRightsValues(void)
{
 boolean first_day = TRUE;
 double guess1, guess2 = 0.0;
 int i = 0;

 for (i = 0; i < MAX_RIGHTS_ENTRIES; i++)
     rights_traded[i] = TRUE;

 if (OpenInputFile(fRIGHTS, Rights_Files[file_no].s))
 {
  Input_Files[fRIGHTS] >> rights_info.share >> rights_info.entries >> rights_info.first_day >> rights_info.last_day;
  Input_Files[fRIGHTS].ignore(80, '\n'); //ignore rest of line
  printf("\n%s,  %d,  %s,  %s", rights_info.share, rights_info.entries, rights_info.first_day, rights_info.last_day);

  for (i = 0; i < rights_info.entries; i++)
  {
   Input_Files[fRIGHTS] >> rights_data[i].day >> rights_data[i].last >> rights_data[i].volume;
   rights_data[i].last = rights_data[i].last/UNITS;
//   printf("\n%s  %f  %ld", rights_data[i].day, rights_data[i].last, rights_data[i].volume);
   if (rights_data[i].volume == 0.0)
      rights_traded[i] = FALSE;
   // Find the lowest and highest rights price
   if (first_day)
   {
    first_day = FALSE;
    guess1 = rights_data[i].last;
    guess2 = rights_data[i].last;
   }
   else
   {
    if (rights_data[i].last < guess1)
       guess1 = rights_data[i].last;
    else if (rights_data[i].last > guess2)
       guess2 = rights_data[i].last;
   }
  }
  CloseInputFile(fRIGHTS, Rights_Files[file_no].s);
  double difference = (guess2-guess1);
  guess1 = guess1 - difference/2;
  if (guess1 <= 0.0) guess1 = 0.1;
  guess2 = guess2 + difference/2;
  W_guess1 = guess1;
  W_guess2 = guess2;
 }
}

/*------------------------------------------------------------------------*/
/* FUNCTION :                                                             */
/* DESCRIPTION :                                                          */
/*------------------------------------------------------------------------*/
void InputSharesValues(void)
{
 char previous_day[10];
 boolean first_day = TRUE;
 int i = 0;
 int line_no = 0;
 double days;
 double t;
 double r;
 double C;
 double W;
 double S;
 double X;
 double q;

 for (i = 0; i < MAX_RIGHTS_ENTRIES; i++)
     shares_traded[i] = TRUE;

 if (OpenInputFile(fSHARES, Shares_Files[file_no].s))
 {
  ResetInputFile(fSHARES, Shares_Files[file_no].s);
  Input_Files[fSHARES] >> shares_info.share >> shares_info.entries >> shares_info.first_day >> shares_info.last_day;
  Input_Files[fSHARES].ignore(80, '\n'); //ignore rest of line
  printf("\n%s,  %d,  %s,  %s", shares_info.share, shares_info.entries, shares_info.first_day, shares_info.last_day);

  i = 0;
  while ((i < rights_info.entries) && (line_no < shares_info.entries))
  {
   Input_Files[fSHARES] >> shares_data[i].day >> shares_data[i].last >> shares_data[i].volume;
   shares_data[i].last = (shares_data[i].last*x_factor[file_no])/UNITS;
   //Check if date read matches the Rights date
   if (strcmp(rights_data[i].day,shares_data[i].day) == 0)
   {
    if (first_day)
    {
     date_class TempDate(previous_day);
     LastHsdDay = TempDate;
     date_class TempDate2 = (LastHsdDay-days_in_year);
     FirstHsdDay = TempDate2;
     first_day = FALSE;
    }
//     printf("\n%s  %f  %ld", shares_data[i].day, shares_data[i].last, shares_data[i].volume);
    if (shares_data[i].volume == 0.0)
       shares_traded[i] = FALSE;
```

```
  i++;
 }
 if (i < rights_info.entries)
    strcpy(previous_day, shares_data[i].day);
 line_no++;
}
CloseInputFile(fSHARES, Shares_Files[file_no].s);

share_C_valid_yes = 0.0;
share_C_valid_no = 0.0;
share_W_valid_yes = 0.0;
share_W_valid_no = 0.0;
date_class Last_Rights_Day(rights_data[rights_info.entries-1].day);
for (i = 0; i < rights_info.entries; i++)
{
 total_W_C_valid_yes_no++;
 date_class Day(shares_data[i].day);
 days = (double)(Last_Rights_Day - Day); //for last day this is 0 giving t=0 and bombing BlackScholes
 if (days == 0.0) days = 1.0;
 t = (days / days_in_year);
 r = ba_rate[i].rate;
 C = rights_data[i].last;
 W = rights_data[i].last;
 S = shares_data[i].last;
 X = exercise_price[file_no];
 q = fi_value[file_no];
 if (C > (S - X*exp(-r*t)))
 {
  C_valid[i] = TRUE;
  share_C_valid_yes++;
  total_C_valid_yes++;
 }
 if (W > ((1.0/(1.0+q))*(S - X*exp(-r*t))))
 {
  W_valid[i] = TRUE;
  share_W_valid_yes++;
  total_W_valid_yes++;
 }
}
share_C_valid_yes = (share_C_valid_yes / (double)rights_info.entries) * 100.0;
share_C_valid_no = 100.0 - share_C_valid_yes;
share_W_valid_yes = (share_W_valid_yes / (double)rights_info.entries) * 100.0;
share_W_valid_no = 100.0 - share_W_valid_yes;
}
}

/*-----------------------------------------------------------------*/
/* FUNCTION :                                                      */
/* DESCRIPTION :                                                   */
/*-----------------------------------------------------------------*/
boolean InputExtraValues(void)
{

 if (OpenInputFile(fEXTRA, extra_file))
 {
  Input_Files[fEXTRA].ignore(80, '\n'); //ignore first line
  Input_Files[fEXTRA].ignore(80, '\n'); //ignore second line
  for (int i = 0; i < MAX_NO_FILES; i++)
  {
   strcpy(Rights_Files[i].drive, "C:");
   strcpy(Shares_Files[i].drive, "C:");
   strcpy(Rights_Files[i].dir, "\\OPTIONS\\RIGHTS");
   strcpy(Shares_Files[i].dir, "\\OPTIONS\\SHARES");
   strcpy(Rights_Files[i].ext, ".OUT");
   strcpy(Shares_Files[i].ext, ".OUT");
   Input_Files[fEXTRA] >> Shares_Files[i].file >> Rights_Files[i].file >> exercise_price[i] >> M_value[i] >> n_value[i]
   exercise_price[i] = exercise_price[i]/UNITS;
   Input_Files[fEXTRA].ignore(80, '\n'); //ignore rest of line
   fnmerge(Rights_Files[i].s, Rights_Files[i].drive, Rights_Files[i].dir, Rights_Files[i].file, Rights_Files[i].ext);
   fnmerge(Shares_Files[i].s, Shares_Files[i].drive, Shares_Files[i].dir, Shares_Files[i].file, Shares_Files[i].ext);
  }
  CloseInputFile(fEXTRA, extra_file);
  return TRUE;
 }
 else
    return FALSE;
}

/*-----------------------------------------------------------------*/
/* FUNCTION :                                                      */
/* DESCRIPTION :                                                   */
/*-----------------------------------------------------------------*/
void InputBaRateValues(void)
{
 int i = 0;
 boolean match_not_found = TRUE;

 if (OpenInputFile(fBA_RATE, ba_rate_file))
 {
  ResetInputFile(fBA_RATE, ba_rate_file);
  Input_Files[fBA_RATE].ignore(80, '\n');  //ignore first of line
  while (match_not_found)
  {
   Input_Files[fBA_RATE] >> ba_rate[i].day >> ba_rate[i].rate;
   ba_rate[i].rate = ba_rate[i].rate / 10000.0;
   Input_Files[fBA_RATE].ignore(80, '\n');  //ignore rest of line
   //Check if date read matches the first Rights date
   if (strcmp(rights_data[i].day,ba_rate[i].day) == 0)
   {
    match_not_found = FALSE;
    for (i = 1; i < rights_info.entries; i++)
    {
```

```
    Input_Files[fBA_RATE] >> ba_rate[i].day >> ba_rate[i].rate;
    ba_rate[i].rate = ba_rate[i].rate / 10000.0;
    Input_Files[fBA_RATE].ignore(80, '\n');  //ignore rest of line
   } //end of for
  } //end of if
 } //end of while
 CloseInputFile(fBA_RATE, ba_rate_file);
} //end of if
}

/*--------------------------------------------------------------------*/
/* FUNCTION :                                                         */
/* DESCRIPTION :                                                      */
/*--------------------------------------------------------------------*/
void InputPreviousYearsValues(void)
{
 int i = 0;
 boolean first_day_found = FALSE;
 boolean last_day_found = FALSE;

 if (OpenInputFile(fSHARES, Shares_Files[file_no].s))
 {
  ResetInputFile(fSHARES, Shares_Files[file_no].s);
  Input_Files[fSHARES].ignore(80, '\n'); //ignore first line
  while (!last_day_found)
  {
   Input_Files[fSHARES] >> hsd_data[i].day >> hsd_data[i].last >> hsd_data[i].volume;
   hsd_data[i].last = (hsd_data[i].last*x_factor[file_no])/UNITS;
   if (!first_day_found)
   {
    date_class Day(hsd_data[i].day);
    if ((FirstHsdDay == Day) || (FirstHsdDay < Day))
    {
     first_day_found = TRUE;
     i++;
    }
   }
   else
   {
    date_class Day(hsd_data[i].day);
    if (LastHsdDay == Day)
       last_day_found = TRUE;
    i++;
   }
  }
  number_hsd_days = i--;
  CloseInputFile(fSHARES, Shares_Files[file_no].s);
 }
}

/*--------------------------------------------------------------------*/
/* FUNCTION :                                                         */
/* DESCRIPTION : Calculate the Historical Standard Deviation (HSD).   */
/*--------------------------------------------------------------------*/
void CalculateHSD(void)
{
 InputPreviousYearsValues();

 int i = 1;
 double price_relative_sum = 0.0;
 double mean = 0.0;
 double daily_variance = 0.0;
 double daily_variance_sum = 0.0;
 double variance = 0.0;

 while (i < number_hsd_days)
 {
  ln_price_relative[i-1] = log((double)hsd_data[i].last / (double)hsd_data[i-1].last);
  price_relative_sum = price_relative_sum + ln_price_relative[i-1];
  i++;
 }
 mean = price_relative_sum / (double)(number_hsd_days-1);
 i = 0;
 while (i < number_hsd_days)
 {
  daily_variance = pow((ln_price_relative[i] - mean), 2.0);
  daily_variance_sum = daily_variance_sum + daily_variance;
  i++;
 }
 variance = (daily_variance_sum / (double)(number_hsd_days-1)) * ((double)(number_hsd_days-1)/(double)(number_hsd_days-
 variance = variance * days_in_year;
 hsd_result = sqrt(variance);
}

/*--------------------------------------------------------------------*/
/* FUNCTION :                                                         */
/* DESCRIPTION :                                                      */
/*--------------------------------------------------------------------*/
void CalculateHSDPrices(void)
{
 double C, W, S, r, t;
 double sd = hsd_result;
 double X = exercise_price[file_no];
 int i = 0;
 double days = 0.0;
 double M = M_value[file_no];
 double n = n_value[file_no];
 double fi = fi_value[file_no];

// InputBaRateValues();
 date_class Last_Rights_Day(rights_data[rights_info.entries-1].day);
```

```
/* Cannot calculate HSD price for last day, as then t=0 and get divide by 0 error in BS formula,
   so can only do till (rights entries - 1) */
for (i = 0; i < (rights_info.entries-1); i++)
{
 //Only interested in trading days
 if (shares_traded[i])
 {
  date_class Day(shares_data[i].day);
  days = (double)(Last_Rights_Day - Day); //for last day this is 0 giving t=0 and bombing BlackScholes
  if (days == 0.0) days = 1.0;
  t = (days / days_in_year);
  S = shares_data[i].last;
  r = ba_rate[i].rate;
  C = CalculateC(sd, S, X, r, t);
  hsd_prices[i] = C;
  W = CalculateW(sd, S, X, r, t, M, n, fi, W_guess1, W_guess2);
  W_hsd_prices[i] = W;
 }
}
}

/*-----------------------------------------------------------------------*/
/* FUNCTION :                                                            */
/* DESCRIPTION :                                                         */
/*-----------------------------------------------------------------------*/
void CalculateISDandISDPrices(void)
{
 double C, sd, S, r, t;
 double X = exercise_price[file_no];
 double days = 0.0;
 double W, W_sd;
 double M = M_value[file_no];
 double n = n_value[file_no];
 double fi = fi_value[file_no];
 int i = 0;
 boolean first_trading_day_found = FALSE;

 date_class Last_Rights_Day(rights_data[rights_info.entries-1].day);

 //Find first valid trading day
 while ( (!first_trading_day_found) && (i < (rights_info.entries-1) ) )
 {
  valid_trading_day[i] = (boolean)(shares_traded[i] && rights_traded[i]);
  if (valid_trading_day[i])
  {
   printf("\nDay Number = %d  was valid trading day", i+1);
   first_trading_day_found = TRUE;
   // First trading day's ISD price is same as that day's calculated HSD price
   isd_prices[i] = hsd_prices[i];
  }
  else
  {
   printf("\nDay Number = %d  was not a valid trading day", i+1);
   isd_prices[i] = 0.0;
  }
  i++;
 }

