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ESO valuation under IFRS 2 – considerations of agency theory, risk aversion and the binomial model

Antti Pirjetä* – Antti Rautiainen**

ABSTRACT *This paper discusses the implications and valuation of employee stock options under International Financial Reporting Standard 2 (IFRS 2). We analyze ESOs in the framework of agency theory. The principal (employer) is considered risk neutral, but the agent (employee) is assumed risk averse. The employee calculates option value with certainty equivalent principle, which leads to a discount in option price. We find that the fair option value stated as an expense in the profit and loss statement should usually be lower than the value suggested by risk-neutral option pricing models. Further, the gap between employer's and employee's valuation grows with the volatility and employee risk aversion. Finally, we discuss the effects of ESOs on managerial behavior using the framework of Ross (2004). Here we find that ESOs are generally risk-inducing, but this effect depends also on share price dynamics after option grant.*

Keywords: employee stock options, IFRS, risk aversion, binomial model, financial accounting

1. Introduction

In an employee stock option (ESO, also executive stock option) plan the employee gets the right to subscribe shares of the employer after a vesting period, in order to align the interests of the owner and the employee. However, the real motivational and committing effects of an ESO contract are ambiguous (Hull and White 2004; Tian 2004; Ikäheimo et al. 2004). The recent IFRS 2 about share-based payment (with effective date of 1.1.2005) requires the recognition of the value of ESO plan as an expense in the company's profit and loss statement. However, the adoption of IFRS 2 may increase the amount of judgmental valuations in the profit and loss statement. Therefore, the implications and valuation problems involved in an ESO contract under IFRS 2 are discussed in this paper.

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An employee stock option is basically a contract between the agent (employee) and the principal (employer). Both parties try to benefit from the contract, although they may have dissimilar power over the design and outcome of the contract and varying risk preferences. In this paper, the implications of the ESO contracts and IFRS 2 are discussed in the light of agency theory (Harris and Raviv 1979) and Pratt's (1964) risk premium.

In the agency theory framework incentive schemes of companies are designed so that the manager's behavior according to his/her self-interest also benefits the owner. Further, the lack of congruence between the agent's and principal's interests is thought to diminish with proper contract design and accounting disclosure (e.g. Jensen and Meckling 1976; Macintosh 1994, 29-37). Thus, the agency theory provides some support for granting options to corporate managers. In an influential paper, Harris and Raviv (1979) prove that if the agent is risk averse and his action is observable, optimal contract always depends on the agent's action. However, we argue that an unbounded linear contract is not feasible in reality, since the contract function (agent's compensation) becomes negative if the payoff is negative. In contrast, the agent will accept a linear contract bounded to positive outcomes. This contract is equivalent to call option on the payoff combined with a fixed payoff. Hence, agency theory implies that both the employer and the employee are better off, when compensation is tied to payoff, equal to change in market value. This result is of course conditional to the assumption that change in market value is an unbiased measure of the employee's effort.

Further, accounting disclosure is an *ex post* control device of the principal about the agent's action informing the owner's capital has been maintained. Function of the financial statements is to convey the true and fair view of the financial position, performance and changes in financial position of an entity. Fair presentation of financial statements is usually expected to be the result from applying generally accepted accounting principles (see IFRS Framework, paragraph 46). However, the agent prepares the statement and may use methods convenient for his or her purposes which may lead to a distorted view of the operations. Hence, in order to facilitate agency theoretical considerations, we define here the true and fair profit and loss statement as a reasoned and materially accurate calculation of the change in the owners' wealth associated with, and caused by, the operations of the reporting entity during a specified period.

2. Expensing employee stock options under IFRS 2

In share-based payment the reporting entity receives goods or services as a consideration for its equity instruments, such as ESOs. As the issuance of shares or rights to shares is recognized as equity, the offsetting debit entry (the grant date fair value of the share-based payment) is recognized as an expense. However, calculating the fair value of an American option with a vesting period and a non-listed or non-liquid underlying asset becomes complicated with existing option pricing methodology. Appendix B of the IFRS 2 requires that factors such as early exercise and changes in the expected volatility are considered in valuation, since they affect the fair value. However, vesting conditions are not to be considered in calculating the fair value according to IFRS 2.

According to appendix B of the IFRS 2, these considerations may sometimes preclude the use of "Black-Scholes-Merton (1973) formula". We argue that some of the complications are easier to deal with in the binomial model and hence we use it below. Usual vesting conditions are restrictions in selling, exercising or transferring the option. These conditions complicate the valuation of options and diminish the manager's perceived value of the option, at least in case of a risk-averse manager. The gap between the perceived value of an ESO to the company and to the manager is called *deadweight loss*. It is caused among other things by vesting conditions, trading restrictions and lack of diversification (Meulbroek 2001). Moreover, the accuracy of financial statements is impaired, if the value stated in the profit and loss statement differs substantially from the fair market value.

After the grant date fair value of an ESO is determined, this amount is expensed over the vesting period of the option plan. Corrections to the annual expense figure may normally be caused by a change in the number of options, but not by a change in the market value of the options after the grant date. However, if an employee leaves the company during the vesting period and thus forfeits the right to options, the expense is corrected. Hence, the number of options expensed is the number of options that actually vest.

An option plan decreases shareholder wealth by the dilution effect and by the opportunity cost of issuing shares below market price, provided that the options are exercised. Because of the dilution effect, in order to benefit from the ESO plan the owners should witness a share price growth above the market growth in the industry (as would have witnessed without the option plan). The adoption of IFRS 2 takes steps to disclose the costs of ESOs explicitly in the profit and loss statement. Therefore, earnings per share will be lower than without the recognition of options as expense. However, the market value of an ESO does not usually equal the prediction of a pricing model (e.g. Ikäheimo et al. 2004); nor will the grant date value of an option equal the cost of option plan to the owners, or to the company, if the price of stock goes down and the options will not be exercised. Recall that later (i.e. post-issue) share price fluctuations have no effect on the stated expense.

