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Hedging employee stock options and the implications for accounting standards

1. INTRODUCTION

Employee (or executive) stock options (ESOs) have generated considerable debate (and not an insignificant volume of research) amongst accountants and finance professionals in recent years. This debate has been fuelled by the growing use of stock options as a component of remuneration and by the institution of international accounting practices that require the expensing of these options in the income statement. The debate has been further compounded by an increasing involvement from financial mathematicians with regard to their pricing. Thus far, no group has managed to reach any consensus regarding the valuation of these stock options, or how they should be reflected in the accounting records. In this paper we integrate the accounting and pricing discussions and provide a model which links the valuation of the stock options with their accounting treatment.

2. CHARACTERISTICS OF EMPLOYEE STOCK OPTIONS

The valuation of employee stock options poses a number of unique problems. ESOs often have features that distinguish them from market-traded options. These features include:

- The options may not be exercised during the "vesting period". The employee must work for the company for a specified time before obtaining access to the option benefit.
- If the employee leaves the company (voluntarily or otherwise) during the vesting period, the options will be forfeited.
- The options are not tradable. Thus employees may be forced to exercise the options irrationally rather than selling them to liquidate their position. The likelihood of this is far greater if the employee has immediate cash flow needs or the value of the option reflects a significant portion of their personal wealth.
- Employees that leave the company after the vesting period, but before the maturity of the options, may forfeit out-of-the-money options or automatically exercise in-the-money options (regardless of whether the exercise makes financial sense or not.)
- Possible stock dilution owing to the issue of new treasury stock in the event of exercise.

All of these features may induce the employee to act in a way that violates some of the assumptions used in standard option pricing models. The vesting period implies that the option is deferred in value. This concurs comfortably with standard option pricing methodology. Employee attrition during (and after) the vesting period can also be incorporated. However, the fact that ESOs cannot be sold has an extreme effect on the pricing methodology. In standard American option pricing, the option holder always has a choice – exercise or sell the option. Because this decision is rational, it can be rigorously modelled mathematically resulting in a partitioning of the valuation region into a *continuation region* and an *exercise region*. Holders of ESOs do not have this choice. They can only exercise the options which may occur when the exercised value is (much) less than the option's time value. The mathematics of this type of exercise decision is imprecise, at best. The issue of dilution is a further complication. Classical option pricing theory assumes explicitly that the existence and (potential) exercise of the derivative has no effect on the underlying security market. In the instance of issuing shares to cover the exercise of an ESO, this condition is violated.

3. ACCOUNTING FOR EMPLOYEE STOCK OPTIONS

The treatment of ESOs from an accounting perspective is determined by International Financial Reporting Standard 2 – Share-based Payment (IASB 2003). IFRS 2 prescribes a two-stage approach to accounting for employee stock options: firstly, value the options on grant date by using an appropriate valuation model; and secondly, recognise the value of the options as an accounting expense over the vesting period.

IFRS 2 provides brief guidance on the valuation of ESOs. As mentioned earlier, options are generally subject to vesting conditions. IFRS 2 distinguishes

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between market related and non-market related vesting conditions. Non-market related vesting conditions are conditions that the employee must satisfy before becoming entitled to the option benefit. These may include a requirement to remain in service with the employer for a specified amount of time, or performance conditions which require certain financial or strategic targets to be met. Market related vesting conditions are conditions related to the market price of the entity's stock. The stock options must then be valued using an accepted valuation model. The valuation model should only consider market related vesting conditions. Non-market related conditions are considered when the options are expensed in the accounting records. The discussion that follows focuses on only one vesting condition, the time that the employee must remain in the service of the employer before becoming entitled to the option. This period is often referred to as the "vesting period".

IFRS 2 addresses the potential for early exercise by adjusting the option life in the Black-Scholes-Merton formula to the expected life of the option, rather than the contract life. As an alternative, it suggests that early exercise be modelled in a binomial pricing model. It does not, however, provide any guidance as to how the early exercise feature should be included in the binomial model.