 /* Cannot calculate ISD price for last day, as then t=0 and get divide by 0 error in BS formula,
    so can only do till (rights entries - 1) */
 while (i < (rights_info.entries-1))
 {
  //Only interested in valid trading days where volume > 0
  valid_trading_day[i] = (boolean)(shares_traded[i] && rights_traded[i]);
  if (valid_trading_day[i])
  {
   printf("\nDay Number = %d  was valid trading day", i+1);
   date_class Day(shares_data[i].day);
   days = (double)(Last_Rights_Day - Day);
   //Use previous day's info to calculate ISD for today
   t = ((days+1.0) / days_in_year); //is extra day as using previous day's stuff
   S = shares_data[i-1].last;
   r = ba_rate[i-1].rate;
   C = rights_data[i-1].last;
   if (C_valid[i-1])
   {
    sd = CalculateVolatility(C, S, X, r, t);
    isd_values[i] = sd;
   }
   //Calculate the diluted ISD for today
   if (W_valid[i-1])
   {
    W = C;
    W_sd = CalculateDilutedVolatility(W, S, X, r, t, M, n, fi);
    W_isd_values[i] = W_sd;
   }

   //Now use previous day's ISD to calculate price for today
   if (days == 0.0) days = 1.0;
   t = (days / days_in_year);
   S = shares_data[i].last;
   r = ba_rate[i].rate;
   if (C_valid[i-1])
   {
    if ((sd != ITERATION_UNSUCCESSFUL) && (sd != 0.0)) //Check that iterative procedure successful
       isd_prices[i] = CalculateC(sd, S, X, r, t);
    else
       isd_prices[i] = sd;
   }
   if (W_valid[i-1])
   {
    if ((W_sd != ITERATION_UNSUCCESSFUL) && (W_sd != 0.0)) //Check that iterative procedure successful
```

```
      W_isd_prices[i] = CalculateW(W_sd, S, X, r, t, M, n, fi, W_guess1, W_guess2);
    else
      W_isd_prices[i] = W_sd;
   }
  }
  else //Not a valid trading day
     printf("\nDay Number = %d  was not a valid trading day", i+1);
  i++;
 }
 valid_trading_day[i] = (boolean)(shares_traded[i] && rights_traded[i]); //for the last rights day
}

/*----------------------------------------------------------------------------*/
/* FUNCTION :                                                                 */
/* DESCRIPTION :                                                              */
/*----------------------------------------------------------------------------*/
void OutputResults(void)
{
 int i = 0;

 Output_Files[fRESULTS] << setw(20) << rights_info.share;
 Output_Files[fRESULTS] << setw(10) << "HSD = " << setw(6) << setprecision(4) << hsd_result;
 Output_Files[fRESULTS] << setw(7) << "X = " << setw(5) << setprecision(0) << exercise_price[file_no];
 Output_Files[fRESULTS] << setw(7) << "q = " << setw(5) << fi_value[file_no];
 Output_Files[fRESULTS] << setw(10) << "C-Yes = " << setw(5) << setprecision(2) << share_C_valid_yes << "%";
 Output_Files[fRESULTS] << setw(10) << "C-No = " << setw(5) << setprecision(2) << share_C_valid_no << "%";
 Output_Files[fRESULTS] << setw(10) << "W-Yes = " << setw(5) << setprecision(2) << share_W_valid_yes << "%";
 Output_Files[fRESULTS] << setw(10) << "W-No = " << setw(5) << setprecision(2) << share_W_valid_no << "%";
 Output_Files[fRESULTS] << endl;

 Output_Files[fRESULTS] << setw(16) << "Day Number";
 for (i = 0; i < rights_info.entries; i++)
     Output_Files[fRESULTS] << setw(8) << (i+1);
 Output_Files[fRESULTS] << endl;

 Output_Files[fRESULTS] << setw(16) << "C > (S-X)";
 for (i = 0; i < rights_info.entries; i++)
 {
  if (C_valid[i])
     Output_Files[fRESULTS] << setw(8) << "Yes";
  else
     Output_Files[fRESULTS] << setw(8) << "No";
 }
 Output_Files[fRESULTS] << endl;

 Output_Files[fRESULTS] << setw(16) << "W>(1/(1+q))(S-X)";
 for (i = 0; i < rights_info.entries; i++)
 {
  if (W_valid[i])
     Output_Files[fRESULTS] << setw(8) << "Yes";
  else
     Output_Files[fRESULTS] << setw(8) << "No";
 }
 Output_Files[fRESULTS] << endl;

 Output_Files[fRESULTS] << setw(16) << "Rights Price";
 for (i = 0; i < rights_info.entries; i++)
     Output_Files[fRESULTS] << setw(8) << setprecision(0) << rights_data[i].last; //actual rights price
 Output_Files[fRESULTS] << endl;

 Output_Files[fRESULTS] << setw(16) << "Share Price";
 for (i = 0; i < rights_info.entries; i++)
     Output_Files[fRESULTS] << setw(8) << setprecision(0) << shares_data[i].last;
 Output_Files[fRESULTS] << endl;

 Output_Files[fRESULTS] << setw(16) << "HSD Price";
 for (i = 0; i < rights_info.entries; i++)
 {
  if (!shares_traded[i])
     Output_Files[fRESULTS] << setw(8) << "n/t";
  else if (hsd_prices[i] == INVALID)
     Output_Files[fRESULTS] << setw(8) << "--";
  else
     Output_Files[fRESULTS] << setw(8) << setprecision(0) << ROUND(hsd_prices[i]); //HSD prices
 }
 Output_Files[fRESULTS] << endl;

 Output_Files[fRESULTS] << setw(16) << "W HSD Price";
 for (i = 0; i < rights_info.entries; i++)
 {
  if (!shares_traded[i])
     Output_Files[fRESULTS] << setw(8) << "n/t";
  else if (W_hsd_prices[i] == -20.0)
     Output_Files[fRESULTS] << setw(8) << "--";
  else if (W_hsd_prices[i] == ITERATION_UNSUCCESSFUL)
     Output_Files[fRESULTS] << setw(8) << "**";
  else
     Output_Files[fRESULTS] << setw(8) << setprecision(0) << ROUND(W_hsd_prices[i]); //W HSD prices
 }
 Output_Files[fRESULTS] << endl;

 Output_Files[fRESULTS] << setw(16) << "ISD Values";
 for (i = 0; i < rights_info.entries; i++)
 {
  if (!valid_trading_day[i])
     Output_Files[fRESULTS] << setw(8) << "n/t";
  else if (isd_values[i] == INVALID)
     Output_Files[fRESULTS] << setw(8) << "--";
  else if (isd_values[i] == ITERATION_UNSUCCESSFUL)
     Output_Files[fRESULTS] << setw(8) << "**";
  else
     Output_Files[fRESULTS] << setw(8) << setprecision(4) << isd_values[i];
```

```
}
Output_Files[fRESULTS] << endl;

Output_Files[fRESULTS] << setw(16) << "ISD Price";
for (i = 0; i < rights_info.entries; i++)
{
 if (!valid_trading_day[i])
    Output_Files[fRESULTS] << setw(8) << "n/t";
 else if (isd_prices[i] == INVALID)
    Output_Files[fRESULTS] << setw(8) << "--";
 else if (isd_prices[i] == ITERATION_UNSUCCESSFUL)
    Output_Files[fRESULTS] << setw(8) << "***";
 else
    Output_Files[fRESULTS] << setw(8) << setprecision(0) << ROUND(isd_prices[i]); //ISD prices
}
Output_Files[fRESULTS] << endl;

Output_Files[fRESULTS] << setw(16) << "W ISD Values";
for (i = 0; i < rights_info.entries; i++)
{
 if (!valid_trading_day[i])
    Output_Files[fRESULTS] << setw(8) << "n/t";
 else if (W_isd_values[i] == INVALID)
    Output_Files[fRESULTS] << setw(8) << "--";
 else if (W_isd_values[i] == ITERATION_UNSUCCESSFUL)
    Output_Files[fRESULTS] << setw(8) << "***";
 else
    Output_Files[fRESULTS] << setw(8) << setprecision(4) << W_isd_values[i];
}
Output_Files[fRESULTS] << endl;

Output_Files[fRESULTS] << setw(16) << "W ISD Price";
for (i = 0; i < rights_info.entries; i++)
{
 if (!valid_trading_day[i])
    Output_Files[fRESULTS] << setw(8) << "n/t";
 else if (W_isd_prices[i] == INVALID)
    Output_Files[fRESULTS] << setw(8) << "--";
 else if (W_isd_prices[i] == ITERATION_UNSUCCESSFUL)
    Output_Files[fRESULTS] << setw(8) << "***";
 else
    Output_Files[fRESULTS] << setw(8) << setprecision(0) << ROUND(W_isd_prices[i]); //W ISD prices
}
Output_Files[fRESULTS] << endl;

Output_Files[fRESULTS] << endl;
Output_Files[fRESULTS] << endl;

if (file_no == (MAX_NO_FILES-1))
{
 double percentage = 0.0;
 percentage = ((double)total_C_valid_yes / (double)total_W_C_valid_yes_no) * 100.0;
 Output_Files[fRESULTS] << setw(30) << "C > (S-X*e(-rt))";
 Output_Files[fRESULTS] << setw(8) << "YES = " << setw(6) << setprecision(2) << percentage << "%";
 percentage = 100.0 - percentage;
 Output_Files[fRESULTS] << setw(8) << "NO = " << setw(6) << setprecision(2) << percentage << "%";

 Output_Files[fRESULTS] << endl;

 percentage = ((double)total_W_valid_yes / (double)total_W_C_valid_yes_no) * 100.0;
 Output_Files[fRESULTS] << setw(30) << "W > (1/(1+q))*(S-X*e(-rt))";
 Output_Files[fRESULTS] << setw(8) << "YES = " << setw(6) << setprecision(2) << percentage << "%";
 percentage = 100.0 - percentage;
 Output_Files[fRESULTS] << setw(8) << "NO = " << setw(6) << setprecision(2) << percentage << "%";

 Output_Files[fRESULTS] << endl;
 Output_Files[fRESULTS] << endl;
}

}

/*-------------------------------------------------------------------------*/
/* FUNCTION :                                                              */
/* DESCRIPTION :                                                           */
/*-------------------------------------------------------------------------*/
void CalculateHsdTstat(void)
{
 int i, j = 0;
 static boolean first_time = TRUE;
 boolean day_valid[MAX_RIGHTS_ENTRIES];
 double share_difference[MAX_RIGHTS_ENTRIES];
 static double daily_difference[MAX_NO_FILES][MAX_RIGHTS_ENTRIES];
 double share_sum = 0;
 static double daily_sum[MAX_RIGHTS_ENTRIES];
 int share_days_valid = 0;
 static int daily_days_valid[MAX_RIGHTS_ENTRIES];
 double share_mean = 0.0;
 double daily_mean = 0.0;
 double sum = 0.0;
 double s = 0.0;
 double t_stat = 0.0;

 if (first_time)
 {
  if (OpenOutputFile(fHSD_TSTAT, hsd_tstat_file))
  {
   first_time = FALSE;
   Output_Files[fHSD_TSTAT] << setw(15) << "HSD TSTAT";
   for (i = 0; i < MAX_RIGHTS_ENTRIES; i++)
   {
    Output_Files[fHSD_TSTAT] << setw(8) << (i+1);
    daily_sum[i] = 0.0;
```

```
      daily_days_valid[i] = 0;
     }
     Output_Files[fHSD_TSTAT] << setw(10) << "T-STAT";
     Output_Files[fHSD_TSTAT] << endl;
     Output_Files[fHSD_TSTAT] << endl;
    }
    else
       printf("\nUnable to open HSD.LOG file -- program aborted");
   }

   Output_Files[fHSD_TSTAT] << setw(15) << rights_info.share;

   for (i = 0; i < MAX_RIGHTS_ENTRIES; i++)
   {
    day_valid[i] = FALSE;
    share_difference[i] = INVALID;
    daily_difference[file_no][i] = INVALID;
    if ( (!shares_traded[i]) || (hsd_prices[i] == INVALID) )
       Output_Files[fHSD_TSTAT] << setw(8) << "--";
    else
    {
     day_valid[i] = TRUE;
     share_difference[i] = rights_data[i].last - ROUND(hsd_prices[i]);
     daily_difference[file_no][i] = share_difference[i];
     Output_Files[fHSD_TSTAT] << setw(8) << share_difference[i];
     share_days_valid++;
     daily_days_valid[i]++;
     share_sum = share_sum + share_difference[i];
     daily_sum[i] = daily_sum[i] + daily_difference[file_no][i];
    }
   }
   //Calculate share's t-stat
   share_mean = share_sum / (double)share_days_valid;
   for (i = 0; i < rights_info.entries; i++)
   {
    if (day_valid[i])
       sum = sum + pow( (share_difference[i] - share_mean), 2.0 );
   }
   if ( (sum != 0.0) && (share_days_valid != 1) )
   {
    s = sqrt( (1.0/((double)share_days_valid - 1.0)) * sum );
    t_stat = (share_mean - 0) / (s / sqrt((double)share_days_valid) );
    Output_Files[fHSD_TSTAT] << setw(10) << setprecision(4) << t_stat;
   }
   else
     Output_Files[fHSD_TSTAT] << setw(10) << "--";

   Output_Files[fHSD_TSTAT] << endl;

   if (file_no == (MAX_NO_FILES-1))
   {
    Output_Files[fHSD_TSTAT] << endl;
    Output_Files[fHSD_TSTAT] << setw(15) << "TSTAT";
    //Calculate day's t-stat
    for (i = 0; i < (MAX_RIGHTS_ENTRIES-1); i++)
    {
     sum = 0.0;
     if (daily_days_valid[i] > 1)
     {
      daily_mean = daily_sum[i] / (double)daily_days_valid[i];
      for (j = 0; j < MAX_NO_FILES; j++)
      {
       if (daily_difference[j][i] != INVALID)
          sum = sum + pow( (daily_difference[j][i] - daily_mean), 2.0 );
      }
      if (sum != 0.0)
      {
       s = sqrt( (1.0/((double)daily_days_valid[i] - 1.0)) * sum );
       t_stat = (daily_mean - 0) / (s / sqrt((double)daily_days_valid[i]) );
       Output_Files[fHSD_TSTAT] << setw(8) << setprecision(4) << t_stat;
      }
      else
         Output_Files[fHSD_TSTAT] << setw(8) << "--";
     }
     else
        Output_Files[fHSD_TSTAT] << setw(8) << "--";
    }
    Output_Files[fHSD_TSTAT] << setw(8) << "--";
    Output_Files[fHSD_TSTAT] << endl;
    CloseOutputFile(fHSD_TSTAT, hsd_tstat_file);
   }
  }