Further, the cost of an option plan may exceed the benefits to the owner for many reasons, but especially if the employee is not committed to common goals. The difference in the perceived value of ESOs to the agent and to the principal (the deadweight loss) causes also a threat to the motivational effects intended. Motivational effects seem low if the exercise price is too low or too high (Tian 2004). Thus, according to Hall and Murphy (2000), more than 90 % of S&P 500 companies set the exercise price of ESOs at-the-money. We agree with Hall and Murphy in that it is difficult to say why most options are issued at-the-money, but it seems likely that the risk-averse manager's valuation of out-of-the money calls would be much below the market, and the owners reject the idea of issuing in-the-money calls.

When financial statements comply with IFRS 2, they reveal the burden of management incentives. It is entirely possible that option-related expenses turn profit into loss. Hence, the recognition of ESO costs facilitates the owners' judgement of whether the management is performing properly. This justifies the idea of reporting the cost of an ESO plan from the principal's point of view. However, the choice of the option valuation method is in the hands of the agent, and thus the reported value may not equal fair value of the options nor the cost to owners. Further, the value of the option plan may vanish if the market value of the underlying asset falls. Thus, the company may benefit from the incentive scheme in better motivation and records the corresponding expense, but nobody – not even the owner – has to compensate this in reality if the option plan has become worthless.

From an agency theory point of view, the agent is more exposed to the option value than the principal if the option generates a significant addition of the agent's wealth or is expected to do so. The principal is usually less exposed, because the opportunity cost of options becomes high only with excellent price performance. In this case, the principal has realized material capital gains, relieving the pain of issuing cheap shares. Next, the valuation problems of

ESO plans, contract design features and the effects of risk-aversion are discussed and illustrated in more detail.

3. An agency model for executive stock options

Here we will refer to agency theory results to show that in the presence of asymmetric information and risk-averse agent, Pareto-optimal contract involves the agent's action. Further, the optimal contract links compensation to realized payoff, which by assumption measures the agent's action without bias. Hence under the optimal contract the agent's compensation depends on market value of the firm. If we amend the optimal contract by limiting the agent's share of the payoff to positive domain, we arrive at a contract that combines fixed salary with a call option. This reasoning is based on the idea that it is optimal for both parties to maximize the firm's market value. Further, in the long run, we have to assume that market value of equity and operational performance move in parallel. Therefore the fact that short-term fluctuations in equity values are often uncorrelated with fundamentals does not invalidate this model, since we treat the employee stock options as a long-term contract. We also assume that the agent has sufficient power to influence the firm's actions and hence operational performance is highly correlated with the agent's action. In summary, the principal knows *ex post* the agent's action and the firm's performance depends on the action.

In this model, which builds on Model 1 of Harris and Raviv (1979), the agent's utility is a concave function of his compensation and action (or effort). Compensation is determined by the contract function *S(z)*. Utility increases with compensation, but action causes disutility, as defined in equation (1).

$$(1) \qquad U^A = f\left(S(z), a\right); \quad U_1^A > 0; \quad U_2^A < 0.$$

In equation (1) subscripts 1 and 2 denote partial derivatives of U with respect to first and second arguments. Market value of the firm is determined by the agent's action as well as an exogenous state variable θ. Compensation contract is signed and the agent chooses his action prior to knowing the realization of state variable. We assume that both parties hold similar views about the distribution of θ. Random payoff to state θ, as defined in equation (2), increases with the agent's action. In our case the payoff is equal to change in the firm's market value.

$$(2) \qquad x = X(a,\theta); \quad X_1 > 0.$$

Parties to this contract share the payoff; the agent's share is *S(z)* and the principal's share is *x−S(z)*. The agent's problem is to maximize his expected utility, where uncertainty is generated by the state variable θ. In our binomial model θ determines the distribution of equity returns. Because we will employ binomial option pricing model, realizations of θ follow the binomial distribution. The agent's problem is formalized in equation (3). Arguments of the utility function are compensation (or contract function) and agent's action.

$$(3) \qquad \max V^A = E_\theta U^A\left(S(z), a\right).$$

Note that taking the expectation over outcomes of θ is equivalent to calculating the certainty equivalent of utility. This yields an important result: because the utility function is concave with respect to compensation, its certainty equivalent becomes lower as the variance of state variable increases. If the agent gets to choose between two compensation schemes with equal means, but different variances, he will take the one with smaller variance because it yields higher certainty equivalent. This effect, illustrated in Figure 1 is what we call the *Jensen's effect*, referring to Jensen's inequality.

The implication to employee option pricing is that increased volatility has a two-way effect on option value. On one hand, option value increases with volatility. On the other, the certainty equivalent decreases, since the agent is risk-averse. This is the intuition for the recently established result that it is not in the interest of employee to increase the volatility of employer stock without bounds. Proponents of this view include Carpenter (2000) as well as Lewellen (2003). In her dynamic model, Carpenter (2000) shows that the optimal share of wealth invested in risky asset converges to Merton constant for manager with CRRA utility. This implies that the optimal share of risky asset decreases as volatility increases. Lewellen (2003) looks at the connection of incentives and capital structure. She argues that volatility costs of debt are higher for managers with in-the-money options, and hence ESOs discourage adding leverage and hence increase risk aversion.

