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The Pricing of Low Exercise Price Options

by

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Abstract:

This paper examines the pricing of Low Exercise Price Options (LEPOs) listed on the Australian Stock Exchange. The cost of carrying model is used to calculate theoretical prices which are then compared to the price at which actual trades occurred. The results indicate that LEPO trades, that are unaffected by dividends, may be underpriced relative to the underlying shares. A possible reason for this may be the difficulty associated with short-selling shares in the Australian market.

Keywords:

LOW EXERCISE PRICE OPTIONS; SHORT-SELLING; OPTIONS; FUTURES.

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1. Introduction

On 7 April 1995 the Australian Stock Exchange allowed trading to begin in a new product called a Low Exercise Price Option (LEPO). A LEPO is similar to a standard exchange-traded call option, in that it gives the taker the right to purchase 1,000 shares in a company at a predetermined exercise price and imposes an obligation upon the writer of the LEPO to sell those shares at the exercise price if the option is exercised. Several important differences distinguish LEPOs from standard exchange-traded options, and these differences have important implications for the pricing of this new security. This paper considers the pricing of LEPOs on eight of the ten companies for which LEPO trading was initially authorised; ANZ Banking Group Ltd, BHP Ltd, CRA Ltd, Foster's Brewing Group Ltd, M.I.M. Holdings Ltd, National Australia Bank Ltd, News Corporation Ltd, Westpac Banking Corporation Ltd and Western Mining Corporation Ltd.¹

The purpose of this paper is to determine whether the LEPOs are being priced without bias. The way in which LEPOs should be priced will be discussed in section 2. Section 3 will detail the data used in the analysis, while section 4 describes the methodology undertaken to determine whether the market is pricing the securities unbiasedly. The results of the tests are in section 5 and section 6 presents the conclusions.

2. Pricing of Low Exercise Price Options

The primary difference between a LEPO and a standard exchange-traded call option is that a LEPO has a nominal exercise price.² As a result, the LEPO will almost always be 'deep-in-the-money', and the price of the underlying share at expiry will almost always be greater than the exercise price specified in the contract. This is especially true given that the companies for which LEPO trading occurs are among the largest companies on the Australian Stock Exchange. Such companies have a lower probability of default than smaller companies. This necessarily implies that the holder of the LEPO will exercise the 'option' in all but the most extraordinary of circumstances.³

Another important difference between LEPOs and standard exchange-traded options is that the taker of the LEPO is not obliged to pay for the option in full; rather, they are only required to deposit an initial margin with the exchange. All positions are marked-to-market daily; that is, changes in the value of positions are credited or debited to accounts on a daily basis. When the LEPO is exercised, the initial margin is returned, all previous mark-to-market postings are reversed and the taker/writer receives/delivers 1,000 shares after paying/receiving 1,000 times the sum of the option price and the exercise price. Petzel (1995) points out; 'The net effect of futures-style margins on a zero-strike price option is to transform it

1. LEPOs for BTR Nylex Ltd and Foster's Brewing Group Ltd were not traded with sufficient frequency over the sample period to warrant inclusion in the sample. There were only 17 valid LEPO trades for Fosters Brewing Group Ltd and no valid trades for BTR Nylex Ltd.
2. All LEPOs currently have an exercise price of 1¢.
3. The only time that a LEPO would not be exercised by a rational investor, is when the price of the share is less than the cost of exercising the option. As the current exercise price of all LEPOs is 1¢, the probability of the option being allowed to lapse is negligible. In the absence of transaction costs, the option would be exercised unless the underlying share has a value of less than or equal to 1¢.

into a futures contract' (p. 33). That is, a European-style call option that is marked-to-market daily and has a negligible exercise price, is virtually identical to a futures contract on the same commodity. As such, the LEPO can be priced in the same way as a futures contract is priced with a small adjustment being made for the value of the exercise price paid at expiry.⁴

The method of valuation is based on the cost of carrying model.⁵ In its simplest form the cost of carrying model states that the value of a futures contract must be equal to the cost of the spot commodity plus the cost associated with holding that commodity until the maturity of the contract. If this condition does not hold, then arbitrage opportunities may arise. Applied to LEPOs, the current value of a contract is equal to the current price of the underlying share compounded by the risk-free interest rate, less the accumulated value of any dividends where the shares went ex-dividend during the life of the contract, less the exercise price of 1¢. That is, the value of a LEPO is equal to the spot price, plus any costs of borrowing, less the accumulated value of dividends and less the exercise price. This paper uses continuously compounded returns, hence the pricing formula is:⁶

$$L_{0,1} = S_0 e^{r(n/365)} - D e^{r((n-y)/365)} - X, \quad (1)$$

where: S_0 = price of underlying share at time 0;
 $L_{0,1}$ = price of LEPO contract entered into at time 0 for delivery at time 1;
 D = value of share dividends where the share went ex-dividend during the life of the LEPO contract;