  /*------------------------------------------------------------------*/
  /* FUNCTION :                                                       */
  /* DESCRIPTION :                                                    */
  /*------------------------------------------------------------------*/
  void CalculateWHsdTstat(void)
  {
   int i, j = 0;
   static boolean first_time = TRUE;
   boolean day_valid[MAX_RIGHTS_ENTRIES];
   double share_difference[MAX_RIGHTS_ENTRIES];
   static double daily_difference[MAX_NO_FILES][MAX_RIGHTS_ENTRIES];
   double share_sum = 0;
   static double daily_sum[MAX_RIGHTS_ENTRIES];
   int share_days_valid = 0;
   static int daily_days_valid[MAX_RIGHTS_ENTRIES];
   double share_mean = 0.0;
   double daily_mean = 0.0;
   double sum = 0.0;
   double s = 0.0;
```

```
double t_stat = 0.0;

if (first_time)
{
 if (OpenOutputFile(fW_HSD_TSTAT, w_hsd_tstat_file))
 {
  first_time = FALSE;
  Output_Files[fW_HSD_TSTAT] << setw(15) << "W HSD TSTAT";
  for (i = 0; i < MAX_RIGHTS_ENTRIES; i++)
  {
   Output_Files[fW_HSD_TSTAT] << setw(8) << (i+1);
   daily_sum[i] = 0.0;
   daily_days_valid[i] = 0;
  }
  Output_Files[fW_HSD_TSTAT] << setw(10) << "T-STAT";
  Output_Files[fW_HSD_TSTAT] << endl;
  Output_Files[fW_HSD_TSTAT] << endl;
 }
 else
    printf("\nUnable to open W_HSD.LOG file -- program aborted");
}

Output_Files[fW_HSD_TSTAT] << setw(15) << rights_info.share;

for (i = 0; i < MAX_RIGHTS_ENTRIES; i++)
{
 day_valid[i] = FALSE;
 share_difference[i] = INVALID;
 daily_difference[file_no][i] = INVALID;
 if ( (!shares_traded[i]) || (W_hsd_prices[i] == INVALID) )
    Output_Files[fW_HSD_TSTAT] << setw(8) << "--";
 else
 {
  day_valid[i] = TRUE;
  share_difference[i] = rights_data[i].last - ROUND(W_hsd_prices[i]);
  daily_difference[file_no][i] = share_difference[i];
  Output_Files[fW_HSD_TSTAT] << setw(8) << share_difference[i];
  share_days_valid++;
  daily_days_valid[i]++;
  share_sum = share_sum + share_difference[i];
  daily_sum[i] = daily_sum[i] + daily_difference[file_no][i];
 }
}
//Calculate share's t-stat
share_mean = share_sum / (double)share_days_valid;
for (i = 0; i < rights_info.entries; i++)
{
 if (day_valid[i])
    sum = sum + pow( (share_difference[i] - share_mean), 2.0 );
}
if ( (sum != 0.0) && (share_days_valid != 1) )
{
 s = sqrt( (1.0/((double)share_days_valid - 1.0)) * sum );
 t_stat = (share_mean - 0) / (s / sqrt((double)share_days_valid) );
 Output_Files[fW_HSD_TSTAT] << setw(10) << setprecision(4) << t_stat;
}
else
  Output_Files[fW_HSD_TSTAT] << setw(10) << "--";

Output_Files[fW_HSD_TSTAT] << endl;

if (file_no == (MAX_NO_FILES-1))
{
 Output_Files[fW_HSD_TSTAT] << endl;
 Output_Files[fW_HSD_TSTAT] << setw(15) << "TSTAT";
 //Calculate day's t-stat
 for (i = 0; i < (MAX_RIGHTS_ENTRIES-1); i++)
 {
  sum = 0.0;
  if (daily_days_valid[i] > 1)
  {
   daily_mean = daily_sum[i] / (double)daily_days_valid[i];
   for (j = 0; j < MAX_NO_FILES; j++)
   {
    if (daily_difference[j][i] != INVALID)
       sum = sum + pow( (daily_difference[j][i] - daily_mean), 2.0 );
   }
   if (sum != 0.0)
   {
    s = sqrt( (1.0/((double)daily_days_valid[i] - 1.0)) * sum );
    t_stat = (daily_mean - 0) / (s / sqrt((double)daily_days_valid[i]) );
    Output_Files[fW_HSD_TSTAT] << setw(8) << setprecision(4) << t_stat;
   }
   else
      Output_Files[fW_HSD_TSTAT] << setw(8) << "--";
  }
  else
     Output_Files[fW_HSD_TSTAT] << setw(8) << "--";
 }
 Output_Files[fW_HSD_TSTAT] << setw(8) << "--";
 Output_Files[fW_HSD_TSTAT] << endl;
 CloseOutputFile(fW_HSD_TSTAT, w_hsd_tstat_file);
}
}

/*----------------------------------------------------------------------*/
/*                                                                      */
/* FUNCTION :                                                           */
/* DESCRIPTION :                                                        */
/*----------------------------------------------------------------------*/
void CalculateWIsdTstat(void)
{
 int i, j = 0;
```

```
static boolean first_time = TRUE;
boolean day_valid[MAX_RIGHTS_ENTRIES];
double share_difference[MAX_RIGHTS_ENTRIES];
static double daily_difference[MAX_NO_FILES][MAX_RIGHTS_ENTRIES];
double share_sum = 0;
static double daily_sum[MAX_RIGHTS_ENTRIES];
int share_days_valid = 0;
static int daily_days_valid[MAX_RIGHTS_ENTRIES];
double share_mean = 0.0;
double daily_mean = 0.0;
double sum = 0.0;
double s = 0.0;
double t_stat = 0.0;

if (first_time)
{
 if (OpenOutputFile(fW_ISD_TSTAT, w_isd_tstat_file))
 {
  first_time = FALSE;
  Output_Files[fW_ISD_TSTAT] << setw(15) << "W ISD TSTAT";
  for (i = 0; i < MAX_RIGHTS_ENTRIES; i++)
  {
   Output_Files[fW_ISD_TSTAT] << setw(8) << (i+1);
   daily_sum[i] = 0.0;
   daily_days_valid[i] = 0;
  }
  Output_Files[fW_ISD_TSTAT] << setw(10) << "T-STAT";
  Output_Files[fW_ISD_TSTAT] << endl;
  Output_Files[fW_ISD_TSTAT] << endl;
 }
 else
    printf("\nUnable to open W_ISD.LOG file -- program aborted");
}

Output_Files[fW_ISD_TSTAT] << setw(15) << rights_info.share;

for (i = 0; i < MAX_RIGHTS_ENTRIES; i++)
{
 day_valid[i] = FALSE;
 share_difference[i] = INVALID;
 daily_difference[file_no][i] = INVALID;
 if ( (!shares_traded[i]) || (W_isd_prices[i] == INVALID) )
    Output_Files[fW_ISD_TSTAT] << setw(8) << "--";
 else
 {
  day_valid[i] = TRUE;
  share_difference[i] = rights_data[i].last - ROUND(W_isd_prices[i]);
  daily_difference[file_no][i] = share_difference[i];
  Output_Files[fW_ISD_TSTAT] << setw(8) << share_difference[i];
  share_days_valid++;
  daily_days_valid[i]++;
  share_sum = share_sum + share_difference[i];
  daily_sum[i] = daily_sum[i] + daily_difference[file_no][i];
 }
}
//Calculate share's t-stat
share_mean = share_sum / (double)share_days_valid;
for (i = 0; i < rights_info.entries; i++)
{
 if (day_valid[i])
    sum = sum + pow( (share_difference[i] - share_mean), 2.0 );
}
if ( (sum != 0.0) && (share_days_valid != 1) )
{
 s = sqrt( (1.0/((double)share_days_valid - 1.0)) * sum );
 t_stat = (share_mean - 0) / (s / sqrt((double)share_days_valid) );
 Output_Files[fW_ISD_TSTAT] << setw(10) << setprecision(4) << t_stat;
}
else
  Output_Files[fW_ISD_TSTAT] << setw(10) << "--";

Output_Files[fW_ISD_TSTAT] << endl;

if (file_no == (MAX_NO_FILES-1))
{
 Output_Files[fW_ISD_TSTAT] << endl;
 Output_Files[fW_ISD_TSTAT] << setw(15) << "TSTAT";
 //Calculate day's t-stat
 for (i = 0; i < (MAX_RIGHTS_ENTRIES-1); i++)
 {
  sum = 0.0;
  if (daily_days_valid[i] > 1)
  {
   daily_mean = daily_sum[i] / (double)daily_days_valid[i];
   for (j = 0; j < MAX_NO_FILES; j++)
   {
    if (daily_difference[j][i] != INVALID)
       sum = sum + pow( (daily_difference[j][i] - daily_mean), 2.0 );
   }
   if (sum != 0.0)
   {
    s = sqrt( (1.0/((double)daily_days_valid[i] - 1.0)) * sum );
    t_stat = (daily_mean - 0) / (s / sqrt((double)daily_days_valid[i]) );
    Output_Files[fW_ISD_TSTAT] << setw(8) << setprecision(4) << t_stat;
   }
   else
      Output_Files[fW_ISD_TSTAT] << setw(8) << "--";
  }
  else
     Output_Files[fW_ISD_TSTAT] << setw(8) << "--";
 }
 Output_Files[fW_ISD_TSTAT] << setw(8) << "--";
```

```
  Output_Files[fW_ISD_TSTAT] << endl;
  CloseOutputFile(fW_ISD_TSTAT, w_isd_tstat_file);
 }
}

/*----------------------------------------------------------------------*/
/* FUNCTION :                                                           */
/* DESCRIPTION :                                                        */
/*----------------------------------------------------------------------*/
int main(void)
{
 clrscr();

 if (InputExtraValues())
 {
  if (OpenOutputFile(fRESULTS, results_file))
  {
   for (int file_number = 0; file_number < MAX_NO_FILES; file_number++)
   {
    file_no = file_number;
    //Reset all variables between each set of Share Calculations
    hsd_result = 0.0;
    for (int i = 0; i < MAX_RIGHTS_ENTRIES; i++)
    {
     hsd_prices[i] = INVALID;
     isd_values[i] = INVALID;
     isd_prices[i] = INVALID;
     W_isd_values[i] = INVALID;
     W_isd_prices[i] = INVALID;
     W_hsd_prices[i] = INVALID;
     valid_trading_day[i] = FALSE;
     shares_traded[i] = FALSE;
     rights_traded[i] = FALSE;
     C_valid[i] = FALSE;
     W_valid[i] = FALSE;
    }
    InputRightsValues();
    InputBaRateValues();
    InputSharesValues();
    CalculateHSD();
    CalculateHSDPrices();
    CalculateISDandISDPrices();
    OutputResults();
    CalculateHsdTstat();
    CalculateWHsdTstat();
    CalculateWIsdTstat();
   }
   CloseOutputFile(fRESULTS, results_file);
  }
  else
     printf("\nUnable to open RESULTS.LOG file -- program aborted");
 }
 else
    printf("\nUnable to open EXTRA.INI file -- program aborted");
 printf("\n\nFinished");
 return (0);
}
```

```
/****************************************************************************/
/*                                                                          */
/* MODULE:       DATECLAS.CPP                                               */
/* DESCRIPTION: Module containing the Date Class functions for manipulating */
/*              days and dates.                                             */
/* AUTHOR:      C.E. Alston                                                 */
/****************************************************************************/
nclude <stdlib.h>

fndef _DATECLAS_HPP_
#include "dateclas.hpp"
endif

*--------------------------------------------------------------------------*/
*                                                                          */
* FUNCTION :                                                               */
* DESCRIPTION : Constructor to make a date class from a given string.      */
*--------------------------------------------------------------------------*/
ate_class::date_class(char* string) : Date (1,1,1)

float value = atol(string);
long year = (long)(value/10000);
long month = (long)(value/100 - (year * 100));
long day = (long)(value - (year * 10000) - (month * 100));
BaseDate::SetYear((int)year);
BaseDate::SetMonth((int)month);
BaseDate::SetDay((int)day);

*--------------------------------------------------------------------------*/
*                                                                          */
* FUNCTION :                                                               */
* DESCRIPTION : Defines the printing format of a date.                     */
*--------------------------------------------------------------------------*/
void date_class::printOn(ostream& os) const

os << Day() << "/" << Month() << "/" << Year();
}

/*--------------------------------------------------------------------------*/
/*                                                                          */
/* FUNCTION :                                                               */
/* DESCRIPTION : Returns the date of the day minus the given days.          */
/*--------------------------------------------------------------------------*/
date_class& date_class::operator-(long days)
{
 static date_class date;
 long number = DateToNumber(*this) - days;
 date = NumberToDate(number);
 return date;
}

/*--------------------------------------------------------------------------*/
/*                                                                          */
/* FUNCTION :                                                               */
/* DESCRIPTION : Returns the number of days between two given dates.        */
/*--------------------------------------------------------------------------*/
date_class& date_class::operator-(date_class& b)
{
 static date_class date;
 long number = DateToNumber(*this) - DateToNumber(b);
 date = NumberToDate(number);
 return date;
}