Over the vesting period, the accountant is required to continuously assess the likelihood of the options actually vesting, such that the final cumulative option expense is equal to the grant date value of the options that ultimately vest. This is best illustrated by means of an example. Assume the company issues options that are in total valued at R100 (ignoring non-market related vesting conditions), which vest after two years and mature at the end of five years. If the company initially estimates that 20% of the employees will leave before vesting, and then finds that 85% of the options ultimately vest, the following expenses will be recognised: in Year 1, R40 = 0.50 x (100% - 20%) x R100, and, in Year 2, R45, ensuring a total of R85 (= 85% x R100).

As has been suggested above, many of the common features of ESOs preclude the use of a standard Black-Scholes or binomial model. Whilst IFRS 2 acknowledges this, its suggested remedies appear rather arbitrary and often have little theoretical basis, an example being the problem of early exercise. IFRS 2 suggests that the option life used as an input to the normal models be reduced to the average expected option life. The existing literature indicates that this is a gross oversimplification and is unlikely to produce a justifiable value.

Another area of concern is that ESOs normally vest after a prescribed period. Employees that leave the firm during the vesting period will lose all benefits under the ESO plan. This will reduce the value of the ESO, but IFRS 2 prohibits consideration of service-type vesting considerations when valuing ESOs. Instead, IFRS 2 only expenses those options that are expected to ultimately vest. The advantage of this approach is that only options that ultimately vest are expensed, but it fails to recognise the fact that a valuable benefit was offered to those employees that have left during the vesting period, and that they chose to forgo this benefit at a later stage.

4. VALUATION MODELS

Many authors have provided alternative valuation methods to those prescribed by IFRS 2[1] (Hull and White 2004; Jain and Subramanian 2004; Jennergren and Naslund 1993; Rubinstein 1995; Carpenter 1998). In many of the most recent articles, the work of Carpenter (1998) is acknowledged as the first attempt at a thorough treatment of the problem in light of the features listed above. Most of the models attempt to include non-market related vesting conditions in the model, in direct contrast to the requirements of IFRS 2. These include introducing a stochastic process with a predefined probability distribution to model both forfeiture during the vesting period and early exercise thereafter (Carpenter 1998; Jennergren and Naslund 1993). Jain and Subramanian (2004) allow for multi-period exercise rather than a single exercise of all existing options. Rubinstein (1995) provides refinements to his binomial model to take account of the specific features of ESOs. His model, however, requires 16 input variables.

None of the models takes into consideration the issue of hedging ESOs. At first glance this may seem like a minor detail. However, option pricing theory is built around the concept of hedging. In essence, the cost of hedging an option completely (if this can be done) is strictly equivalent to the price of the option at any point in time during its life. Consequently, if we determine the cost of hedging the ESO, we have in effect priced it.

In the absence of a clear market standard, we have based our valuation approach on that of Hull and White (2004) (HW). The reason for this is two-fold. The HW model addresses all of the features mentioned above explicitly in a discrete-time framework[2]. In addition, they model the option as an exotic type of barrier option. A convenient feature of barrier options is that they are best hedged by using a static strategy. We use the HW model to create an optimal hedging

[1]These articles all deal with the U.S. equivalent of IFRS 2, Statement of Financial Accounting Standards No. 123, Accounting for Stock-Based Compensation (FASB 1995). In all areas relevant to this paper, the requirements of the two standards are the same.

[2]They use a trinomial tree instead of a binomial tree for technical reasons.

strategy based on Derman, Ergener and Kami (1994) (DEK). In addition to valuing the ESO, this strategy will be useful in managing the risks associated with employee stock options. Because the hedging strategy is static, we then argue that the cost of this optimal strategy should be the expense reflected in the accounting records. The expense derived by this approach differs from that currently prescribed by IFRS 2.