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4. LEPOs were introduced by the Australian Stock Exchange (ASX) on 7 April 1995 whilst the Sydney Futures Exchange (SFE) introduced Individual Share Futures Contracts on 16 May 1994. These contracts have been examined by Brailsford and Cusack (1997) and Twite and Wood (1997). The ASX differentiates its product on two main grounds. Firstly, that the LEPO premium can be off-set against other exchange-traded options, hence providing the opportunity to significantly reduce margins. Secondly, LEPOs require physical delivery of the underlying asset, whilst ISFs, up until 26 September 1996, were cash settled instruments.
 5. For a more comprehensive discussion of this model see Black (1976) and Cox, Ingersoll and Ross (1981). This model also assumes a frictionless capital market where funds can be borrowed and lent at the risk-free rate which is itself non-stochastic. For a discussion of the importance of this assumption see Twite (1992).
 6. The use of the cost of carry model assumes that the LEPO contract will always be exercised. As the only time that a LEPO will not be exercised by a rational investor is when the price of the share is less than the 1¢ cost of exercising the option, this is a very realistic assumption.

The trivial difference made to the analysis by making this assumption may be illustrated by comparing the value of a LEPO using the cost of carry model and a modified Black-Scholes model. The Black-Scholes model must be modified to recognise that the premium is paid at the expiry of the contract. The modified formula is:

$$L_{0,1} = [S_0 N(d_1) - X e^{-r(n/365)} N(d_2)] e^{r(n/365)},$$

where $N(d_1)$ and $N(d_2)$ are as defined in the standard Black-Scholes formula.

For a LEPO with an underlying share price of \$1, a volatility of the underlying share of 80% per annum, a time to maturity of two years, an exercise price of 1¢, and where the risk-free rate of interest is 40% per annum, the value from the modified Black-Scholes model is \$2.2155410, and the value using the cost of carry model is \$2.2155409, the difference being \$0.0000001. Therefore, even when extreme values of all parameters are selected to maximise the possibility of not exercising the option, the value of this right is worth only \$0.000,000,1. This would be undetectable in empirical tests. For a comprehensive discussion of the pricing issues relating to LEPOs see Martini (1994).

- r = risk-free rate of return over the life of the contract ;
- X = exercise price (equals 1¢);
- n = number of days until contract maturity; and
- y = number of days until dividend is paid.

The question that arises when the underlying share goes ex-dividend during the life of the LEPO is; at what value should that dividend be incorporated into the pricing equation? The actual value of the dividend to each shareholder will depend on their tax position. If only the cash value of the dividend is used then the implicit assumption being made is that the franking credit cannot be used by the shareholder. Alternatively, if the full grossed-up value of the dividend is incorporated, the assumption being made is that the franking credit can be fully utilised by the shareholder. To examine the sensitivity of the results to the treatment of franking credits attached to the dividends, dividend-affected trades are considered separately from those trades not affected by dividends.

3. Data

This paper examines the pricing of LEPO contracts traded in the period August 1995 to July 1996. Trades in the contracts and in the underlying shares were collected from the Equinet Database. Information gathered included; the time that each trade took place (to the nearest minute), the price at which the trade took place, the volume of the contracts/shares traded and any special comments accompanying the trade (e.g. whether the trade was a special crossing). LEPO trades were excluded from the analysis where the comment accompanying the trade indicated that the trade was a crossing or that there was something 'special' about it indicating that the price of the trade could not be regarded as market-determined.⁷ The share price used in the pricing formula was the price at which the underlying share traded in the minute closest to the LEPO trade.⁸ If more than one trade took place in that minute, the price relating to the largest number of shares traded in that minute was used.

Proxies for the risk-free rate of return were obtained from the Equinet Database. Specifically, the daily values for the Reserve Bank of Australia (RBA) 11 a.m. Cash Rate, the RBA 90-Day Dealers Bill Rate, and the RBA 180-Day Dealers Bill Rate were obtained for the sample period. The interest rate used in equation 1 varied depending on the amount of time until dividend payment or contract maturity. That is, if the relevant number of days was 45 or less the cash rate was used, if there were between 46 and 135 days the 90 day rate was chosen and if there were more than 135 days until the contract matures or the dividend is paid the 180 day rate was utilised.⁹

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7. Of the 1,442 trades that were collected for the eight companies over the sample period, 237 were excluded leaving a valid sample of 1,205 trades.
 8. The average amount of time between the trade in the LEPO and the matched trade in the underlying share was 1.01 minutes. For 81% of matched trades the time difference was 1 minute or less.
 9. The analysis was repeated using each of the three rates exclusively and the results in each case were very similar.