/*--------------------------------------------------------------------------*/
/*                                                                          */
/* FUNCTION :                                                               */
/* DESCRIPTION : Returns the number of days between two given dates.        */
/*--------------------------------------------------------------------------*/
boolean date_class::operator<(date_class& b)
{
 static date_class date;
 long number = DateToNumber(*this) - DateToNumber(b);
 if (number < 0.0) return TRUE;
 else return FALSE;
}

/*--------------------------------------------------------------------------*/
/*                                                                          */
/* FUNCTION :                                                               */
/* DESCRIPTION : Returns the date the given number of days ahead.           */
/*--------------------------------------------------------------------------*/
date_class& date_class::operator+(long days)
{
 static date_class date;
 long number = DateToNumber(*this) + days;
 date = NumberToDate(number);
 return date;
}

/*--------------------------------------------------------------------------*/
/*                                                                          */
/* FUNCTION :                                                               */
/* DESCRIPTION : Converts a given date class to a number of days.           */
/*--------------------------------------------------------------------------*/
long date_class::DateToNumber(date_class& b)
{
 float value;
 value = b.Day();
 value += 30.437 * (b.Month() - 1);
 value += 365.24 * b.Year();
 return value;
}

/*--------------------------------------------------------------------------*/
/*                                                                          */
/* FUNCTION :                                                               */
/* DESCRIPTION : Converts a given number of days into a date class.         */
/*--------------------------------------------------------------------------*/
date_class& date_class::NumberToDate(long number)
```

```
{
 static date_class date;
 float value = number;
 long year = value / 365.24;
 long month = (value - (year * 365.24) ) / 30.437;
 long day = value - (year * 365.24) - (long)(month * 30.437);
 date.BaseDate::SetYear((int)year);
 date.BaseDate::SetMonth((int)(month)+1);
 date.BaseDate::SetDay((int)day);
 return date;
}
```

```
/***************************************************************************/
/* MODULE:      DATECLAS.HPP                                               */
/* DESCRIPTION: Header file for the Date Class Module.                     */
/* AUTHOR:      C.E. Alston                                                */
/***************************************************************************/
#ifndef _DATECLAS_HPP_
#define _DATECLAS_HPP_

#include <ldate.h>

//Assume: 365.24 days in a year; and 30.437 days in an average month
typedef enum boolean
{
 FALSE = 0,
 TRUE  = 1
};

class date_class: public Date
{
private:
 long DateToNumber(date_class&);
 date_class& NumberToDate(long);

public:
 date_class() : Date() {}
 date_class(char* string);
 void printOn(ostream&) const;
 date_class& operator-(long days);
 date_class& operator-(date_class&);
 boolean operator<(date_class&);
 date_class& operator+(long days);
 operator long() {return DateToNumber(*this);}
 ~date_class() {}
}; //end of class date_class

#endif
```

```
/***********************************************************************/
/* MODULE:       BLCKSHOL.HPP                                          */
/* DESCRIPTION: Header file for the Black Scholes Module.              */
/* AUTHOR:       C.E. Alston                                           */
/***********************************************************************/
#ifndef _BLCKSHOL_HPP_
#define _BLCKSHOL_HPP_

#define ITERATION_UNSUCCESSFUL 0xFE

//Function Prototypes
double CalculateVolatility(double C, double S, double X, double r, double t);
double CalculateC(double sd, double S, double X, double r, double t);
double CalculateDilutedVolatility(double W, double S, double X, double r, double t, double M, double n, double fi, double guess1, double
double CalculateW(double sd, double S, double X, double r, double t, double M, double n, double fi);

#endif
```

```
/*************************************************************************/
/*                                                                       */
/* MODULE:      BLCKSHOL.CPP                                             */
/* DESCRIPTION: Module to perform the normal and diluted Black Scholes   */
/*              calculations, and the numerical methods iterative procedure */
/*              to calculate the volatility.                             */
/* AUTHOR:      C.E. Alston                                              */
/*************************************************************************/
#include <stdlib.h>
#include <stdio.h>
#include <conio.h>
#include <math.h>

#ifndef _DATECLAS_HPP_
 #include "dateclas.hpp"
#endif

#ifndef _BLCKSHOL_HPP_
 #include "blckshol.hpp"
#endif

#define MAX_ITERATIONS 100
#define ALLOWED_ERROR 1.0*pow(10.0,-6.0) //for iterative root calculation

#define APPROX_SD  (2.5/sqrt(t))*(C/S)
#define APPROX_SD1 0.000000001
#define APPROX_SD2 20.0

typedef enum
{
 THESIS = 0,
 BOOK   = 1
} tMethods;
static tMethods method = BOOK;

static double NormalDistribution(double d);
static double CalculateDilutedBlackScholesSD(double sd);
static double CalculateDilutedBlackScholesW(double W);
static double CalculateBlackScholes(double sd);
static double GetGuess1(void);
static double GetGuess2(void);
static double GetActualResult(void);
static double CalculateResult(double guess);
static double RegulaFalsiIteration(void);

typedef struct
{
 double sd;
 double S;
 double X;
 double r;
 double t;
 double M;
 double n;
 double fi;
 double W;
 double C;
 double guess1;
 double guess2;
 double actual;
} sData;

static sData data = {0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0};

typedef enum
{
 BLACK_SCHOLES = 0,
 DILUTED_BLACK_SCHOLES = 1,
 VOLATILTTY = 2,
 DILUTED_VOLATILITY = 3
} tCalculation;
static tCalculation CURRENT_CALCULATION = VOLATILITY;

/*----------------------------------------------------------------------*/
/*                                                                      */
/* FUNCTION :                                                           */
/* DESCRIPTION :                                                        */
/*----------------------------------------------------------------------*/
static double NormalDistribution(double d)
{
 double z, y, x = 0.0;

 z = 0.39894228 * exp( - (d*d) / 2.0);
 y = 1.0 / ( 1.0 + 0.2316419 * fabs(d) );
 x = 1.0 - z * ( 1.330274429 * pow(y,5.0) - 1.821255978 * pow(y,4.0)
              + 1.781477937 * pow(y,3.0) - 0.35653782 * pow(y,2.0)
              + 0.31938153 * y );
 if (d > 0.0)
    return x;
 else
    return (1.0-x);
}

/*----------------------------------------------------------------------*/
/*                                                                      */
/* FUNCTION :                                                           */
/* DESCRIPTION :                                                        */
/*----------------------------------------------------------------------*/
static double CalculateBlackScholes(double sd)
{
 double d1, d2 = 0.0;
 double Nd1, Nd2 = 0.0;
 double tempC = 0.0;

 if (method == THESIS)
```

```
{
 d1 = (log(data.S/(data.X*exp(-data.r*data.t)))+(sd*sd)*data.t/2.0)/(sd*sqrt(data.t));
 d2 = d1 - sd * sqrt(data.t);
}
else if (method == BOOK)
{
 d1 = (log(data.S/data.X) + (data.r + (sd*sd)/2.0)*data.t) / (sd * sqrt(data.t));
 d2 = (log(data.S/data.X) + (data.r - (sd*sd)/2.0)*data.t) / (sd * sqrt(data.t));
}
Nd1 = NormalDistribution(d1);
Nd2 = NormalDistribution(d2);
 if (method == THESIS)
    tempC = data.S * Nd1 - data.X * (exp(-data.r*data.t)) * Nd2;
 else if (method == BOOK)
    tempC = data.S * Nd1 - (data.X * Nd2) / exp(data.r*data.t);
// printf("\nd1=%f; d2=%f; Nd1=%f; Nd2=%f; C=%f", d1, d2, Nd1, Nd2, tempC);
 return (tempC);
}

/*-----------------------------------------------------------------------*/
/* FUNCTION :                                                            */
/* DESCRIPTION :                                                         */
/*-----------------------------------------------------------------------*/
static double CalculateDilutedBlackScholesSD(double sd)
{
 double result = 0.0;

 result = CalculateBlackScholes(sd);
 result = (1.0 / (1.0+data.fi)) * result;
 return (result);

}

/*-----------------------------------------------------------------------*/
/* FUNCTION :                                                            */
/* DESCRIPTION :                                                         */
/*-----------------------------------------------------------------------*/
static double CalculateDilutedBlackScholesW(double W)
{
 double d1, d2 = 0.0;
 double Nd1, Nd2 = 0.0;

 d1 = (log((data.S+(data.M/data.n)*W)/data.X) + (data.r + (data.sd*data.sd)/2.0)*data.t) / (data.sd*sqrt(data.t));
 d2 = (log((data.S+(data.M/data.n)*W)/data.X) + (data.r - (data.sd*data.sd)/2.0)*data.t) / (data.sd*sqrt(data.t));
 Nd1 = NormalDistribution(d1);
 Nd2 = NormalDistribution(d2);
 double result = (data.n/(data.n/data.fi+data.M)) * ((data.S+(data.M/data.n)*W)*Nd1 - data.X*(exp(-data.r*data.t))*Nd2)
 return result;
}

/*-----------------------------------------------------------------------*/
/* FUNCTION :                                                            */
/* DESCRIPTION :                                                         */
/*-----------------------------------------------------------------------*/
static double CalculateResult(double guess)
{
 switch (CURRENT_CALCULATION)
 {
  case DILUTED_BLACK_SCHOLES: return CalculateDilutedBlackScholesW(guess);
  case VOLATILITY: return CalculateBlackScholes(guess);
  case DILUTED_VOLATILITY: return CalculateDilutedBlackScholesSD(guess);
  default: return 0.0;
 }
}

/*-----------------------------------------------------------------------*/
/* FUNCTION : RegulaFalsiIteration                                       */
/* DESCRIPTION : This method requires 2 initial guesses for the unknown x. */
/*               The iteration algorithm is as follows:                  */
/*               Find a and b so that f(a)*f(b)<0.                       */
/*               x = [a*f(b) - b*f(a)]/[f(b)-f(a)]                       */
/*               if a*f(x)<=0 then a=a and b=x                           */
/*               else a=x, b=b.                                          */
/*-----------------------------------------------------------------------*/
static double RegulaFalsiIteration(void)
{
 int iterations = 0;
 boolean convergence_possible = TRUE;
 double error = 20.0;  //Start with large error
 double guess1 = data.guess1;
 double guess2 = data.guess2;
 double xactual = data.actual;
 double xmod1 = CalculateResult(guess1); //This must be < xactual for a solution
 double xmod2 = CalculateResult(guess2); //This must be > xactual for a solution
 double error1 = xactual - xmod1;
 double error2 = xactual - xmod2;
 double answer = 0.0;
 while ( (iterations < MAX_ITERATIONS) && (fabs(error) > ALLOWED_ERROR) )
 {
  if ( (error1 == error2) || ((guess1 == error1) && (guess2 == error2)) )
  {
   printf("\nerror1 = error2, so no solution");
   iterations = MAX_ITERATIONS+1;
   convergence_possible = FALSE;
   return (ITERATION_UNSUCCESSFUL);
  }
  answer = guess2-(guess2-guess1)/(error2-error1)*error2;
  xmod2 = CalculateResult(answer);
  error = xactual - xmod2;
//  printf("\nanswer=%f; xmod2=%f; ERROR=%f; iterations=%d", answer, xmod2, error, iterations);
  if (error == 0.0)
  {
```

```
  printf("\nerror = 0.0, so no solution");
  iterations = MAX_ITERATIONS+1;
  convergence_possible = FALSE;
  return (ITERATION_UNSUCCESSFUL);
 }
 if (error1/error > 0.0)
 {
  if (error2/error > 0.0)
  {
   // no convergence - both roots same sign (+ve) - therefore root solver crashes
   printf("\nNo convergence -- both roots +ve");
   iterations = MAX_ITERATIONS+1;
   convergence_possible = FALSE;
  }
  else
  {
   error1 = error;
   guess1 = answer;
  }
 }
 else
 {
  if (error2/error < 0.0)
  {
   // no convergence - both roots same sign (-ve) - therefore root solver crashes
   printf("\nNo convergence -- both roots -ve");
   iterations = MAX_ITERATIONS+1;
   convergence_possible = FALSE;
  }
  else
  {
   error2 = error;
   guess2 = answer;
  }
 }
 iterations++;
} //end of while
if ( (iterations == MAX_ITERATIONS) && (convergence_possible) )
{
 // no convergence - bouncing above and below 0 - therefore root solver crashes
 printf("\nNo convergence -- MAX_ITERATIONS reached");
 convergence_possible = FALSE;
}
if (convergence_possible)
   return (answer);
else
   return (ITERATION_UNSUCCESSFUL);
}

/*--------------------------------------------------------------------------*/
/* FUNCTION :                                                               */
/* DESCRIPTION :                                                            */
/*--------------------------------------------------------------------------*/
double CalculateVolatility(double C, double S, double X, double r, double t)
{
 CURRENT_CALCULATION = VOLATILITY;
 data.C = C;
 data.S = S;
 data.X = X;
 data.r = r;
 data.t = t;
 data.guess1 = APPROX_SD1;
 data.guess2 = APPROX_SD2;
 data.actual = C;
 return RegulaFalsiIteration();
}

/*--------------------------------------------------------------------------*/
/* FUNCTION :                                                               */
/* DESCRIPTION :                                                            */
/*--------------------------------------------------------------------------*/
double CalculateC(double sd, double S, double X, double r, double t)
{
 CURRENT_CALCULATION = BLACK_SCHOLES;
 data.S = S;
 data.X = X;
 data.r = r;
 data.t = t;
 return CalculateBlackScholes(sd);
}

/*--------------------------------------------------------------------------*/
/* FUNCTION :                                                               */
/* DESCRIPTION :                                                            */
/*--------------------------------------------------------------------------*/
double CalculateDilutedVolatility(double W, double S, double X, double r, double t, double M, double n, double fi)
{
 CURRENT_CALCULATION = DILUTED_VOLATILITY;
 data.W = W;
 data.S = S;
 data.X = X;
 data.r = r;
 data.t = t;
 data.M = M;
 data.n = n;
 data.fi = fi;
 data.guess1 = APPROX_SD1;
 data.guess2 = APPROX_SD2;
 data.actual = W; //(T/(1+fi)) * W;  //0.0;
 return RegulaFalsiIteration();
}
```