5. THE HULL-WHITE MODEL FOR VALUING EMPLOYEE STOCK OPTIONS

The HW model ("Enhanced FAS 123") augments the ordinary binomial model by testing for termination of the options according to a fixed probability based on an employee exit rate (e). If termination occurs during the vesting period, the payoff is zero; if termination occurs post the vesting period, the payoff is the (positive) intrinsic value of the option. In addition, they add another (simplifying) exercise condition for the post-vesting period. The options are immediately exercised when the stock price (S(t)) reaches a predetermined multiple (M) of the strike price (K)[3].

The consequence of the above modelling assumptions is that the ESO can be considered a combination of two exotic options and one non-standard option.

Consider the pricing scheme in Figure 1. Let t = 0 be the grant date of the ESO, t* be its vesting date, and T its maturity. Prior to vesting, the number of existing (or live) options is reduced at a constant rate - the pre-vesting employee exit rate - which may be different from the post-vesting employee exit rate, e (defined above).

At t*, the underlying stock price will either be above or below the barrier level KM. If it is above (S(t*) > KM) , the holder will exercise immediately. ESOs are typically issued at-the-money (i.e. S(0) = K), so the payoff of this part of the ESO is S(t*) – K, conditional on S(t*) > KM. This type of option is known as a "Gap Option" (Rubinstein and Reiner 1991) and has a closed-form solution of Black-Scholes type, if it is European (which, in our case, it is).

If S(t*) < KM, the ESO can be regarded as a type of up-and-out barrier call option with a rebate[4], struck at K. The option ceases to exist as soon as the value of S reaches the barrier, and the rebate represents the full value of exercising the ESO in this event. As a consequence, the rebate is a fixed value, R = KM – K. The barrier produces a slight complication in that it is a partial (as opposed to a full) barrier, because it only comes into existence at t*. This would be a significant complication if we were going to price the option in a continuous-time framework. However, the ESO can best be valued on a risk-neutral trinomial tree (Hull and White (2004)), which incorporates automatic exercise when the stock price reaches KM, or if the stock price is greater than (or equal to) KM on the vesting date[5]. This neatly overcomes the partial barrier complication.

Finally, the assumption regarding the behaviour of employees who leave the company after the vesting period, but before the maturity of the ESO, is dealt with idiosyncratically. At each node of the trinomial tree where t* < t <T and K < S(t) <KM, the option value is split into two parts. The post-vesting employee exit rate (e) acts as a fixed probability over each of the discrete time-periods of the tree and assigns a payoff of the positive intrinsic value of the option (max (S(t) – K, 0)) to a (small) fraction of the option holders. This represents the behaviour forced on any employee leaving the company prior to T, and for whom the underlying value of the stock price is below KM. For a full explanation of this scheme, see Hull and White (2004). This option is non-standard because it does not have a rational exercise policy associated with it. However, we propose to deal with the employee exit rate in a slightly different fashion to HW through our hedging scheme. In any case, the barrier option portion of the ESO dominates the value of this non-standard option unless the exit rate is very large. The boundary values of the ESO and its decomposition are given in Figure 1, below.

Finally, we have chosen to use the HW model because it provides a valuation solution which addresses most of the features mentioned above, and yet is simple and reasonably easy to apply. The HW model also allows for the development of an optimal static hedging strategy in the spirit of Derman *et al*. (1994), which forms the foundation of our approach to accounting for ESOs.

6. THE HEDGING STRATEGY

We propose using the DEK procedure to devise a portfolio of vanilla (European call) options which can be used to hedge employee stock options. We argue that the value of this portfolio should be the accounting cost at issue. Since the ESO can be regarded as a type of exotic barrier option, this approach is particularly apt, because the standard market

[3] This concept was first suggested by Huddart (1994).

[4] The exercise behaviour implied by this assumption is supported in part by the empirical findings of Carpenter (1998) and Huddart and Lang (1996), who find that the "market-to-strike ratio" of the option has an explanatory effect with regard to early exercise. Unfortunately, the high variability of the mean market-to-strike ratio may mitigate against the use of a vanilla single-barrier option in the model.