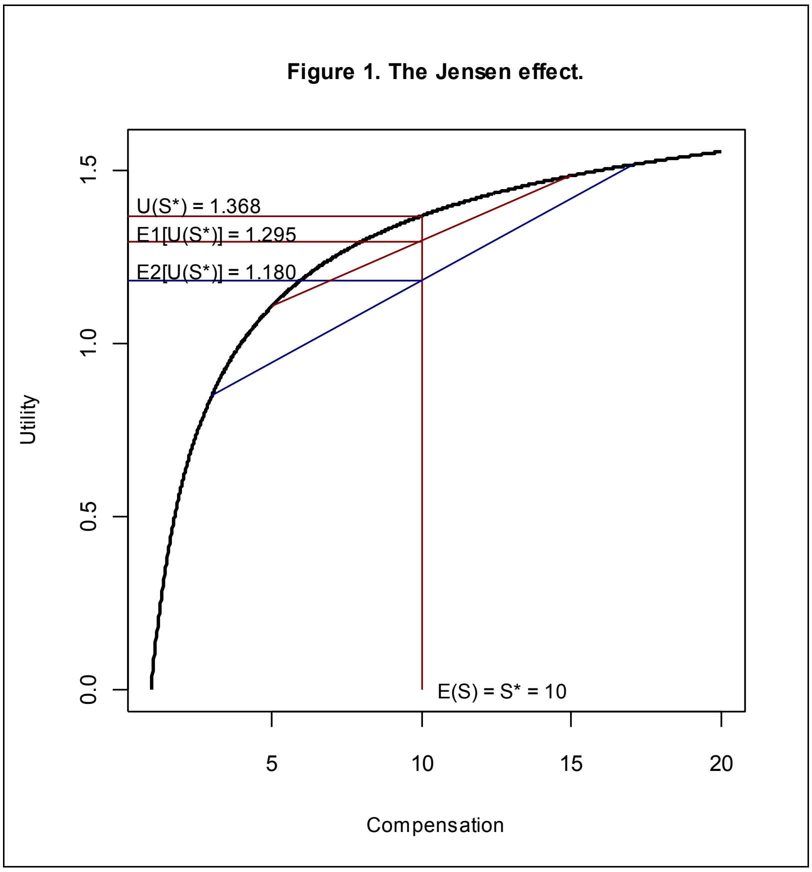

Figure 1. *The Jensen effect. Certainty equivalent of compensation decreases as variance increases. Compensation scheme 1 has range of [5, 15], whereas compensation scheme 2 has range of [3, 17]. Both schemes offer the agent an expected compensation of 10 units. The figure is drawn using power utility function.*

Harris and Raviv (HR, 1979) characterize in their Proposition 2 the Pareto-optimal contract in this setup. Since we assume that there is no uncertainty *ex post* about the agent's action, Pareto-optimal contract does not involve monitoring his action. Hence the contract function depends only on the realized payoff and the agent's action. HR show that any Pareto-optimal contract is of the form (4), where S_1 is (an arbitrary) Pareto-optimal contract, x is the realized payoff and $X^*(\theta)$ is the expected payoff given state θ.

(4) $$S^*(X,\theta) = S_1(X^*(\theta),\theta) + x - X^*(\theta)$$

Hence the optimal contract combines a fixed salary, which may by a function of the state variable, with a state-dependent element tied to the actual payoff. If we limit the moving element to its positive domain, in other words replace $x - X^*(\theta)$ by $\max[0, x - X^*(\theta)]$ in equation (4), the contract function becomes a combination of fixed salary and call option on the payoff. While this contract is not Pareto-optimal, it can be viewed as a real-world proxy of the optimal contract or a second-best solution. In practice it is unsustainable that the employee would accept a contract that yields negative compensation with positive probability.

4. Employee stock option valuation with binomial model

4.1 Review of binomial option pricing

Derivatives pricing in discrete time, specifically the binomial model, builds on an arbitrage argument saying that the price of portfolio that replicates the option payoffs must be equal to the option price. Consider the classical set-up presented by Cox, Ross & Rubinstein (1979). The problem is to price a call option on stock that may take only two values one period from now. First step is to form a hedging portfolio that invests in the stock and a risk-free deposit. Portfolio weights are such that the value of the hedging portfolio is in both states equal to the value of option when it expires. Specifically, the weight of underlying stock is Δ (known as delta) and weight of risk-free deposit is *B*. Values of the call option and the hedging portfolio are given in Figure 2. In terms of notation, *u* and *d* give the relative magnitudes of up and down movements and *r* is the risk-free rate. *S* denotes stock price and *K* the strike price. It is fair to assume the order $d < 1 + r < u$. Positive superscript (+) means using the expression in brackets if it is positive and otherwise zero.

Call option		Hedge portfolio	
	$C_u = (uS - K)^+$		$\Delta uS + Be^{rt}$
C		$\Delta S + B$	
	$C_d = (dS - K)^+$		$\Delta dS + Be^{rt}$

Figure 2. *Payoffs to call option and hedging portfolio.*

Since we have two equations with two unknown variables, it is easy to solve for portfolio weights Δ (in equity) and *B* (in deposit). The exercise is completed by deriving the one-period option pricing formula with the idea that values of the hedging portfolio and the option must be equal. Basic binomial pricing relations are given by equations (5−7), where *r* is the (continuously compounded) risk-free rate for period *t* and *n* is the number of periods.

(5) $$\Delta = \frac{C_u - C_d}{S(u-d)} \text{ and } B = \frac{uC_d - dC_u}{e^{rt/n}\ (u-d)}$$

(6) $$C_j = \frac{pC_{j+1,u} + (1-p)C_{j+1,d}}{e^{rt/n}} \text{ for } j = 0,...,n-1$$

(7) $$p = \frac{e^{rt/n} - d}{u-d} = q$$
$$u = \exp(\sigma\sqrt{t/n}); \quad d = \exp(-\sigma\sqrt{t/n})$$

The pricing formula contains the risk-neutral probability q, even if we haven't assumed anything about probabilities. This is a key insight of the model: derivatives can be priced using the risk-neutral measure, even if investors use subjective probabilities p and $(1-p)$. Cox, Ross & Rubinstein (1979, p. 236) state this explicitly: "Since the formula does not involve q or any measure of attitudes toward risk, then it must be the same for any set of preferences, including risk neutrality." Equations (8−10) introduce the risk-neutral one-period *pricing kernel* $\xi_{n,n+1}$, which can be used to price any option (and in fact any asset if we assume risk-neutrality). To see the idea of pricing kernel, assume that we know the payoffs to asset at all future states. Price of the asset is the weighted sum of payoffs, and the weights are given by the pricing kernel. Values of the pricing kernel can also be interpreted as *state price densities*.