4. Methodology

For each LEPO trade that occurred, equation 2 was used to calculate a theoretical price. In order to ascertain whether the market is pricing the LEPO contracts in an unbiased fashion, the theoretical price is compared with the actual price using non-parametric statistics.¹⁰

If the LEPOs are being priced without bias, then it would be expected that there would be an approximately equal number of occasions when the theoretical price of the LEPO exceeds the actual price as there are instances when the actual price exceeds the theoretical price. The sign test can be used to make inferences about the proportion of underpricings and overpricings in the population from which the sample of LEPO prices have been drawn. If we define P as the proportion of occasions when the LEPO is underpriced/overpriced, then a test of the unbiased pricing hypothesis is;

$$H_0: P = 0.5.$$

By counting the number of times that the LEPO contracts are overpriced versus underpriced, relative to the underlying share, the probability that the sample is drawn from a population where there is an equal chance of either form of mispricing can be calculated by reference to the cumulative binomial distribution.

Analysis of those trades affected by dividends is somewhat problematic. At first glance, it may seem a reasonable approach to attempt to account for the value of the dividend by examining what the ex-dividend date drop-off has traditionally been for the shares underlying the LEPO contracts (an approach favoured by a number of previous studies that have attempted to estimate the value of dividends Hathaway & Officer (1992), Brown & Clarke (1993), and Bruckner, Dews & White (1994)). Heath and Jarrow (1988) however, suggest that the ex-dividend date drop-off is an inadequate proxy for the value of the dividend, as trading in shares is riskier around the time of the ex-dividend date. This implies that the decrease in share value on the ex-dividend date may not only be a result of the lapsing of the entitlement to the dividend, but may also reflect a higher risk premium applied to the shares themselves. The only appropriate solution to this problem is to calculate the bounds within which the value of the dividend would lie. If all investors could make full use of the tax credit, whilst incurring no tax liability themselves, the appropriate value for the dividend would be its grossed-up value. Conversely, if all investors were exempt from the Australian taxation system, and hence were unable to take advantage of the value of the imputation credit, then the cash dividend amount would represent the total value of the distribution of profit.

Testing is carried out twice for the dividend-affected trades; firstly, with no adjustment to the cash dividend and secondly, with full adjustment for the franking credit attached to the dividend.¹¹ Inferences may only be drawn where the results are robust to using the cash dividend and the grossed-up dividend.

10. Parametric techniques were excluded because of the restrictive assumptions that need to be made about the distribution of the variables concerned.

11. M.I.M. Holdings Ltd and News Corporation Ltd were the only firms whose dividends were unfranked. ANZ paid a dividend of which only 33% attracted a franking credit. The remaining securities paid fully-franked dividends.

However, it should be noted that the clearest results may be obtained from those trades unaffected by dividends.

5. Results

Table 1 considers the pricing of LEPO trades that have not been affected by dividends.

Table 1
Sign Test Results for Trades Not Affected by Dividends

Company	<i>N</i>	Over-pricings	Under-pricings	Probability	Median Days until Maturity	Median Mispricing (%)	Median Absolute Mispricing (%)
ANZ Banking Group Ltd	28	7	21	0.006*	66	-0.28	0.32
BHP Ltd	250	107	143	0.013*	35	-0.02	0.09
CRA Ltd	197	61	136	0.000*	42	-1.21	1.21
M.I.M. Holdings Ltd	75	22	53	0.000*	106	-0.42	0.78
National Australia Bank	74	30	44	0.065	57	-0.12	0.26
News Corp. Ltd	52	28	24	0.339	24	0.08	0.27
Westpac Banking Corp.	30	3	27	0.000*	77	-1.98	1.98
Western Mining Corp.	255	98	157	0.000*	42	-0.11	0.24
All Companies	961	356	605	0.000*	43	-0.09	0.23
All Companies by Maturity							
0 – 21 Days	219	75	144	0.000*	9	-0.05	0.14
22 – 42 Days	256	79	177	0.000*	31	-0.14	0.27
43 – 72 Days	267	117	150	0.025*	57	-0.05	0.23
73 – 252 Days	219	85	134	0.001*	87	-0.12	0.31

Note: * Denotes significance at the 5% level for the two-tailed sign test.