```
/*-----------------------------------------------------------------------*/
/* FUNCTION :                                                            */
/* DESCRIPTION :                                                         */
/*-----------------------------------------------------------------------*/
double CalculateW(double sd, double S, double X, double r, double t, double M, double n, double fi, double guess1, doubl
{
 CURRENT_CALCULATION = DILUTED_BLACK_SCHOLES;
 data.sd = sd;
 data.S = S;
 data.X = X;
 data.r = r;
 data.t = t;
 data.M = M;
 data.n = n;
 data.fi = fi;
 data.guess1 = guess1;
 data.guess2 = guess2;
 data.actual = 0.0;
// return RegulaFalsiIteration();
 double result = (1.0 / (1.0+fi)) * CalculateBlackScholes(sd);
 return result;
}
```

APPENDIX B

Computer Program Output

ABSNPL HSD = 0.637 X = 120 q = 1 C-Yes = 77.78% C-No = 22.22% W-Yes = 77.78% W-No = 22.22%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	Yes
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	Yes
Rights Price	1	1	1	1	1	3	3	3	5	5	5	5	4	2	1	1	1	1
Share Price	120	120	120	120	120	120	120	120	120	120	120	120	120	125	125	125	125	120
HSD Price	8	8	8	n/t	n/t	7	7	n/t	n/t	5	5	n/t	5	7	6	6	n/t	--
W HSD Price	4	4	4	n/t	n/t	4	3	n/t	n/t	3	3	n/t	2	4	3	3	n/t	--
ISD Values	n/t	n/t	n/t	n/t	n/t	--	0.2573	n/t	n/t	0.5498	0.5767	n/t	0.6427	0.543	--	--	n/t	n/t
ISD Price	n/t	n/t	n/t	n/t	n/t	7	3	n/t	n/t	5	5	n/t	5	7	--	--	n/t	n/t
W ISD Values	n/t	n/t	n/t	n/t	n/t	--	0.5497	n/t	n/t	1.129	1.1814	n/t	1.311	1.1093	--	--	n/t	n/t
W ISD Price	n/t	n/t	n/t	n/t	n/t	--	3	n/t	n/t	5	5	n/t	5	5	--	--	n/t	n/t

AMREL-NPL HSD = 0.5618 X = 750 q = 2.25 C-Yes = 11.76% C-No = 88.24% W-Yes = 100% W-No = 0%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
C > (S-X)	No	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes	No	No	No
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	75	63	68	40	30	25	30	35	40	40	40	50	35	30	15	10	12
Share Price	925	825	825	800	800	800	800	800	800	800	800	800	775	775	775	775	775
HSD Price	n/t	94	93	73	69	n/t	n/t	66	65	n/t	n/t	n/t	38	n/t	n/t	n/t	--
W HSD Price	n/t	29	29	22	21	n/t	n/t	20	20	n/t	n/t	n/t	12	n/t	n/t	n/t	--
ISD Values	n/t	--	--	--	--	n/t	n/t	--	--	n/t	n/t	n/t	--	n/t	n/t	n/t	--
ISD Price	n/t	94	--	--	--	n/t	n/t	--	--	n/t	n/t	n/t	--	n/t	n/t	n/t	--
W ISD Values	n/t	--	2.1776	2.4675	1.5198	n/t	n/t	1.1195	1.4569	n/t	n/t	n/t	3.1855	n/t	n/t	n/t	--
W ISD Price	n/t	--	62	61	39	n/t	n/t	29	34	n/t	n/t	n/t	42	n/t	n/t	n/t	--

BASREADNP HSD = 0.8786 X = 105 q = 1 C-Yes = 7.69% C-No = 92.31% W-Yes = 84.62% W-No = 15.38%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13
C > (S-X)	No	No	Yes	No	No	No	No	No	No	No	No	No	No
W>(1/(1+q))(S-X)	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	2	2	50	50	45	45	40	40	40	42	50	70	70
Share Price	125	130	145	170	160	155	155	160	160	160	165	175	180
HSD Price	n/t	27	41	66	56	51	50	55	55	55	60	70	--
W HSD Price	n/t	14	20	33	28	25	25	28	28	28	30	35	--
ISD Values	n/t	n/t	--	2.4073	--	--	--	--	--	--	--	--	--
ISD Price	n/t	n/t	41	71	--	--	--	--	--	--	--	--	--
W ISD Values	n/t	n/t	--	8.5882	6.0327	6.0411	6.8195	6.2884	6.3715	7.3634	11.4838	17.9936	--
W ISD Price	n/t	n/t	--	60	45	42	44	41	39	38	40	46	--

CAPITAL-N HSD = 0.1529 X = 245 q = 0.4 C-Yes = 10.53% C-No = 89.47% W-Yes = 57.89% W-No = 42.11%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
C > (S-X)	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes
W>(1/(1+q))(S-X)	No	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes	Yes
Rights Price	10	10	10	20	20	20	20	35	30	30	10	10	20	30	25	25	27	27	27
Share Price	261	261	261	270	270	270	275	280	280	280	260	265	270	280	280	280	280	265	265
HSD Price	n/t	n/t	n/t	27	n/t	n/t	32	37	n/t	n/t	16	21	26	36	n/t	n/t	n/t	20	--
W HSD Price	n/t	n/t	n/t	20	n/t	n/t	23	26	n/t	n/t	12	15	19	26	n/t	n/t	n/t	14	--
ISD Values	n/t	n/t	n/t	--	n/t	n/t	n/t	--	n/t	n/t	--	--	--	--	n/t	n/t	n/t	--	--
ISD Price	n/t	n/t	n/t	27	n/t	n/t	n/t	--	n/t	n/t	--	--	--	--	n/t	n/t	n/t	--	--
W ISD Values	n/t	n/t	n/t	--	n/t	n/t	n/t	--	n/t	n/t	0.9731	--	--	0.6261	n/t	n/t	n/t	1.7389	--
W ISD Price	n/t	n/t	n/t	--	n/t	n/t	n/t	--	n/t	n/t	19	--	--	26	n/t	n/t	n/t	16	--

CLICKS-N HSD = 0.3655 X = 2000 q = 0.13 C-Yes = 47.06% C-No = 52.94% W-Yes = 58.82% W-No = 41.18%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
C > (S-X)	No	Yes	Yes	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No
W>(1/(1+q))(S-X)	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Rights Price	310	310	310	200	200	200	200	200	200	250	325	350	325	325	325	325	400
Share Price	2300	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2300	2300	2300	2300	2300	2500
HSD Price	323	274	n/t	n/t	n/t	266	265	263	262	259	n/t	306	305	n/t	302	301	--
W HSD Price	286	243	n/t	n/t	n/t	235	234	233	232	229	n/t	271	270	n/t	267	266	--
ISD Values	n/t	n/t	n/t	n/t	n/t	--	--	--	--	--	n/t	1.3271	1.2665	n/t	1.4962	1.8519	--
ISD Price	n/t	n/t	n/t	n/t	n/t	266	--	--	--	--	n/t	355	342	n/t	313	308	--
W ISD Values	n/t	n/t	n/t	n/t	n/t	--	--	--	--	--	n/t	1.7208	1.7571	n/t	2.2741	2.7977	--
W ISD Price	n/t	n/t	n/t	n/t	n/t	--	--	--	--	--	n/t	347	338	n/t	303	291	--

CRULIFE-N HSD = 0.4196 X = 210 q = 0.47 C-Yes = 83.33% C-No = 16.67% W-Yes = 83.33% W-No = 16.67%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
W>(1/(1+q))(S-X)	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Rights Price	13	1	1	1	1	1	2	2	10	12	13	15	15	3	10	3	1	1
Share Price	210	210	210	190	205	205	205	210	215	215	220	220	215	215	210	210	205	205
HSD Price	10	10	n/t	2	6	n/t	n/t	8	10	10	13	12	8	8	4	n/t	0	n/t
W HSD Price	7	7	n/t	1	4	n/t	n/t	5	7	7	9	8	6	5	3	n/t	0	n/t
ISD Values	n/t	--	n/t	n/t	n/t	n/t	n/t	0.2102	0.0763	0.4031	0.6231	0.4557	0.6777	1.0218	--	n/t	0.469	n/t
ISD Price	n/t	10	n/t	n/t	n/t	n/t	n/t	4	6	10	15	13	11	14	--	n/t	0	n/t
W ISD Values	n/t	--	n/t	n/t	n/t	n/t	n/t	0.2702	0.1366	0.7108	1.0359	0.9671	1.2735	1.6326	--	n/t	0.6973	n/t
W ISD Price	n/t	--	n/t	n/t	n/t	n/t	n/t	3	4	10	14	12	12	14	--	n/t	1	n/t

DIDATA-N HSD = 0.4168 X = 850 q = 0.25 C-Yes = 44.44% C-No = 55.56% W-Yes = 100% W-No = 0%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	No	No	No	No	No	No	No	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	225	250	250	250	250	250	225	225	250	250	250	300	300	300	300	325	325	300
Share Price	1075	1100	1100	1100	1100	1100	1100	1100	1050	1100	1100	1100	1100	1100	1100	1100	1100	1100
HSD Price	232	256	256	255	n/t	n/t	n/t	n/t	204	253	252	252	n/t	252	251	251	250	n/t
W HSD Price	185	205	205	204	n/t	n/t	n/t	n/t	163	203	202	202	n/t	201	201	200	200	n/t
ISD Values	--	--	--	--	n/t	n/t	n/t	n/t	--	1.7252	n/t	--	n/t	n/t	2.8315	4.0262	6.0365	n/t
ISD Price	232	--	--	--	n/t	n/t	n/t	n/t	--	287	n/t	--	n/t	n/t	291	281	286	n/t
W ISD Values	--	1.4237	1.6094	1.6498	n/t	n/t	n/t	n/t	1.4748	2.7579	n/t	2.565	n/t	n/t	4.6567	6.6006	9.3404	n/t
W ISD Price	--	239	248	248	n/t	n/t	n/t	n/t	189	275	n/t	244	n/t	n/t	286	271	271	n/t

ENGEN-NPL HSD = 0.2973 X = 2500 q = 0.4 C-Yes = 0% C-No = 100% W-Yes = 100% W-No = 0%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
C > (S-X)	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	450	450	445	470	470	470	425	455	470	440	440	440	450	470	450	450	450
Share Price	3000	3000	3000	2980	2980	2980	2950	3000	3000	2950	2950	2950	2950	2970	2970	3000	2975
HSD Price	527	526	525	504	502	499	468	516	515	464	460	459	457	476	472	501	--
W HSD Price	377	376	375	360	359	356	334	369	368	331	329	328	326	340	337	358	--
ISD Values	n/t	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	n/t
ISD Price	n/t	526	--	--	--	--	--	--	--	--	--	--	--	--	--	--	n/t
W ISD Values	n/t	--	1.1103	1.1056	1.3849	1.5138	1.5645	1.4019	1.473	1.6591	1.8829	1.99	2.2682	2.5735	3.8179	4.2819	n/t
W ISD Price	n/t	--	446	429	464	463	446	446	448	434	429	428	424	441	428	409	n/t

ETINGTN-NPL HSD = 0.4523 X = 400 q = 1 C-Yes = 0% C-No = 100% W-Yes = 82.35% W-No = 17.65%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
C > (S-X)	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
W>(1/(1+q))(S-X)	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	1	5	5	12	12	12	12	12	12	12	10	12	12	12	10	10	10
Share Price	415	415	415	415	415	415	415	415	415	415	415	415	415	415	415	415	415
HSD Price	n/t	n/t	n/t	n/t	27	25	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	16	n/t	--
W HSD Price	n/t	n/t	n/t	n/t	13	12	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	8	n/t	--
ISD Values	n/t	n/t	n/t	n/t	--	--	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	--	n/t	--
ISD Price	n/t	n/t	n/t	n/t	27	--	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	--	n/t	--
W ISD Values	n/t	n/t	n/t	n/t	--	0.4076	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	1.0237	n/t	--
W ISD Price	n/t	n/t	n/t	n/t	--	12	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	11	n/t	--

FIRSTBK-N HSD = 0.2054 X = 5000 q = 0.15 C-Yes = 83.33% C-No = 16.67% W-Yes = 100% W-No = 0%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	900	900	900	901	900	925	925	915	905	900	900	920	930	950	900	850	800	850
Share Price	5950	5800	5800	5800	5800	5875	5875	5850	5850	5825	5850	5850	5850	5850	5800	5800	5800	5850
HSD Price	1002	850	848	846	844	910	908	880	878	851	870	867	865	863	811	804	802	--
W HSD Price	871	739	737	735	734	791	789	766	764	740	756	754	752	750	705	699	698	--
ISD Values	--	--	0.5639	0.5831	0.6069	0.6983	0.5182	0.55	0.6613	0.6398	0.8657	0.7891	0.9779	1.116	1.3335	1.8639	1.7818	--
ISD Price	1002	--	895	894	895	959	921	897	909	876	912	892	908	914	885	857	814	--
W ISD Values	--	0.5441	0.9311	0.9558	0.9848	1.1081	1.0586	1.0982	1.1683	1.1805	1.4138	1.4213	1.6064	1.7721	2.0234	2.7705	2.9587	--
W ISD Price	--	778	891	891	891	940	914	896	902	874	898	881	896	902	881	830	762	--