(8) $$C_n = E^Q\left[\xi_{n,n+1}C_{n+1}\right]$$

(9) $$\xi_{n,n+1} \equiv \frac{\xi_{n+1}}{\xi_n} = \frac{1}{r}\begin{cases} (q/p) & \text{w.p. } p \\ (1-q)/(1-p) & \text{w.p. } (1-p) \end{cases}$$

(10) $$C_{n+1} = \frac{q(uS_n - K)^+ + (1-q)(dS_n - K)^+}{r}.$$

The pricing kernel is an essential tool in valuing ESOs, which will materialize in the next section. In general, we argue that the fundamental advantages of the binomial model are its transparency and flexibility. Since the model breaks the lifetime of the option into a discrete number of periods and option value at $t = 0$ is calculated recursively, intermediate value points become transparent. These values become useful when we investigate early exercise.

4.2 *Valuation of employee stock options*

We aim to show that in general the prices of ESOs and standardized options need not converge, if we account for contract differences. Specifically, three features reduce the ESO value: the vesting period, non-transferability and individual risk preferences. First, we will briefly review the combined effect of vesting period and restricted transfer using an incomplete markets framework. Second, we will look at the effect of concave preferences with an example.

The employee endowed with options does not operate in a complete market, which is a fundamental difference to the standard valuation framework. ESOs are not transferable during the vesting period, and in many instances it is impossible to take a short position in the underlying equity. These restrictions could arise because the option holder is unable to assume short position in his employer's stock, or alternatively, the underlying stock is a non-traded asset. We argue that it is very difficult, if not impossible, to short the underlying even if it is listed. In general, shorting requires either stock borrowing or using derivatives (e.g. buying puts or selling calls). Use of both options is quite restricted for any employee who operates under insider trading rules. Such persons can usually trade only after report disclosure, and their trades will be subject to close scrutiny. Borrowing stock is quite difficult for private investors. When it comes to derivatives, frequent trading is a virtual impossibility for anyone operating under insider trading rules.

Incompleteness of the market challenges the usual arbitrage considerations that are fundamental in pricing any derivative. Value of the option is reduced, if it is impossible to form hedging portfolio when it requires taking short position in the underlying. To see this, think about a call option trading below fair value suggested by a standard (binomial or Black-Scholes) pricing model. In order to lock in the profit, the arbitrageur has to buy the "cheap" call option and sell the hedge portfolio of Fig. 2. But now the portfolio weights Δ (in equity) and B (in deposit) become negative, which is a breach of the short-selling constraint. Hence the arbitrage opportunity vanishes, and the option value must be lower than in complete markets. Detemple and Sundaresan (1999) show that the effect of no-short-sales constraint in the underlying asset can be incorporated in the option value by adjusting the risk-neutral measure. Their main conclusion is the following. In the presence of short-sales constraint, valuing a derivative asset on a non-dividend paying stock is similar to valuing a derivative on a dividend-paying asset without the constraint.

Constrained trading may also help to explain the evidence that ESO holders tend to exercise their options prematurely. For instance, Carpenter (1998) finds that the average exercise of a 10-year ESO takes place at 5.8 years. This has surprised academicians, because premature exercise is equal to giving up some time value of the option, and hence decreases the wealth of the option holder. However, if a great deal of the employee's wealth is invested in options, and the only way to reduce exposure is through exercise, especially the risk-averse agent is likely to give up some time value in order to smooth her consumption. This effect is analyzed in the next section.

4.3 The effect of concave preferences

We have pointed out above that the binomial model values derivatives as if investors were risk neutral. While this assumption is not unreasonable in pricing when looking at the aggregate market, it is not likely to hold for a single agent (employee). If we drop risk-neutrality and assume that the option holder is risk-averse, her behavior will change. Consider a situation where the option has vested and it is in the money. Further, there is some time left to expiration. Since the underlying stock goes up or down every period, keeping the option exposes its holder to some probability that the option will expire worthless. If the holder is risk-averse, she will strongly avoid adverse states where the option value is zero. The outcome is that she will prefer selling or exercising the option prior to expiration. More formally, the risk-averse employee uses a risk premium in valuing the contract, but the risk-neutral market does not. This effect is magnified when value of the option represents a significant part of the individual's wealth.

Assume that the employee has power utility function of equation (11) with consumption W and risk aversion γ. We will use the range $1.5 \leq \gamma \leq 2.5$ to incorporate risk-averse preferences. When gamma is equal to one, utility function (11) corresponds to log utility.

(11) $$U(W) = \frac{W^{1-\gamma} - 1}{1-\gamma} \quad \text{where} \gamma > 1 .$$

We apply risk-averse pricing by calculating the certainty equivalent (CE) price of option. CE could also be called the reservation price, because it is the price that makes the employee indifferent between holding the option or selling it and investing the proceeds at risk-free rate. Below we will calculate CE values at time of grant, but also at the later points, especially at the vesting point. Our approach is motivated by the empirical Finnish data on ESO prices presented in Ikäheimo, Kuosa and Puttonen (2004). The data contains actual trading prices of managers whose options have vested.