The results suggest that LEPOs traded on six of the eight companies are systematically underpriced relative to the underlying shares, whilst there is no evidence that the LEPOs traded on the other two companies are mispriced.

This finding may be explained by the difficulty associated with short-selling shares.¹² Puttonen (1993) found that stock market returns were positively related

12. ASX Business Rule 2.18 (11)(a) provides that 'A Short Sale of Public Securities shall not be made with a settlement date more than 10 Trading Days after the date of sale'. Hence, exploiting an arbitrage opportunity when the LEPO is relatively underpriced and has more than 10 days until expiry will be problematic. Even when there are 10 days or less until expiry, it is relatively more difficult to short-sell a share than it is to write a LEPO, as brokers will require security and may withhold a proportion of the proceeds from the short-sale to protect themselves against non-delivery of the shares.

with lagged futures and options returns. This relationship was found to be stronger for negative returns than for positive returns. This result was explained by the fact that short-selling constraints reduce the speed with which the share market incorporates negative information into prices, whilst there is no such difficulty in derivative markets. Figlewski and Webb (1993) also found that constraints on the short-selling of shares caused negative information to be underweighted in the market price of shares. The results in table 1 indicate that LEPOs are underpriced relative to the corresponding shares. If there is a lagged relationship between shares and derivatives in Australia, and if this relationship is stronger for negative returns than for positive returns, then the results in table 1 may not be an indication of the LEPOs being relatively underpriced, but may instead simply be the result of share prices being slow to adjust to negative information.

The apparent underpricing may also be related to the difference in the transaction costs that need to be incurred in order to take advantage of a mispriced LEPO. If a LEPO is overpriced then the arbitrageur incurs transaction costs in selling the LEPO and buying the share. If a LEPO is underpriced, then the arbitrageur pays the transaction costs associated with buying the LEPO and short-selling the share. Whilst we may assume that the costs associated with buying or selling the LEPO would be identical, it is likely that the costs associated with short-selling a share are greater than those associated with buying a share. If this is the case, then we would expect to observe more instances of apparent LEPO underpricing than occasions where the LEPO is apparently overpriced.¹³

When trades are considered on the basis of term to maturity, systematic underpricing is apparent across all periods. The underpricing bias, however, appears to be stronger for the shorter terms to maturity. In order to test for the independence between term to maturity and the number of underpricings and overpricings, a chi-square test is performed. The calculated test statistic of 10.48 is significant at the 5% level. Therefore the hypothesis that the number of underpricings or overpricings is independent of the number of days until the LEPO contract matures is rejected. A possible explanation for this result may be the estimation error associated with the interest rate used in equation 1. As the LEPOs term to maturity increases so too does the impact of the interest rate on the calculated LEPO price. If the interest rate specified in equation 1 is too low, then an increase in the term to maturity will necessarily result in an increase in the apparent number of overpricings relative to underpricings. In order to study the strength of the apparent underpricing, independent of the interest rate effect, the trades with the shortest term to maturity, that is with between 1 and 21 days until maturity, are examined. Even when interest rates are decreased by 2%, there is still statistically significant evidence of underpricing.

Hence, there seem to be two separate effects that influence the pricing of LEPOs, each working in an opposite direction. The difficulty associated with exploiting underpriced LEPOs due to short-selling constraints, results in the systematic underpricing of the security. At the same time, the estimation error associated with the interest rate used in the pricing model has resulted in a tendency for the model to underestimate the LEPOs value. The apparent overpricing that results from this estimation error becomes more prevalent as the

13. We thank Garry Twite for recognising this possible explanation.

term to maturity increases, due to the increased influence of interest rates on the LEPO's theoretical price.

Those trades that are affected by dividends are considered in table 2.

Table 2
Binomial Test Results for Trades Affected by Dividends

Company	Dividend Adjustment	<i>N</i>	Over-pricings	Under-pricings	Prob.	Median No. of Days	Median Mispricing (%)	Median Absolute Mispricing (%)
ANZ Banking Group Ltd	Cash Only	20	16	4	0.006*	133	0.45	0.55
	Grossed Up	20	19	1	0.000*	133	1.08	1.08
BHP Ltd	Cash Only	105	56	49	0.279	87	0.02	0.11
	Grossed Up	105	105	0	0.000*	87	0.79	0.79
CRA Ltd	Cash Only	5	2	3	0.500	114	-0.37	1.68
	Grossed Up	5	3	2	0.500	114	0.43	0.90
M.I.M. Holdings Ltd	Cash Only	42	32	10	0.001*	188	0.70	1.14
National Australia Bank	Cash Only	5	4	1	0.188	155	0.12	0.26
	Grossed Up	5	5	0	0.031	155	2.38	2.38
News Corporation Ltd	Cash Only	23	13	10	0.339	106	0.18	0.25
Westpac Banking Corp.	Cash Only	10	7	3	0.172	199	0.52	0.52
	Grossed Up	10	10	0	0.001*	199	2.26	2.26
Western Mining Corp.	Cash Only	34	22	12	0.061	119	0.27	0.39
	Grossed Up	34	32	2	0.000*	119	1.03	1.06
All Companies	Cash Only	244	152	92	0.000*	119	0.10	0.24
	Grossed Up	244	219	25	0.000*	119	0.79	0.85