FIT-NPL HSD = 0.3726 X = 900 q = 0.3 C-Yes = 76.47% C-No = 23.53% W-Yes = 100% W-No = 0%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
C > (S-X)	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	No
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	85	65	50	50	50	110	115	90	80	70	65	105	110	140	135	120	135
Share Price	980	950	940	940	940	1000	1000	970	960	950	950	1000	1015	1035	1035	1010	1040
HSD Price	96	70	62	n/t	n/t	108	108	79	70	60	57	103	118	137	137	110	--
W HSD Price	74	54	47	n/t	n/t	83	83	61	54	46	44	79	90	105	105	85	--
ISD Values	--	--	0.2922	n/t	n/t	0.2325	0.4293	0.5805	0.5992	0.5862	0.6426	0.5766	0.5292	--	0.8272	--	--
ISD Price	96	--	56	n/t	n/t	106	109	89	81	71	68	106	118	--	138	--	--
W ISD Values	--	0.5998	0.5657	n/t	n/t	0.4856	1.0319	1.1731	1.0458	0.9938	1.0457	0.9859	1.4149	1.4128	2.1969	3.2376	--
W ISD Price	--	67	59	n/t	n/t	86	108	96	82	73	67	91	110	119	133	103	--

GENBEHR-N HSD = 0.4125 X = 900 q = 0.18 C-Yes = 61.11% C-No = 38.89% W-Yes = 77.78% W-No = 22.22%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	Yes	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No	Yes
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	Yes
Rights Price	70	50	70	75	80	85	85	80	95	80	60	40	35	25	22	12	20	45
Share Price	950	950	960	960	950	970	985	975	960	950	950	935	930	950	925	925	925	940
HSD Price	75	74	80	n/t	71	84	96	86	72	63	60	46	41	56	34	28	26	--
W HSD Price	63	62	68	n/t	60	71	81	73	61	54	51	39	35	47	29	24	22	--
ISD Values	--	0.3489	--	n/t	0.3395	0.5827	0.4377	--	--	0.8111	0.7932	0.4229	0.237	0.2425	--	--	--	--
ISD Price	75	69	--	n/t	66	93	97	--	--	86	77	47	35	53	--	--	--	--
W ISD Values	--	0.5132	0.1304	n/t	0.5432	0.7817	0.6911	0.5155	0.5832	1.0774	1.0487	0.6611	0.4314	0.4157	--	--	--	--
W ISD Price	--	69	58	n/t	68	90	93	77	69	87	77	49	36	47	--	--	--	--

GENCOR-N HSD = 0.3576 X = 1000 q = 0.17 C-Yes = 55.56% C-No = 44.44% W-Yes = 100% W-No = 0%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	No	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	130	105	125	129	133	135	145	160	150	140	120	90	80	85	75	50	90	125
Share Price	1125	1100	1125	1120	1130	1130	1140	1150	1140	1130	1100	1070	1075	1060	1055	1050	1090	1110
HSD Price	138	115	137	132	140	138	147	157	146	136	105	76	79	65	59	51	90	--
W HSD Price	118	98	117	113	120	118	126	134	125	116	90	65	68	55	50	44	77	--
ISD Values	--	--	--	--	**	--	--	--	0.5245	0.5329	0.6172	0.7999	0.7181	0.3838	0.8986	1.0997	--	--
ISD Price	138	--	--	--	**	--	--	--	150	140	112	94	91	65	78	65	--	--
W ISD Values	--	0.593	0.4887	0.5429	0.6912	0.7131	0.7775	0.8662	1.0536	1.0375	1.1301	1.1848	1.0126	0.7691	1.2042	1.4844	0.838	--
W ISD Price	--	112	122	120	135	132	140	150	151	141	117	98	90	68	78	64	78	--

HIGATE-N HSD = 0.1357 X = 680 q = 0.3 C-Yes = 70% C-No = 30% W-Yes = 100% W-No = 0%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
C > (S-X)	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	46	46	46	46	46	46	25	30	30	35	30	28	28	28	28	30	30	30	30	30
Share Price	701	701	701	701	701	701	701	701	710	710	700	700	700	700	700	700	710	710	710	710
HSD Price	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	34	n/t	24	24	n/t	23	n/t	n/t	31	n/t	n/t	--
W HSD Price	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	26	n/t	18	18	n/t	18	n/t	n/t	24	n/t	n/t	--
ISD Values	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	--	n/t	0.2051	0.2959	n/t	0.2786	n/t	n/t	0.6127	n/t	n/t	n/t
ISD Price	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	34	n/t	26	29	n/t	27	n/t	n/t	35	n/t	n/t	n/t
W ISD Values	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	--	n/t	0.4554	0.4813	n/t	0.4697	n/t	n/t	0.9487	n/t	n/t	n/t
W ISD Price	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	--	n/t	29	29	n/t	27	n/t	n/t	32	n/t	n/t	n/t

HOLDAIN-N HSD = 0.2147 X = 4000 q = 0.2 C-Yes = 55.56% C-No = 44.44% W-Yes = 94.44% W-No = 5.56%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No	No	No
W>(1/(1+q))(S-X)	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	500	700	750	775	775	775	775	800	875	880	880	850	850	850	850	800	800	750
Share Price	4700	4700	4700	4700	4700	4750	4750	4750	4800	4850	4850	4850	4850	4850	4800	4800	4800	4750
HSD Price	730	729	728	727	725	771	n/t	768	817	865	861	n/t	n/t	n/t	806	803	n/t	--
W HSD Price	609	608	606	606	604	643	n/t	640	680	721	718	n/t	n/t	n/t	672	669	n/t	--
ISD Values	n/t	--	--	0.5213	0.664	n/t	n/t	0.4813	0.7278	0.94	0.7939	n/t	n/t	n/t	--	1.7935	n/t	--
ISD Price	n/t	729	--	748	769	n/t	n/t	773	841	911	875	n/t	n/t	n/t	--	825	n/t	--
W ISD Values	n/t	--	0.8643	1.077	1.1956	n/t	n/t	1.2623	1.4208	1.6677	1.7715	n/t	n/t	n/t	2.1022	3.3076	n/t	--
W ISD Price	n/t	--	694	743	765	n/t	n/t	765	820	892	862	n/t	n/t	n/t	790	786	n/t	--

JOEL-NPL HSD = 1.2123 X = 290 q = 1 C-Yes = 38.89% C-No = 61.11% W-Yes = 94.44% W-No = 5.56%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	No	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes	No	No	No	No	No	No	No	Yes
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Rights Price	33	40	35	27	25	30	30	20	30	25	20	15	20	15	10	8	5	1
Share Price	330	335	315	310	310	330	315	310	315	310	315	310	310	310	300	300	305	280
HSD Price	65	68	53	47	47	60	48	41	43	38	38	33	32	31	22	16	17	--
W HSD Price	33	34	27	24	23	30	24	21	21	19	19	17	16	15	11	8	9	--
ISD Values	--	--	--	0.6079	0.4491	0.3706	--	0.4985	--	0.5666	0.5903	--	--	--	--	--	--	--
ISD Price	65	--	--	31	27	43	--	26	--	26	29	--	--	--	--	--	--	--
W ISD Values	--	1.241	1.6129	1.8524	1.4445	1.3349	1.2249	1.8187	1.2035	2.0242	1.9627	1.3234	1.0032	1.7256	1.1672	1.3395	1.1602	--
W ISD Price	--	34	33	33	27	31	24	28	21	27	26	18	14	19	11	9	9	--

LASER-NPL HSD = 0.5098 X = 450 q = 0.8 C-Yes = 17.65% C-No = 82.35% W-Yes = 88.24% W-No = 11.76%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
C > (S-X)	No	Yes	Yes	No	No	No	No	No	No	No	No	No	Yes	No	No	No	No
W>(1/(1+q))(S-X)	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Rights Price	15	80	90	110	125	100	95	95	80	80	65	65	65	25	40	50	32
Share Price	480	480	480	625	600	560	560	560	540	540	525	525	500	500	510	520	500
HSD Price	43	n/t	n/t	178	152	112	112	n/t	92	91	76	n/t	52	51	60	70	--
W HSD Price	24	n/t	n/t	99	85	62	62	n/t	51	51	42	n/t	29	28	33	39	--
ISD Values	n/t	n/t	n/t	--	--	--	--	n/t	--	--	--	n/t	n/t	1.3882	--	--	--
ISD Price	n/t	n/t	n/t	178	--	--	--	n/t	--	--	--	n/t	n/t	63	--	--	--
W ISD Values	n/t	n/t	n/t	--	1.754	3.1749	2.8825	n/t	2.8322	2.8236	2.9792	n/t	n/t	3.7163	--	2.3769	--
W ISD Price	n/t	n/t	n/t	--	97	106	98	n/t	85	78	71	n/t	n/t	61	--	41	--

M-NET-NPL HSD = 0.6145 X = 575 q = 0.29 C-Yes = 4.76% C-No = 95.24% W-Yes = 100% W-No = 0%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
C > (S-X)	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	185	170	150	150	145	150	172	170	160	155	157	170	180	185	170	172	185	205	210	210	210
Share Price	740	740	720	720	720	720	760	750	745	740	744	750	760	760	750	750	765	780	800	810	810
HSD Price	177	176	155	154	153	153	190	180	175	169	173	178	188	187	177	177	191	206	226	235	--
W HSD Price	137	137	120	119	119	118	147	140	135	131	134	138	145	145	137	137	148	160	175	182	--
ISD Values	--	0.8441	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	n/t	n/t
ISD Price	177	184	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	n/t	n/t
W ISD Values	--	1.7758	1.6505	1.5045	1.5749	1.4871	1.7469	1.7131	1.8969	1.7492	1.7522	1.9547	2.3875	2.6499	2.9928	2.8166	3.6886	4.3464	5.7355	n/t	n/t
W ISD Price	--	183	156	149	148	144	173	164	165	155	156	158	173	176	174	166	174	185	202	n/t	n/t

METKOR-N HSD = 0.4316 X = 220 q = 0.11 C-Yes = 16.67% C-No = 83.33% W-Yes = 38.89% W-No = 61.11%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	No	No	No	No	No	Yes	Yes	Yes	No	No	No	No	No	No	No	No	No	No
W>(1/(1+q))(S-X)	No	No	No	No	No	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes	Yes	Yes
Rights Price	1	1	1	1	18	18	20	20	20	30	30	30	35	35	40	40	40	45
Share Price	225	230	230	240	240	235	235	235	250	260	260	260	260	260	260	260	260	265
HSD Price	13	17	16	24	24	n/t	n/t	n/t	32	41	41	41	41	41	40	40	40	--
W HSD Price	12	15	15	22	21	n/t	n/t	n/t	28	37	37	37	37	37	36	36	36	--
ISD Values	n/t	n/t	n/t	n/t	--	n/t	n/t	n/t	0.5559	--	--	--	--	--	--	--	--	--
ISD Price	n/t	n/t	n/t	n/t	24	n/t	n/t	n/t	32	--	--	--	--	--	--	--	--	--
W ISD Values	n/t	n/t	n/t	n/t	--	n/t	n/t	n/t	0.7034	--	--	--	--	--	--	2.0029	2.468	--
W ISD Price	n/t	n/t	n/t	n/t	--	n/t	n/t	n/t	30	--	--	--	--	--	--	38	37	--

METPOL-NP HSD = 0.3238 X = 850 q = 0.5 C-Yes = 55.56% C-No = 44.44% W-Yes = 100% W-No = 0%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No	No	Yes
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	130	125	130	130	135	140	145	160	160	200	150	160	160	170	210	200	235	280
Share Price	985	950	970	970	985	985	985	1000	1000	1075	1000	1000	1000	1000	1075	1075	1100	1100
HSD Price	145	111	129	129	143	141	141	156	155	230	154	153	153	n/t	227	n/t	250	n/t
W HSD Price	96	74	86	86	95	94	94	104	103	153	102	102	102	n/t	151	n/t	167	n/t
ISD Values	n/t	--	0.6204	n/t	0.3917	--	--	0.5602	0.6336	0.67	--	--	0.9255	n/t	1.4552	n/t	--	n/t
ISD Price	n/t	111	140	n/t	144	--	--	158	159	231	--	--	158	n/t	233	n/t	--	n/t
W ISD Values	n/t	--	1.4436	n/t	1.4328	1.5148	1.6759	1.8476	2.0955	2.1783	2.5567	2.3447	2.7998	n/t	3.5938	n/t	5.801	n/t
W ISD Price	n/t	--	133	n/t	135	133	137	149	157	194	157	145	154	n/t	199	n/t	188	n/t

MID-WITS-NPL HSD = 0.701 X = 550 q = 0.33 C-Yes = 83.33% C-No = 16.67% W-Yes = 100% W-No = 0%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	50	69	40	32	20	35	50	45	55	70	63	40	22	30	38	20	6	6
Share Price	580	615	580	560	560	570	590	575	600	620	625	585	555	575	585	565	555	550
HSD Price	60	85	58	44	41	46	59	47	64	78	81	47	25	36	39	21	11	--
W HSD Price	45	64	44	33	31	35	44	36	48	58	61	35	19	27	29	16	8	--