4.3.1 Risk premium in ESO valuation

We will use the well-known definition of Pratt (1964) to find out how concave preferences affect subjective value of the option. Specifically, in our setup Pratt's risk premium is the difference between objective and subjective valuations of the employee stock option. Consider a risky payoff with expected value of $E(c) = \tilde{c}$ and its certainty equivalent $\bar{c}$. Other variables are the risk premium (in absolute terms) π and initial wealth w_0. Equation (12) gives the generic definition of Pratt's risk premium.

$$(12) \qquad U(w_o + \bar{c} - \pi) = E[U(w_o + \tilde{c})].$$

We define the Pratt risk premium as equal to the maximum discount at which the employee is ready to sell her option. The following formula, derived by Pratt (1964) shows that risk premium increases in the variance of uncertain payoff:

$$(13) \qquad \pi(x, \tilde{c}) = \frac{1}{2}\sigma^2 \cdot A(x + \tilde{c}) \quad \text{where } A(x) = -\frac{U''(x)}{U'(x)}.$$

In equation (13) *A(x)* is the measure of absolute risk aversion. Note that the power utility function (11) has decreasing absolute risk aversion, in short we call it DARA.

Now we will highlight the effects of risk aversion on pricing as well as exercise with a basic example. Certainty equivalent is calculated as risk-neutral option price less Pratt risk premium. To get started, assume that the employee has initial wealth W_0, terminal value of the option is C_T and discount in option price is δ. Equations (14 – 15) define our CE framework. If the manager holds the option until expiration, she gets terminal wealth W_T, sum of initial wealth invested at risk-free rate and terminal value of the option. If the manager takes the CE, terminal wealth W_T' is the sum of initial wealth and certainty equivalent of the option premium, invested at risk-free rate. Discount in option price can be calculated using equation (15a) for any period. However, if the calculation is done for the initial period, equation (15a) simplifies to (15b), since there is only one possible outcome W_T'. Left-hand side of (15a-b) calculate the expected terminal wealth by integrating W_T over the binomial distribution of stock price S.

(14a) $$W_T = W_0 e^{rT} + C_T = W_0 e^{rT} + (S_T - K)^+$$

(14b) $$W'_{T,i} = (W_0 e^{ri} + (1-\delta)C_i)e^{r(T-i)} \qquad \text{for } i = 0,\ldots,T-1$$

(15a) $$\int U(W'_{T,i}) f(S_i) dS = \int U(W_T) f(S_T) dS \quad \text{for } i = 1,\ldots,T-1$$

(15b) $$U(W'_{T,0}) \cdot 1 = U((W_0 + (1-\delta)C_0)e^{rT}) \cdot 1 = \int U(W_T) f(S_T) dS \qquad \text{for } i = 0$$

We look at the behavior of an executive who gets a three-year option vesting after two years. The setup is modelled with 12-period binomial grid. The vesting period is accounted for by assuming that the manager may trade once every quarter. Given two-year vesting period, the manager may trade only in periods 8−12. The binomial model is calibrated with the pricing kernel given by equations (7−10).

		Equity volatility		
		12 %	15 %	20 %
Risk aversion	1.5	5.9	8.9	14.3
	2.0	7.9	11.7	18.5
	2.5	9.8	14.5	22.5

Table 1. *Discount (%) in ESO price at different levels of risk aversion and volatility.*

Table 1 shows how the discount depends on risk aversion and equity volatility. Discounts are in the range of 6 – 23 %. The values are sustainable compared to actual trading prices of Finnish ESOs reported by Ikäheimo, Kuosa and Puttonen (2004). In line with intuition, as the person becomes more risk averse she will agree to higher discount. Naturally the chances of very favourable outcome increase as well, but this is unimportant with concave utility. Tian (2004) reports similar findings for the risk-averse option holder: discount to ordinary option values increases with risk aversion and volatility of stock returns. In general our results indicate smaller discounts than the "executive value lines" of Hall and Murphy (2000, 2002). Most likely the difference is due to different choice of parameters and model calibration. Like Carpenter (1998), we use risk-neutral probabilities, whereas Hall & Murphy (2002) employ a pricing kernel, where the expected return is equal to stock return. How

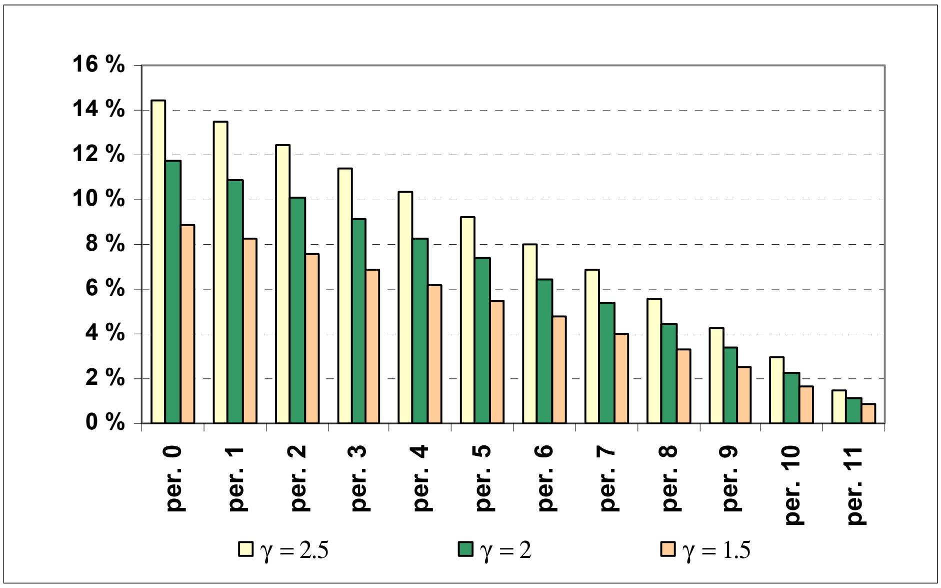

Figure 3. *Evolution of discount in the certainty equivalent option price calculated with 12-period binomial model. Three series are drawn using risk aversion coefficients of 2.5, 2.0 and 1.5. The figure shows how the discount to risk-neutral price decreases during the option's lifetime.*