[5] This may provide a partial explanation for the high frequency in the exercise of ESOs immediately post-vesting.

approach to hedging barrier options is that of **static hedging**[6].

The ESO position could be dynamically hedged via a position in the underlying stock, as is often done in the financial trading industry[7]. This implies continuously restructuring the hedge so that the hedging position will offset changes in the value of the underlying position on a short-term basis. This approach is costly due to the trading costs involved in regularly changing the hedging portfolio. It also exposes the entity to risk if the position is not updated regularly, or if there are large short-term changes in the market. These problems can be overcome by using a "static" hedge, which is set up at the outset, and does not require interim readjustment. Static hedging does not involve the underlying stock but uses standard options to replicate exotic payoffs. Common uses for static replication also include the valuation of exotic options. This is because the market value of the replicating portfolio often provides a realistic estimate of the target option's value. In fact, this value may better represent the true cost of the option because it is composed of market values.

A static hedging strategy also lends itself more readily to the objective of this paper: to use the hedging strategy to devise an accounting approach. Being able to define a once off hedging position for employee stock options provides an upfront cost that can be recognised in the accounting records. This is consistent with the principles in IFRS 2, which require recognition of the initial value of employee stock options.

We now derive a generic example of an ESO and its static hedge portfolio. The pricing model of HW uses a trinomial model, whereas the hedging procedure of DEK uses the binomial model. This does not lead to any additional complications. In all other respects, we follow the DEK format.

We first generate a trinomial tree of stock prices. The discrete time period for the tree is 3 months, which is very coarse, but the example is merely for illustrative purposes. The risk-free rate of return is 5% p.a., the dividend yield is zero, the initial value of the stock is 50 and the stock volatility is 29,72% p.a.[8]. The risk-neutral probabilities associated with this tree are p(up) = 0,1695, p(no movement) = 0,6667, p(down) = 0,1638. The values for the resulting trinomial tree are given in Figure 2, below.

We assume that the ESO has the following characteristics: the strike price is at-the-money, $K = S(0) = 50$, the vesting period is $t^* = 2$ years, the maturity is $T = 5$ years, and the exercise multiple is $M = 2{,}8$[9]. The consequential rebate is given by $R = KM - K = 90$, and occurs at the up-boundary $KM = 140$. For reasons which will become clear, the pre- and post-vesting employee exit rates are set equal to zero. The boundary values and consequential internal node values (discounted, risk-neutral expected values) are given in Figure 3, below. The calculated value of the ESO is 17,3275.

The static replication of the ESO is quite straightforward. Matching the boundary conditions ensures that the tree values for the ESO and the hedge portfolio converge. The more nodes that are matched, the larger the hedge portfolio[10] and the closer the convergence in value. We will match the boundary values at the 2-,3-,4- and 5-year annual nodes only. The calculated hedge portfolio for our example is:

It is interesting to contrast these values with the calculator supplied by Hull and White[11]. The calculated value from their ESOP software (Enhanced FASB 123) with the same inputs as the example above is 17,4349. The Black-Scholes value of the (5 option) static hedge portfolio given in Table 1 is 17,4335, which is very close.

Table 1: Hedge portfolio for the example ESO. The portfolio contains 5 vanilla call options of varying maturities and strikes. The number of constituent options depends on the number of times at which the boundary conditions are matched (in our case, 4).

Position	Size	Strike	Maturity	Value[12]
long European call	1,0000	50	5 years	17,7507
short European call	0,1300	140	5 years	-0,3494
short European call	0,0540	140	4 years	-0,0818
short European call	0,0428	140	3 years	-0,0268
long European call	0,2135	140	2 years	0,0258
				17,3185

[6]Barrier options have very high gamma in the region of the barrier (Derman and Kani 1997). This renders dynamic hedging impractical and makes static hedging the logical alternative.