ISD Values	--	0.5014	--	0.301	0.486	0.2345	0.4409	0.4563	0.6457	0.4165	--	--	0.4277	0.6013	0.5528	0.6276	0.6341	--
ISD Price	60	77	--	24	31	27	50	38	62	73	--	--	17	34	37	20	10	--
W ISD Values	--	0.8205	0.8504	0.5991	0.707	0.3854	0.7073	0.8874	1.0046	1.0429	1.2552	0.836	0.931	0.8418	1.0522	1.4246	1.0791	--
W ISD Price	--	68	49	30	31	25	44	41	57	65	71	38	24	30	33	24	11	--

NORTHAM-NPL HSD = 0.3906 X = 2200 q = 1 C-Yes = 47.06% C-No = 52.94% W-Yes = 94.12% W-No = 5.88%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
C > (S-X)	No	No	Yes	Yes	No	Yes	Yes	Yes	No	Yes	Yes	Yes	No	No	No	No	No
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Rights Price	200	225	250	230	150	220	200	220	205	225	235	220	200	200	190	100	100
Share Price	2450	2450	2350	2350	2350	2350	2350	2400	2400	2400	2400	2400	2400	2400	2450	2425	2300
HSD Price	n/t	n/t	198	193	n/t	184	181	223	n/t	214	212	n/t	208	204	252	226	--
W HSD Price	n/t	n/t	99	97	n/t	92	91	111	n/t	107	106	n/t	104	102	126	113	--
ISD Values	n/t	n/t	--	0.7029	n/t	--	0.6475	0.5383	n/t	--	0.5546	n/t	0.5844	--	--	--	--
ISD Price	n/t	n/t	198	246	n/t	--	216	237	n/t	--	222	n/t	216	--	--	--	--
W ISD Values	n/t	n/t	--	1.9487	n/t	1.0878	1.9248	1.7609	n/t	1.9398	2.3421	n/t	2.5825	2.9971	3.4683	3.3992	--
W ISD Price	n/t	n/t	--	245	n/t	147	214	211	n/t	198	216	n/t	208	182	192	151	--

NORTHAM-N HSD = 0.401 X = 1475 q = 0.42 C-Yes = 81.25% C-No = 18.75% W-Yes = 100% W-No = 0%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
C > (S-X)	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	88	75	100	120	110	110	125	120	120	110	115	120	105	80	120	150
Share Price	1563	1563	1563	1563	1500	1525	1535	1535	1535	1550	1550	1550	1550	1575	1575	1575
HSD Price	n/t	n/t	n/t	n/t	68	83	88	n/t	n/t	88	86	84	82	101	101	--
W HSD Price	n/t	n/t	n/t	n/t	48	58	62	n/t	n/t	62	61	59	58	71	71	--
ISD Values	n/t	n/t	n/t	n/t	--	0.7478	0.6443	n/t	n/t	0.8913	0.7038	0.8243	0.9662	1.0804	--	--
ISD Price	n/t	n/t	n/t	n/t	68	122	114	n/t	n/t	125	106	110	114	115	--	--
W ISD Values	n/t	n/t	n/t	n/t	--	1.1253	1.038	n/t	n/t	1.445	1.2609	1.4403	1.6548	1.951	1.0389	--
W ISD Price	n/t	n/t	n/t	n/t	--	117	111	n/t	n/t	121	105	109	112	104	74	--

OTIS-NPL HSD = 0.5496 X = 220 q = 0.2 C-Yes = 66.67% C-No = 33.33% W-Yes = 83.33% W-No = 16.67%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
W>(1/(1+q))(S-X)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	58	58	58	55	55	55	40	40	20	20	20	20	22	22	22	22	22	27
Share Price	278	290	275	250	250	250	250	250	250	250	240	240	240	240	240	240	240	240
HSD Price	n/t	72	58	34	34	33	n/t	33	32	n/t	22	22	n/t	n/t	21	n/t	20	n/t
W HSD Price	n/t	60	48	29	28	28	n/t	27	27	n/t	19	18	n/t	n/t	18	n/t	17	n/t
ISD Values	n/t	n/t	n/t	--	n/t	n/t	n/t	n/t	1.1324	n/t	--	--	n/t	n/t	0.6577	n/t	1.218	n/t
ISD Price	n/t	n/t	n/t	34	n/t	n/t	n/t	n/t	39	n/t	--	--	n/t	n/t	22	n/t	21	n/t
W ISD Values	n/t	n/t	n/t	--	n/t	n/t	n/t	n/t	1.6338	n/t	--	0.7249	n/t	n/t	1.1705	n/t	2.0739	n/t
W ISD Price	n/t	n/t	n/t	--	n/t	n/t	n/t	n/t	39	n/t	--	20	n/t	n/t	21	n/t	19	n/t

PERSKOR-N HSD = 0.4834 X = 2500 q = 0.29 C-Yes = 50% C-No = 50% W-Yes = 100% W-No = 0%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Yes	Yes	Yes	No	No
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	368	475	475	500	500	500	500	600	600	550	525	475	450	450	425	425	350	350
Share Price	2868	2950	2950	2950	2950	2950	2950	3100	3150	3100	3100	2975	2975	2925	2900	2900	2875	2875
HSD Price	n/t	484	n/t	480	n/t	n/t	n/t	616	665	614	n/t	484	483	432	406	n/t	376	n/t
W HSD Price	n/t	375	n/t	372	n/t	n/t	n/t	478	515	476	n/t	375	374	335	314	n/t	292	n/t
ISD Values	n/t	n/t	n/t	--	n/t	n/t	n/t	0.8087	--	--	n/t	--	--	--	1.0124	n/t	1.7815	n/t
ISD Price	n/t	n/t	n/t	480	n/t	n/t	n/t	632	--	--	n/t	--	--	--	421	n/t	383	n/t
W ISD Values	n/t	n/t	n/t	--	n/t	n/t	n/t	1.675	1.8127	1.6389	n/t	1.5483	1.9523	1.8252	2.3185	n/t	3.86	n/t
W ISD Price	n/t	n/t	n/t	--	n/t	n/t	n/t	582	621	560	n/t	436	462	406	416	n/t	352	n/t

PLATEGL-N HSD = 0.2079 X = 4300 q = 0.5 C-Yes = 11.76% C-No = 88.24% W-Yes = 94.12% W-No = 5.88%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
C > (S-X)	No	No	No	Yes	No	No	No	No	No	No	No	No	No	No	No	No	Yes
W>(1/(1+q))(S-X)	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	467	700	750	850	900	950	1000	1000	1050	1050	1000	1000	950	800	700	400	115
Share Price	5050	5050	5050	5050	5300	5300	5300	5300	5350	5350	5350	5400	5300	5150	5075	4700	4400
HSD Price	793	n/t	n/t	n/t	1035	1030	n/t	n/t	1074	1072	n/t	1115	1013	861	784	402	--
W HSD Price	529	n/t	n/t	n/t	690	686	n/t	n/t	716	715	n/t	743	675	574	523	268	--
ISD Values	n/t	n/t	n/t	n/t	--	--	n/t	n/t	--	--	n/t	--	--	--	--	--	--
ISD Price	n/t	n/t	n/t	n/t	1035	--	n/t	n/t	--	--	n/t	--	--	--	--	--	--
W ISD Values	n/t	n/t	n/t	n/t	--	1.7646	n/t	n/t	2.4254	2.6386	n/t	2.9005	2.9228	3.1369	2.8624	4.2135	--
W ISD Price	n/t	n/t	n/t	n/t	--	887	n/t	n/t	1005	1028	n/t	996	918	839	727	419	--

POWTECH-N HSD = 0.3704 X = 400 q = 0.11 C-Yes = 72.22% C-No = 27.78% W-Yes = 88.89% W-No = 11.11%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	No	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
W>(1/(1+q))(S-X)	No	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	60	105	100	100	90	95	90	55	55	70	75	80	80	80	80	80	80	85
Share Price	470	495	495	495	490	490	490	480	450	460	480	470	460	465	470	465	465	480
HSD Price	74	98	98	98	93	92	92	82	52	62	81	71	61	66	71	65	65	--
W HSD Price	66	88	88	88	83	83	83	74	47	56	73	64	55	59	64	59	59	--
ISD Values	--	--	0.858	0.6344	0.6526	--	0.7443	--	--	0.5946	1.0574	--	1.2921	1.8132	1.7496	2.1552	3.0661	--
ISD Price	74	--	104	100	95	--	94	--	--	63	86	--	70	81	81	72	72	--
W ISD Values	--	--	1.2476	1.1019	1.1302	0.9671	1.2279	1.0418	--	0.8773	1.4087	0.8408	1.7458	2.2404	2.232	2.8855	3.8958	--
W ISD Price	--	--	104	99	95	89	94	81	--	62	83	66	71	80	80	70	69	--

RD-LEASE-NPL HSD = 1.0974 X = 30 q = 9 C-Yes = 64.71% C-No = 35.29% W-Yes = 94.12% W-No = 5.88%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
C > (S-X)	No	Yes	No	Yes	Yes	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
W>(1/(1+q))(S-X)	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Share Price	50	30	35	30	30	32	32	33	32	30	30	27	27	30	30	30	30
HSD Price	20	3	7	3	3	4	4	4	4	2	2	1	1	2	1	1	--
W HSD Price	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	--
ISD Values	--	--	0.2937	--	0.3146	0.3522	--	--	--	--	0.4979	n/t	n/t	1.4806	n/t	1.1139	--
ISD Price	20	--	5	--	1	2	--	--	--	--	1	n/t	n/t	2	n/t	1	--
W ISD Values	--	--	3.5524	2.3653	3.7386	4.0805	3.6229	3.7525	3.5843	4.0587	5.4608	n/t	n/t	8.2	n/t	11.6263	--
W ISD Price	--	--	1	1	1	1	1	1	1	1	1	n/t	n/t	1	n/t	1	--

SAPPI-NPL HSD = 0.3581 X = 3200 q = 0.35 C-Yes = 44.44% C-No = 55.56% W-Yes = 100% W-No = 0%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	400	400	400	370	370	370	390	400	350	350	340	340	335	340	355	360	415	550
Share Price	3625	3625	3610	3575	3600	3575	3575	3575	3500	3500	3500	3525	3525	3550	3575	3550	3610	3700
HSD Price	467	465	449	414	435	404	402	400	327	324	317	339	n/t	359	382	353	411	--
W HSD Price	346	344	332	306	322	300	298	296	242	240	235	251	n/t	266	283	261	305	--
ISD Values	--	--	--	--	--	--	--	--	0.358	0.5356	0.635	0.6036	n/t	--	--	--	0.9494	--
ISD Price	467	--	--	--	--	--	--	--	327	345	344	356	n/t	--	--	--	412	--
W ISD Values	--	0.7247	0.7452	0.8137	0.7849	0.7788	0.8955	1.0477	1.1483	1.1368	1.3099	1.314	n/t	1.3492	1.3828	1.9985	2.7594	--
W ISD Price	--	396	387	375	380	351	364	383	352	342	339	342	n/t	336	341	313	346	--

SBIC-NPL HSD = 0.2777 X = 6000 q = 0.1 C-Yes = 55% C-No = 45% W-Yes = 95% W-No = 5%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
C > (S-X)	No	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	No	Yes	No	Yes
W>(1/(1+q))(S-X)	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	1150	1100	950	1000	950	1000	1075	1125	1050	1075	1075	1135	1135	1250	1400	1600	1600	1750	1750	1750
Share Price	7150	7150	7000	6900	6850	6900	7050	7100	7000	7000	7000	7100	7100	7200	7400	7600	7650	7725	7750	7700
HSD Price	1202	1200	1049	947	896	938	1085	1133	1030	1029	1022	1120	1118	1216	1414	1608	1656	1729	1752	--
W HSD Price	1093	1091	953	861	814	853	986	1030	936	935	929	1018	1016	1105	1285	1462	1505	1572	1593	--
ISD Values	--	--	--	--	0.534	0.5716	0.6127	--	--	0.5256	0.7387	0.7836	0.6415	0.6923	0.91	--	--	n/t	2.0653	n/t
ISD Price	1202	--	--	--	950	987	1127	--	--	1046	1065	1156	1130	1225	1430	--	--	n/t	1754	n/t
W ISD Values	--	0.6088	0.4079	--	0.7792	0.8149	0.8758	0.7964	0.8621	0.9031	1.1044	1.1607	1.1677	1.2364	1.4802	1.8756	2.3804	n/t	3.839	n/t
W ISD Price	--	1145	966	--	954	977	1101	1105	1037	1040	1058	1133	1118	1194	1382	1528	1591	n/t	1652	n/t

SENCHEMNP HSD = 0.2665 X = 850 q = 0.3 C-Yes = 7.14% C-No = 92.86% W-Yes = 92.86% W-No = 7.14%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14
C > (S-X)	No	No	No	No	No	No	No	No	No	No	No	No	Yes	No
W>(1/(1+q))(S-X)	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	120	120	120	120	120	120	120	120	120	120	120	120	130	130
Share Price	1000	1000	1000	1000	975	975	980	980	975	975	975	975	975	980
HSD Price	n/t	n/t	n/t	n/t	130	129	134	133	128	128	127	127	125	--
W HSD Price	n/t	n/t	n/t	n/t	100	100	103	103	98	98	98	98	96	--
ISD Values	n/t	n/t	n/t	n/t	--	--	--	n/t	--	--	--	--	--	--
ISD Price	n/t	n/t	n/t	n/t	130	--	--	n/t	--	--	--	--	--	--
W ISD Values	n/t	n/t	n/t	n/t	--	0.9444	0.9768	n/t	1.0648	1.1979	1.2605	1.333	2.8907	--
W ISD Price	n/t	n/t	n/t	n/t	--	119	122	n/t	115	118	118	117	107	--

SIMMERS-NPL HSD = 0.7993 X = 225 q = 1.95 C-Yes = 56.25% C-No = 43.75% W-Yes = 100% W-No = 0%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
C > (S-X)	No	Yes	No	Yes	Yes	Yes	No	No	No	No	Yes	Yes	No	Yes	Yes	Yes