We extend the results of Hall and Murphy (2000, 2002) by investigating, how the certainty equivalent value develops during the option's lifetime. Most compensation schemes have a vesting period during which the manager cannot trade. Therefore it is relevant to look at the CE value when the option vests. At this point the variance of underlying return distribution is smaller compared to the start, and hence the Pratt risk premium is smaller. This implies that if we are interested in the actual trading prices or exercise profiles of managers, we should calculate CE values when the options are sold or exercised. As shown in Figure 3, the discount in CE values declines rapidly during the option's lifetime. Three bars are drawn for each period corresponding to risk aversion coefficients of 2.5, 2.0 and 1.5 (going from left to right). For instance, the moderately risk averse manager with $\gamma = 2$ agrees to discount of 11.7% at the outset, but as the option vests after two years (in period 8) she is ready to sell at a meager 4.4% discount. If the option is in the money, it is quite possible that this is more than the time value and hence the option will be exercised early. While our model incorporates early exercise, it is probably too unlikely compared to empirics. If we calibrate of our grid using 20 % volatility, the expected exercise time for a 3-year in-the-money option (S, K) = (100, 80) varies between 2.6 and 2.9 years. This is assuming that the option vests after two years.

In the certainty equivalent framework early exercise of the option is triggered by the Pratt risk premium being higher than the time value, and as a result it is rational in some cases. One cannot get this result in a binomial framework without CE modelling. For example, in the binomial model of Hull and White (HW, 2004) exercise occurs when the stock price reaches some multiple *M* of strike price. No explicit rule is given for determining the value of *M*. In other words, they assume that employees in general tend to exercise options as they go deeper in the money. Our calculations produce similar results. Early exercise takes place when the underlying stock has done very well, that is in the top nodes of the binomial grid.

4.3.2 Convexifying effect of call options

Recent literature on compensation has discussed the question if giving call options to executives makes them less risk averse. In formal terms, the discussion is about the impact of convex instruments (such as call options) on the executive’s concave utility function. Ross (2004) presents general conditions, under which a given compensation scheme convexifies or concavifies the agent’s utility function. According to Theorem 1 of Ross (2004), a generic compensation plan $f(x)$ *convexifies* the agent’s utility if the condition (16) holds. In other words, the manager is less risk averse after receiving the option.

(16) $$\frac{f''(x)}{f'(x)} > A\big(f(x)\big)f'(x) - A(x)$$

An important corollary of Ross’s analysis is that a convex compensation scheme does not always convexify the agent’s utility. Like Ross, we are able to treat call option as convex function of the underlying security price by assuming that the option has some time value. This is fair since the IFRS valuation of executive stock options is performed when they are granted and in general ESOs have long maturities.

Ross (2004) also develops a formula that decomposes effect of a generic compensation schedule on absolute risk aversion into three components. Equation (17) defines the Ross decomposition, which we will try numerically below.

$$(17) \qquad A_V(x) - A(x) = [A(f) - A(x)] + A(f)[f' - 1] + A_f(x)$$

$$\text{where} \qquad A(\cdot) = -\frac{U''(\cdot)}{U'(\cdot)} \quad \text{and} \quad A_f(x) = -\frac{f''(x)}{f'(x)}.$$

There are three terms on the right hand side of eq. (17), representing three effects of a generic compensation plan *f (x)*. Intuition for the first term, *translation effect,* is quite simple. Locus of the employee's evaluation points on her utility function moves from *x* to *f*(*x*), when she is awarded options. The second term, *magnification effect*, maps the effect of option delta. Magnification effect increases (risk aversion decreases) as the option delta decreases, and therefore out-of-the-money (OTM) options induce the manager to accept more risk. She will take projects giving a distant chance of positive outcomes, because the OTM option is worthless unless the share price increases materially. On the other hand, magnification effect for in-the-money options is small, since their behavior is stock-like. Here the risk-averse manager thinks that a bird in hand is better than two in the bush. The third term, *convexity effect*, adds the impact of the compensation plan's convexity or concavity.