[7]In fact, using any Black-Scholes variant (e.g. binomial or trinomial trees) to value ESOs implicitly assumes that this is possible and logical. In reality, it may however be neither. It appears that the prevailing attitude to hedging ESOs ranges between the two extremes of completely "covering" the issued options (i.e. purchasing all the necessary stock, regardless of whether the ESOs might vest and/or end in-the-money) or just issuing new stock in the event of ESO exercise, and thereby diluting the capital.

[8]This value for the volatility ensures that the tree has a line of nodes at 140, which is the barrier level in this example.

[9]This value for the exercise multiple is chosen from Hull and White (2004), which, in turn, is the average value calculated from the Carpenter (1998) sample.

[10]A "perfect" hedge portfolio would contain an infinite number of vanilla call options.

[11]Software downloaded from www.rotman.utoronto.ca/~hull/.

[12]Value calculated on the same trinomial tree as the ESO.

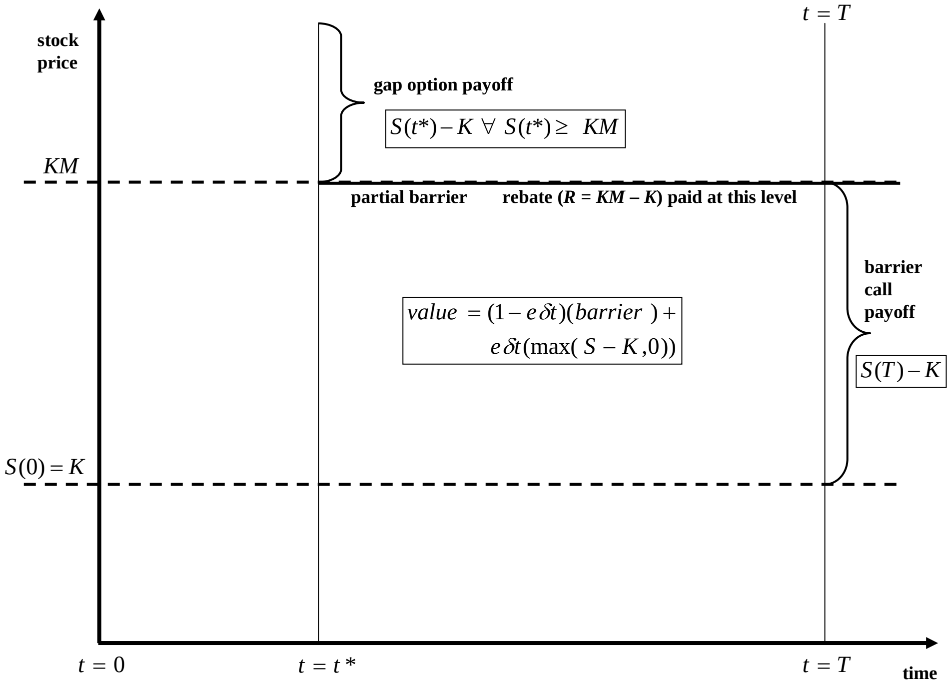

Figure 1: Graphical depiction of the HW model and its decomposition.