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	5	5	6	9	10	7	20	15	13	11	8	6	4	2	2	2
Share Price	228	220	230	225	230	220	250	250	245	245	225	225	230	225	220	225
HSD Price	n/t	16	21	18	20	14	33	32	28	n/t	12	11	13	5	2	--
W HSD Price	n/t	5	7	6	7	5	11	11	9	n/t	4	4	4	2	1	--
ISD Values	n/t	n/t	--	--	0.3737	0.2904	0.4431	--	--	n/t	--	0.532	0.4174	--	0.2838	--
ISD Price	n/t	n/t	21	--	12	4	28	--	--	n/t	--	8	9	--	0	--
W ISD Values	n/t	n/t	--	0.6328	1.2191	1.2923	1.1648	2.2656	1.5212	n/t	1.3049	1.6466	1.3025	1.0799	0.8721	--
W ISD Price	n/t	n/t	--	5	10	8	13	20	14	n/t	6	8	7	2	1	--

STANPRO-NPL HSD = 0.3626 X = 125 q = 0.15 C-Yes = 16.67% C-No = 83.33% W-Yes = 33.33% W-No = 66.67%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No	No	No	Yes	Yes
W>(1/(1+q))(S-X)	No	No	No	No	Yes	No	Yes	No	No	No	No	No	No	Yes	Yes	No	Yes	Yes
Rights Price	5	5	5	6	6	5	6	7	3	3	3	5	4	4	4	1	1	1
Share Price	137	137	137	137	130	130	130	135	130	130	130	134	132	129	129	129	125	125
HSD Price	n/t	n/t	n/t	n/t	8	7	7	11	7	7	6	10	8	5	5	4	1	--
W HSD Price	n/t	n/t	n/t	n/t	7	6	6	10	6	6	5	8	7	4	4	4	1	--
ISD Values	n/t	n/t	n/t	n/t	--	--	--	0.1626	--	--	--	--	--	--	--	--	--	--
ISD Price	n/t	n/t	n/t	n/t	8	--	--	11	--	--	--	--	--	--	--	--	--	--
W ISD Values	n/t	n/t	n/t	n/t	--	0.2824	--	0.3154	--	--	--	--	--	--	0.2705	0.494	--	--
W ISD Price	n/t	n/t	n/t	n/t	--	6	--	10	--	--	--	--	--	--	4	4	--	--

SUN-BOP-N HSD = 0.4141 X = 3200 q = 0.05 C-Yes = 94.44% C-No = 5.56% W-Yes = 94.44% W-No = 5.56%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
W>(1/(1+q))(S-X)	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	500	525	525	550	530	550	650	650	675	700	700	700	700	850	850	850	850	850
Share Price	3765	3650	3650	3675	3675	3675	3750	3750	3800	3800	3800	3850	3850	4000	4000	4000	3950	3950
HSD Price	n/t	492	489	510	508	503	574	n/t	619	618	n/t	661	660	808	807	803	751	--
W HSD Price	n/t	468	466	486	484	479	547	n/t	590	588	n/t	630	628	770	769	765	716	--
ISD Values	n/t	--	0.6144	0.6353	0.6769	0.6141	0.7561	n/t	1.0257	0.9742	n/t	1.3719	1.136	1.2259	1.5111	2.1911	2.7052	--
ISD Price	n/t	492	521	542	545	526	609	n/t	684	668	n/t	729	691	827	837	825	766	--
W ISD Values	n/t	--	0.733	0.7558	0.8066	0.7612	0.8943	n/t	1.1877	1.1654	n/t	1.5874	1.4165	1.5228	1.9104	2.7409	3.3729	--
W ISD Price	n/t	--	520	539	544	525	602	n/t	679	666	n/t	723	687	811	831	811	749	--

SUNCRSH-N HSD = 0.2104 X = 40000 q = 0.1 C-Yes = 43.75% C-No = 56.25% W-Yes = 50% W-No = 50%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
C > (S-X)	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	No
W>(1/(1+q))(S-X)	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Yes
Rights Price	5909	5909	4600	4600	4600	4600	4300	4300	4300	3600	3000	2500	2500	2500	2500	2500
Share Price	41150	41150	45500	45500	44000	44000	44000	44000	44000	44000	43500	43500	43500	43500	43500	42500
HSD Price	n/t	n/t	5775	5774	4274	n/t	4200	n/t	n/t	n/t	3592	3579	n/t	3526	n/t	--
W HSD Price	n/t	n/t	5250	5249	3885	n/t	3818	n/t	n/t	n/t	3265	3254	n/t	3206	n/t	--
ISD Values	n/t	n/t	--	--	n/t	n/t	0.4997	n/t	n/t	n/t	--	--	n/t	--	n/t	n/t
ISD Price	n/t	n/t	5775	--	n/t	n/t	4555	n/t	n/t	n/t	--	--	n/t	--	n/t	n/t
W ISD Values	n/t	n/t	--	--	n/t	n/t	0.6841	n/t	n/t	n/t	--	--	n/t	--	n/t	n/t
W ISD Price	n/t	n/t	--	--	n/t	n/t	4538	n/t	n/t	n/t	--	--	n/t	--	n/t	n/t

SYCOM-NPL HSD = 0.2027 X = 700 q = 0.2 C-Yes = 27.78% C-No = 72.22% W-Yes = 66.67% W-No = 33.33%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	Yes	Yes	No	No	No	No	Yes	Yes	No	No	No	No	No	No	No	No	No	Yes
W>(1/(1+q))(S-X)	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Rights Price	10	20	30	35	35	45	45	40	40	40	40	38	38	38	30	30	30	35
Share Price	665	665	735	735	735	750	735	735	745	745	745	745	745	740	730	730	730	730
HSD Price	n/t	n/t	43	n/t	n/t	55	41	n/t	49	n/t	48	n/t	n/t	42	32	31	30	n/t
W HSD Price	n/t	n/t	36	n/t	n/t	46	34	n/t	41	n/t	40	n/t	n/t	35	27	26	25	n/t
ISD Values	n/t	n/t	n/t	n/t	n/t	--	--	n/t	0.1968	n/t	--	n/t	n/t	--	--	--	--	n/t
ISD Price	n/t	n/t	n/t	n/t	n/t	55	--	n/t	49	n/t	--	n/t	n/t	--	--	--	--	n/t
W ISD Values	n/t	n/t	n/t	n/t	n/t	--	--	n/t	0.4342	n/t	--	n/t	n/t	--	0.4629	0.6178	0.7723	n/t
W ISD Price	n/t	n/t	n/t	n/t	n/t	--	--	n/t	46	n/t	--	n/t	n/t	--	30	28	27	n/t

TAMBOTI-NPL HSD = 0.1979 X = 270 q = 0.4 C-Yes = 11.11% C-No = 88.89% W-Yes = 38.89% W-No = 61.11%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes
W>(1/(1+q))(S-X)	No	No	No	No	No	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	No	Yes	Yes
Rights Price	0	1	3	5	5	5	5	5	5	3	3	5	5	5	5	3	2	2
Share Price	272	272	272	275	275	275	275	280	280	280	280	280	275	275	275	275	270	270
HSD Price	n/t	n/t	n/t	10	n/t	9	9	12	12	12	n/t	n/t	7	7	6	n/t	1	--
W HSD Price	n/t	n/t	n/t	7	n/t	6	6	9	9	9	n/t	n/t	5	5	4	n/t	1	--
ISD Values	n/t	n/t	n/t	--	n/t	n/t	--	--	--	--	n/t	n/t	--	--	--	n/t	--	--
ISD Price	n/t	n/t	n/t	10	n/t	n/t	--	--	--	--	n/t	n/t	--	--	--	n/t	--	--
W ISD Values	n/t	n/t	n/t	--	n/t	n/t	0.0574	0.0835	--	--	n/t	n/t	--	0.2167	0.2426	n/t	--	--
W ISD Price	n/t	n/t	n/t	--	n/t	n/t	5	8	--	--	n/t	n/t	--	5	5	n/t	--	--

TEMPORA-NPL HSD = 0.4085 X = 1500 q = 0.25 C-Yes = 0% C-No = 100% W-Yes = 38.89% W-No = 61.11%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
W>(1/(1+q))(S-X)	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	No	No
Rights Price	100	100	250	300	325	335	335	335	335	335	300	300	300	275	200	225	200	200
Share Price	2350	2350	2350	2350	2350	1900	1900	1900	1900	1900	1925	1925	1925	1925	1700	1750	1750	1750
HSD Price	866	n/t	n/t	n/t	n/t	411	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	204	251	251	n/t
W HSD Price	693	n/t	n/t	n/t	n/t	329	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	163	201	201	n/t
ISD Values	n/t	n/t	n/t	n/t	n/t	--	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	--	--	--	n/t
ISD Price	n/t	n/t	n/t	n/t	n/t	411	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	--	--	--	n/t
W ISD Values	n/t	n/t	n/t	n/t	n/t	--	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	--	2.1427	2.3871	n/t
W ISD Price	n/t	n/t	n/t	n/t	n/t	--	n/t	n/t	n/t	n/t	n/t	n/t	n/t	n/t	--	219	209	n/t

TEMPORA-N HSD = 0.5046 X = 1500 q = 0.25 C-Yes = 52.94% C-No = 47.06% W-Yes = 100% W-No = 0%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
C > (S-X)	Yes	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes	Yes	No	No	No	Yes	No
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	380	375	375	375	375	300	300	300	300	350	300	300	300	300	175	225	200
Share Price	1828	1828	1828	1828	1828	1828	1828	1800	1800	1800	1750	1750	1800	1800	1700	1700	1700
HSD Price	n/t	n/t	n/t	n/t	n/t	n/t	n/t	309	308	n/t	255	255	n/t	303	201	n/t	--
W HSD Price	n/t	n/t	n/t	n/t	n/t	n/t	n/t	247	247	n/t	204	204	n/t	242	161	n/t	--
ISD Values	n/t	n/t	n/t	n/t	n/t	n/t	n/t	--	--	n/t	1.4668	1.4296	n/t	--	--	n/t	--
ISD Price	n/t	n/t	n/t	n/t	n/t	n/t	n/t	309	--	n/t	303	293	n/t	--	--	n/t	--
W ISD Values	n/t	n/t	n/t	n/t	n/t	n/t	n/t	--	1.4701	n/t	2.5083	2.3655	n/t	2.2073	3.1473	n/t	--
W ISD Price	n/t	n/t	n/t	n/t	n/t	n/t	n/t	--	295	n/t	310	289	n/t	290	216	n/t	--

TEMPORA-N HSD = 0.2944 X = 1800 q = 0.5 C-Yes = 0% C-No = 100% W-Yes = 100% W-No = 0%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
C > (S-X)	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	200	175	160	150	150	75	125	150	150	110	125	125	125	120	120	120
Share Price	2050	2000	1950	1950	1950	1900	1925	1950	1950	1950	1950	1925	1925	1925	1925	1925
HSD Price	265	216	169	169	n/t	121	n/t	162	n/t	n/t	n/t	129	127	126	n/t	n/t
W HSD Price	177	144	113	113	n/t	81	n/t	108	n/t	n/t	n/t	86	85	84	n/t	n/t
ISD Values	--	--	--	--	n/t	--	n/t	--	n/t	n/t	n/t	--	--	--	n/t	n/t
ISD Price	265	--	--	--	n/t	--	n/t	--	n/t	n/t	n/t	--	--	--	n/t	n/t
W ISD Values	--	0.664	0.6976	0.7895	n/t	0.7814	n/t	0.7174	n/t	n/t	n/t	0.8736	1.4495	1.6804	n/t	n/t
W ISD Price	--	172	148	158	n/t	124	n/t	135	n/t	n/t	n/t	108	116	113	n/t	n/t

TIGOATS-N HSD = 0.3387 X = 3700 q = 0.15 C-Yes = 61.11% C-No = 38.89% W-Yes = 94.44% W-No = 5.56%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
C > (S-X)	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
W>(1/(1+q))(S-X)	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	465	375	400	375	400	375	350	350	400	430	405	350	400	400	360	375	325	425
Share Price	4175	4100	4100	4075	4075	4075	4050	4025	4025	4050	4050	3950	3950	3950	3950	3975	3950	4000
HSD Price	521	449	446	421	418	410	384	358	n/t	376	368	270	267	264	261	278	252	--
W HSD Price	453	390	388	366	363	356	334	311	n/t	327	320	235	232	229	227	242	219	--
ISD Values	n/t	--	--	--	--	--	--	--	n/t	0.6046	0.7623	0.6662	0.8448	1.1757	1.2758	1.5079	1.8277	--
ISD Price	n/t	449	--	--	--	--	--	--	n/t	414	421	317	338	382	379	345	305	--
W ISD Values	n/t	--	--	0.4175	0.4003	0.5896	0.4781	0.462	n/t	0.8624	1.0721	0.9957	1.1069	1.4821	1.6063	1.9379	2.3841	--
W ISD Price	n/t	--	--	378	372	395	353	328	n/t	408	419	330	336	380	377	336	297	--

WAICOR-NPL HSD = 0.8344 X = 70 q = 1.5 C-Yes = 75% C-No = 25% W-Yes = 93.75% W-No = 6.25%

Day Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
C > (S-X)	Yes	Yes	Yes	No	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
W>(1/(1+q))(S-X)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rights Price	6	10	9	5	4	3	5	2	1	1	1	1	1	1	1	1
Share Price	70	75	75	75	74	70	75	75	70	70	70	70	70	70	70	70
HSD Price	6	9	9	n/t	7	5	n/t	7	4	n/t	3	n/t	2	2	1	--
W HSD Price	2	4	4	n/t	3	2	n/t	3	2	n/t	1	n/t	1	1	0	--
ISD Values	n/t	--	n/t	n/t	--	--	n/t	--	--	n/t	0.2181	n/t	0.326	0.3812	0.4725	n/t
ISD Price	n/t	9	n/t	n/t	--	--	n/t	--	--	n/t	1	n/t	1	1	1	n/t
W ISD Values	n/t	--	n/t	n/t	1.594	1.3184	n/t	1.9344	--	n/t	0.5825	n/t	0.8404	0.9749	1.1995	n/t
W ISD Price	n/t	--	n/t	n/t	5	3	n/t	5	--	n/t	1	n/t	1	1	1	n/t

C > (S-X*e(-rt)) YES = 44.22% NO = 55.78%
W > (1/(1+q))*(S-X*e(-rt)) YES = 85.44% NO = 14.56%