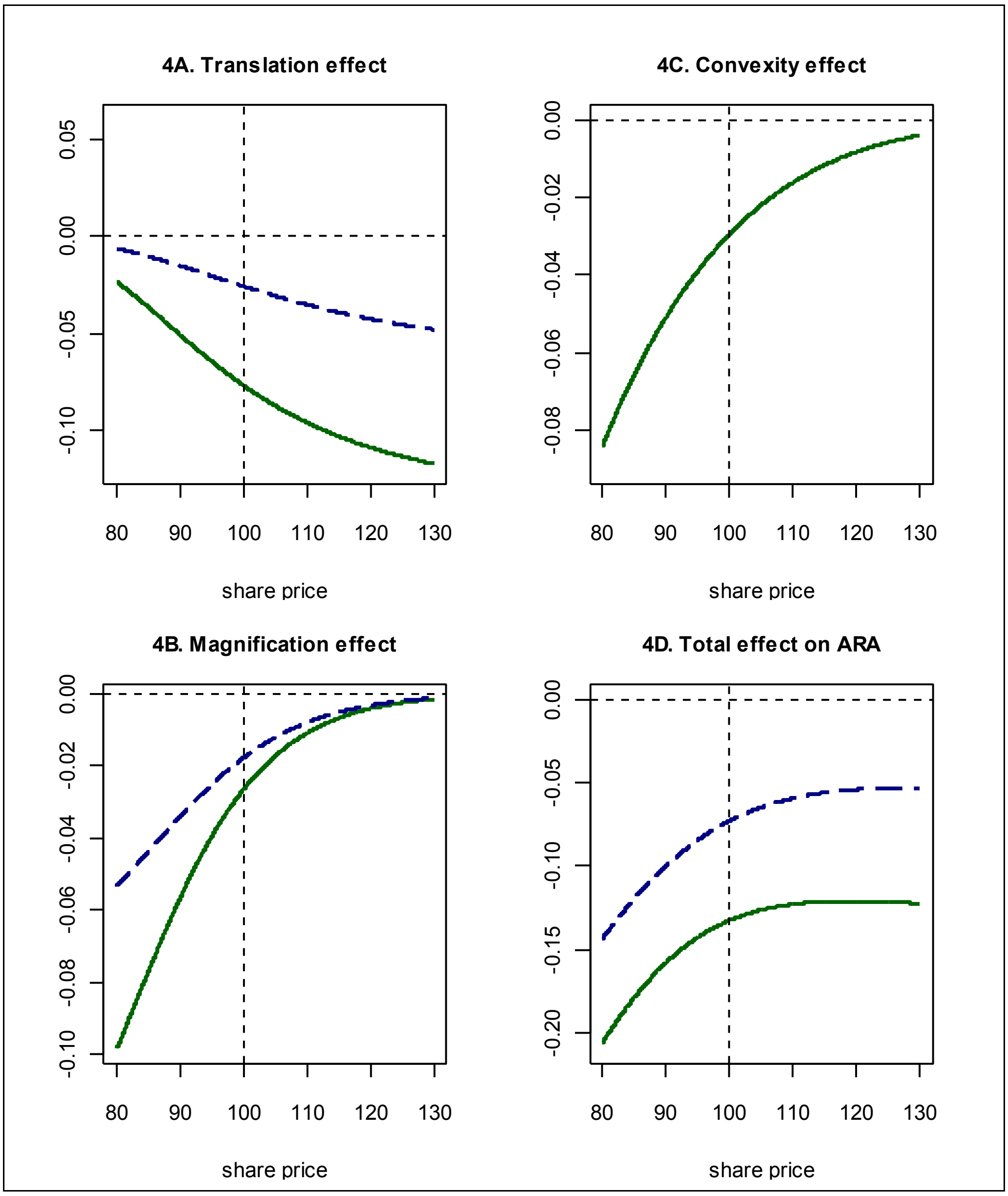

Figure 4. *Decomposition of the call option's convexifying effect, measured as decrease in absolute risk aversion. Continuous lines plot case 1, where a call option with B-S value of 10.45 units is added to fixed salary of 10 units. Dashed lines plot case 2, where the same option is added to fixed salary of 20 units. Note that the size of fixed salary has no effect on the convexity effect of panel C. Current share price is 100.*

Figure 4 maps the Ross decomposition as a function of underlying share price. It shows two cases; in the first one (smooth lines) the manager's compensation is split 1:1 between fixed salary and options. In the second case (dashed lines), compensation is dominated by fixed salary with the ratio 2:1. There is nothing new to the result that the option-endowed manager is less risk averse, as shown in panel D. But the dynamics of risk aversion are somewhat surprising. Since we have DARA utility, one would guess that the call option's negative effect on ARA would increase with share price. But in fact the effect decreases with share price. A look at panels B and C shows that the convexity and magnification effects are working behind this feature. Especially the magnification effect is at work here. As the stock price increases, option delta approaches unity, and in effect the option turns into a stock. Third term (convexity effect) in eq. (17) also decreases with share price since the numerator (option gamma) decreases (when the option is in-the-money) and denominator increases with stock price. We have calculated the option value using standard Black-Scholes formula, since it is more convenient to use continuous time model here, and the Ross decomposition formula holds under any option pricing model.

Before summarizing the main results, we would like to comment the use of risk-neutral probabilities. Rationale for doing so is that we assume the aggregate market to be risk neutral. The reader might object to our results by arguing that the employee does not use risk-neutral probabilities in valuation. But the topic of this study is the effect of risk aversion, and not the choice of probability measure. Further, one ought to remember that the employee has to trade at the market. Therefore it is the market that chooses the probability measure. The effect of subjective probabilities (or decision weights) on risk premium is a different topic, and it is treated by Levy and Levy (2002), for example. Generally speaking, the effect of subjective probabilities on Pratt's risk premium is ambiguous, as the "probability bias" depends on the shape of return distribution.

We will now summarize our main results in two propositions. Proposition 1 below generalizes the results of Table 1. Proposition 2 summarizes the convexifying effects of call options on the DARA manager.

Proposition 1. (a) *Assume that the option holder has an increasing and concave utility function U(w). Then she applies a risk premium in valuing her wealth distribution given by the binomial grid. As a result her subjective value of the ESO is always lower than the market value calculated with risk-neutral option pricing model.* ***(b)*** *The risk premium increases, or her subjective value decreases as the level of risk aversion (α) increases.*

Proof: (a) *by Jensen's inequality, see Appendix 1.* ***(b)*** *Given in Pratt's Theorem 1 (Pratt 1964).*

Proposition 2. (a) *Holding other things constant, the subjective value of employee stock option decreases as the variance of equity returns increases. Therefore it is not optimal for the employee (agent) to increase riskyness of the firm's cash flows without bounds.* ***(b)*** *Whether a convex incentive such as call option convexifies the employee's utility function (i.e. makes her less risk averse), depends on risk preferences of the employee. However, call options always convexify the DARA manager.* ***(c)*** *Managerial risk aversion decreases, as the strike price of the call option increases (it becomes out-of-the-money).*

Proposition 2 summarizes the effects of risk aversion on the subjective valuation of the option. The first argument is due to the fact that to the employee the left tail of return distribution (domain of losses) weighs more than the right tail (domain of gains). The second argument is to say that convexity of the payoff determines whether the employee will increase the firm's risk level after receiving options. Formal proof Proposition 2a is unnecessary, since it is easy to see from Pratt's formula (10) that risk premium increases with variance. Figure 1 gives a graphic illustration of this effect. Proposition 2b is based on Theorem 1 of Ross (2004). It can be checked by applying condition (16). Assume that the compensation scheme is the sum of call option $c(S,K,T,\sigma,r)$ and fixed salary: $f(S) = a + c(S)$. Left-hand side of (16) is always positive for call options, since their delta ($f' = \partial C / \partial S$) and gamma ($f'' = \partial^2 C / \partial S^2$) are positive. However, the right-hand side of (16) must be negative if we assume contract function $f(x)$. This is because we have DARA utility with absolute risk aversion $A(a + c(S)) < A(a)$, because $f(S) \geq a$. In addition we make use of the fact that call option delta is between zero one: $0 < f' < 1$.