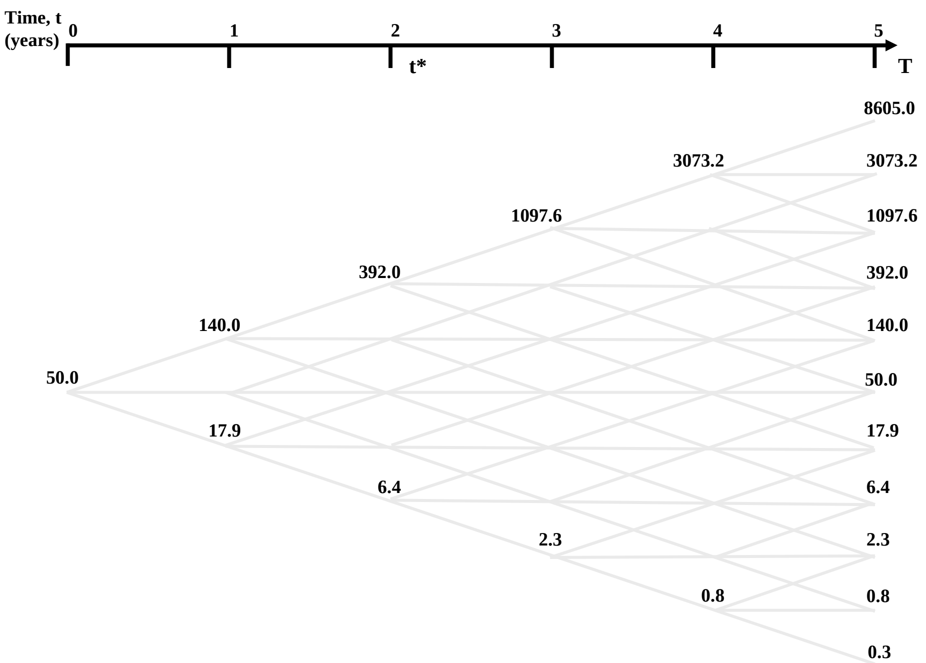

Figure 2: A trinomial tree of stock prices. The tree shows only the annual nodes.

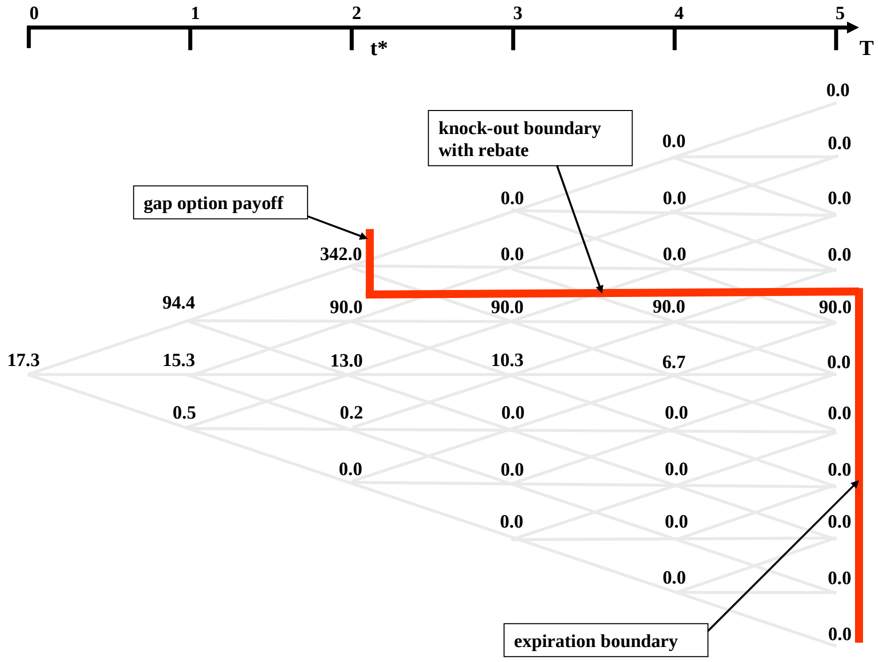

Figure 3: A trinomial tree of ESO prices corresponding to the tree of stock prices in Figure 2. The tree shows only the annual nodes. There are three relevant boundaries for the option: the gap option payoff at vesting (t* = 2 years), the up-and-out boundary (KM = 140) with rebate (R = KM – K = 90) and the expiration boundary for the underlying call option (K = 50).