Note: * Denotes significance at the 5% level for the two-tailed sign test.

The results indicate that LEPOs relating to two of the eight companies, ANZ Banking Group Ltd and M.I.M. Holdings Ltd, are systematically overpriced relative to the underlying shares. Further, for all but one of the companies, and for both cash dividend-adjusted prices and grossed-up dividend-adjusted prices, the number of relatively overpriced LEPOs exceeds the number of underpriced LEPOs.

As the term to maturity of dividend affected trades is generally greater than for non-dividend affected trades, the results will be more sensitive to interest rate misspecification. If investors cannot borrow at the risk-free rate, then the interest rate used in the calculation of theoretical LEPO prices may be too low, resulting in the apparent systematic overpricing of LEPOs. In order to test the sensitivity of the results to interest rate misspecification, table 2 is reformulated after increasing the interest rate used in equation 2 by 1%. The new results are contained in table 3.

Table 3
Binomial Test Results for Trades Affected by Dividends with Interest Rates Increased by 1%

Company	Dividend Adjustment	<i>N</i>	Over-pricings	Under-pricings	Prob.	Median No. of Days	Median Mispricing (%)	Median Absolute Mispricing (%)
ANZ Banking Group Ltd	Cash Only	20	11	9	0.412	133	0.07	0.27
	Grossed Up	20	19	1	0.000*	133	0.68	0.68
BHP Ltd	Cash Only	105	5	100	0.000*	87	-0.26	0.27
	Grossed Up	105	103	2	0.000*	87	0.51	0.51
CRA Ltd	Cash Only	5	1	4	0.188	114	-0.68	1.43
	Grossed Up	5	3	2	0.500	114	0.11	1.21
M.I.M. Holdings Ltd	Cash Only	42	22	20	0.439	188	0.13	0.76
National Australia Bank	Cash Only	5	0	5	0.031	155	-0.23	0.23
	Grossed Up	5	5	0	0.031	155	1.97	1.97
News Corporation Ltd	Cash Only	23	5	18	0.005*	106	-0.23	0.27
Westpac Banking Corp.	Cash Only	10	4	6	0.377	199	-0.00	0.50
	Grossed Up	10	10	0	0.001*	199	1.67	1.67
Western Mining Corp.	Cash Only	34	14	20	0.196	119	-0.11	0.20
	Grossed Up	34	27	7	0.000*	119	0.68	0.69
All Companies	Cash Only	244	62	182	0.000*	119	-0.21	0.31
	Grossed Up	244	194	50	0.000*	119	0.50	0.57

Note: * Denotes significance at the 5% level for the two-tailed sign test.

When interest rates are increased by 1%, there is no evidence that the dividend-affected LEPO trades are systematically mispriced.

Whilst the results have indicated that LEPOs are systematically underpriced, there is no evidence that the mispricing is economically significant. The median absolute mispricing is less than 1% for both dividend-affected and non-dividend-affected trades. Transaction costs such as brokerage fees and state-duty could easily account for why the mispricing has not been arbitrated away. These costs, however, do not explain the existence of the systematic mispricing in the first instance.

Market illiquidity will serve as an impediment to any apparent mispricing being arbitrated away. Following Twite and Wood (1997), a thorough analysis was undertaken to detect any possible clustering in the data, as clustering would suggest that there were greater opportunities to exploit. No evidence of clustering was found. This suggests why the mispricing was not arbitrated away but once again it does not explain the existence of the systematic mispricing.

6. Conclusion

The purpose of this study was to determine whether Low Exercise Price Options were priced without bias by the market. The results indicate that of those LEPO trades not affected by dividends, six of the eight companies examined were systematically underpriced. A possible explanation for this apparent mispricing may be the higher transaction costs and other impediments associated with short-selling shares on the Australian Stock Exchange. Separate analysis of LEPO trades that were affected by dividends indicated a bias towards overpricing. This result may be explained by the estimation error associated with the interest rate used in the calculation of the theoretical LEPO price.

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