We have set the pre- and post-vesting employee exit rates to zero. This leads to a situation where the ESOs are over-hedged as soon as any of the holders leave the company. We propose that the logical and pragmatic strategy with regards to this is to reduce the hedge portfolio by the proportion of employees that have left the company at discrete intervals. In other words, the strategy is retrospective and requires no estimation of the pre- and post-vesting employee exit rates. The frequency with which the hedge is rebalanced depends on the conventions of the particular issuing company and could be as often as monthly. Reducing the hedge portfolio will result in an inflow of cash. In particular this deals neatly with the strategy required for the non-standard part of the ESO described above.

In conclusion, what is important is not the exact nature of the hedging portfolio (number of options, various strike prices, etc.) but rather that the hedging is both possible and static. If the HW model is used to value the ESO, then the underlying assumption is that the ESO is the type of exotic barrier option described in the previous section, and the valuation methodology is that of a trinomial tree. Under these modelling conditions, the calculated value can be shown to correspond to the value of a static portfolio of a small number of vanilla European call options. In the limit of continuous-time, the value of a relatively small hedge portfolio can be shown to converge to the HW value.

7. IMPLICATIONS FOR IFRS 2

The IFRS 2 valuation approach has been criticised as having no sound theoretical basis[13]. Empirical research indicates that this may be evident in real world applications. Bell, Landsman, Miller and Yeh (2002) find evidence of an intangible asset related to employee stock options in the computer software industry. This would imply that an ESO intangible asset should be recognised when the ESOs are issued to employees. Their findings also suggest that the option expense should be recognised over a longer period than the vesting period. This view is supported by Rubinstein (1995) who argues that the non-transferability of the options means that employees are forced to work beyond the vesting period in order to realise the full benefit of the options (assuming that the options mature some time after the vesting period). Aboody's (1996) results suggest that the stock option expense should be adjusted each year for changes in stock price, dividend yield, risk-free interest rate and stock price volatility.

Our hedging strategy provides a theoretically sound approach to determining the stock option expense. The DEK static hedge provides an upfront cost that can be recognised over a period. The hedge supports the approach followed by IFRS 2 with regard to re-measuring the option value. The static hedge will not

[13] See, for example, Hull and White (2004).

need adjustment through the life of the option, which suggests that the ESO should not be revalued.

This approach can be justified by applying a similar logic to the risk-neutral approach used in valuing options. Assume a company issues stock options to its employees. If the company hedges those options, the risks and cash flows of the business will be exactly the same as before the issue of the options. The cost to hedge those options must thus represent the loss to the company on the issue of those options. If a company chooses not to hedge the options, the hedging costs must represent the best valuation of the additional risks to which the company is now exposed. As a static hedge can be devised, it is not necessary to account for subsequent changes in the option values.

The other problem that needs to be dealt with is the treatment of the ESO expense over the vesting period. As illustrated previously, IFRS 2 requires that only those options that are expected to vest be expensed, and that the estimate of the proportion that will vest must be revised each year. Once the options have vested, the full value of these options must have been expensed. A prudent hedging approach, however, would dictate that all the options issued be hedged, and not just those that are expected to vest. This strategy is supported by the fact that there is likely to be a negative correlation between the value of the options and the employee exit rate (i.e. less employees are likely to leave as the option value increases)[14]. This suggests that the company will be exposing itself to considerable risk if it does not hedge all the options issued. If any employees leave, a portion of the hedge can be liquidated. This will translate into an accounting treatment of expensing the grant date value of all the options issued, and recognising income when employees leave. The income should be measured at the fair value of the options on the departure date. At this point, any unrecognised ESO value should also be expensed.

This accounting treatment can be linked back to the objectives of IFRS 2. The primary purpose of IFRS 2 is to account for the services received from employees, not the consideration given. The options given as consideration need only be valued if the services received cannot be valued. Whilst this is likely to be the case with most share-based compensation schemes, it should not detract from the fact that we are trying to measure the services rendered by the employees. In the case of ESOs, the expense recognised should mirror the services rendered by the employees. When the ESOs are granted, all the eligible employees will be working towards earning and maximising the ESO benefit. Thus the full ESO value should be expensed, not just the portion that is ultimately expected to vest. When the employee leaves the company, he generally foregoes any future potential benefits from the ESOs. This is a direct consequence of him leaving the company. This should not affect expenses already recognised, but may result in a net gain in that period. The net gain will represent the obligations now cancelled, less any unrecognised ESO expense. During the vesting period, the gain will be the full value of the ESO on the exit date, and during the post-vesting period, it will be the remaining time value of the ESO (assuming the employee exercises the ESO on leaving). The gain will thus equal the cash flow that will result if the ESOs are fully hedged.

This accounting approach corresponds with the "advance view" explained in Mozes (1998). This view describes the issue of ESOs as an advance in lieu of future services rendered. The ESOs must be valued at grant date as this is the amount the employees receive when they enter into the contract with the firm. The ESO expense (and the corresponding increase in equity) would occur as the services are rendered. All ESOs issued must be expensed, as this is the advance the employees have received. If the employees forfeit the benefit for any reason, the firm would not reverse out previously recognised expense, but rather account for the direct economic consequences of the forfeiture.

Our model does contradict Aboody's suggestion that the options should be revalued for changes in value, post grant date. Aboody's approach could be justified by arguing that the motivation effects of the ESOs are related to their current value. If the options are well out-of-the-money, they are less likely to motivate employees, and the services received will be less. Options that are in-the-money will encourage employees to work harder to enhance the value of the options. Our hedging strategy clearly indicates that the options need not be revalued at fair value, and we do not offer any more arguments in this regard[15]. It is concerning to note, however, that the requirements of IFRS 2 change dramatically if the options are cash-settled, rather than settled by selling or issuing the underlying shares to the employee. Cash-settled options must be revalued at fair value in each reporting period. Thus a relatively small economic change results in a radically different accounting treatment.

The hedging model does not provide any clear answer with regard to the period over which the option cost should be expensed. Normal accounting principles would dictate that the expense be recognised over the periods in which the benefits are received. IFRS 2 indicates that this is the vesting period. As referred to previously, some of the research suggests that the recognition period should be longer than the vesting

[14] Ammann and Seiz (2004) propose an adjustment to the ESO valuation model to recognise this correlation. See also the comments in Rubinstein (1995).

[15] For a radically different approach to valuing and expensing ESOs see Bulow and Shoven (2005) and Hancock *et al*. (2005).

period. As our hedging model is not directly related to the benefits received from the employees, we cannot contribute further to this question. It is important to note, however, that recognising the expense over a period that is longer than the vesting period may result in undesirable accounting consequences. If an employee leaves the organisation before the full ESO expense has been recognised, his departure will result in an immediate recognition of the remaining ESO expense. This could possibly cause a sudden and large expenditure that is beyond the control of management, and has no real economic justification. Recognition over the vesting period overcomes this problem because the employee's departure during this period will result in him losing the ESO benefit altogether. As discussed previously, the employee's loss must be the employer's gain, and our suggested accounting approach will result in recognition of income at this point. The vesting period is also a clear and verifiable time period which will enhance the reliability and comparability of the ESO expense.

8. CONCLUSION

The abundance of research into the valuation of ESOs has allowed for a better understanding of the true economic value of ESO incentives. In part, our research has concerned itself with deriving a static hedging strategy for these options. The fact that it is possible to hedge these ESOs, and, in particular, to derive a static hedge, has important implications for accounting. The static hedge provides economic substance for the accounting approach prescribed by IFRS 2. This standard requires recognition of the grant date value of the ESOs; subsequent changes in the value of ESOs are not recognised. This corresponds with our static hedge. Unlike IFRS 2, however, we argue that the full value of the ESOs should be expensed, and not just the portion that vests. Our model then suggests that income should be recognised if the employee forfeits the options, and that this income should be the fair value of the options foregone.

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