Proposition 2c says that the convexifying effect of call option increases with strike price. In our case call options convexify the manager's utility, since we use DARA utility. In other words, Ross's condition (16) always holds. Figures 5A and 5B explore the (total) convexifying effect, conveying the message that the convexifying effect decreases, as the call option becomes in-the-money. This effect becomes less pronounced as volatility increases, but it does not disappear. As shown by Figure 5, it is possible to create a locally risk-neutral manager with OTM calls.

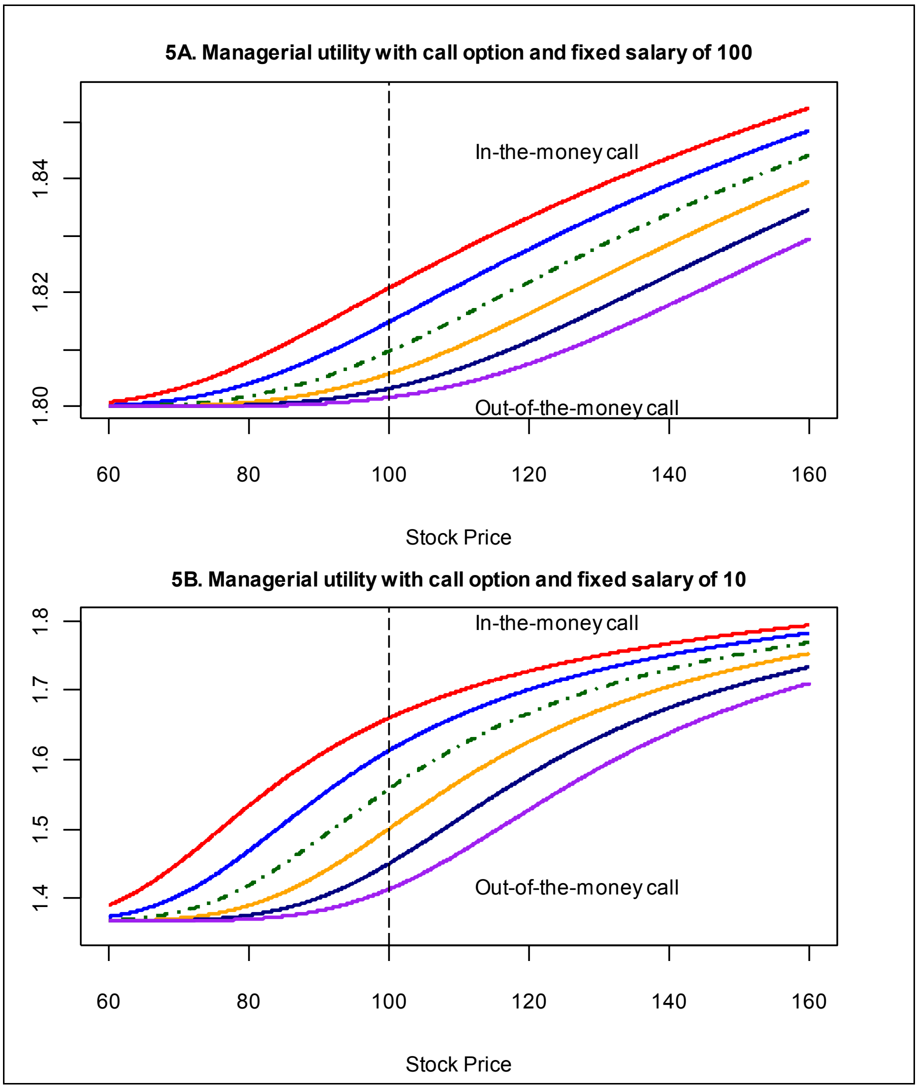

***Figure 5**. Managerial utility functions U(f(S)), where U(·) is power utility given by eq. (11) and compensation scheme f(S)= a + c(S) is the sum of fixed salary a and call option value c(S). The convexifying effect (decrease in risk aversion) induced by f(S) is stronger for out-of-the money calls than in-the-money calls. Starting from top, strike prices increase from 80 to 130. Dashed line plots at-the-money option. Current stock price is 100.*

To understand the strike price effect, think about how option delta increases with stock price. The delta of in-the-money (ITM) option increases at a slower pace than the delta of out-of-the-money (OTM) option. In order to earn some money on her option, the manager who is granted OTM options has a stronger incentive to take risky projects and increase underlying volatility than the manager with ITM options. This might explain the fact, documented by Hall and Murphy (2000), that most option grants have at-the-money strike price. It is also in line with the findings of Lewellen (2003) that corporate executives holding in-the-money calls are not willing to increase leverage, since it would decrease the certainty equivalent of their wealth.

4.4 Empirical evidence on underpricing and early exercise

Recent empirical evidence of discount in ESO prices is presented in Ikäheimo et al. (2004), who employ the Black-Scholes model with historical volatility as a yardstick for fair value. They find that the average underpricing of Finnish ESOs is 15.5 % in a sample consisting of approximately 15,800 trades in ESOs of seven listed firms. However, as shown in their Table 4, discounts on a given issuer's options vary materially across different emissions. For instance, if we take the three options plans of Nokia, the 1995 and 1997 issues trade at less than 1 % average discount, but average discount on the 1999 plan is around 18 %. An interesting finding of *[op.cit.]* is that the discount is particularly high for ten days after listing. If we took the liberty to interpret these results, we would say that there is a population of highly risk-averse employees willing to dispose their options at the first instant. In countries where ESOs are not listed, these employees are forced to exercise their options, contributing data to the literature on early exercise.

Carpenter (1998) presents results on the exercise profiles on option plans of 40 firms listed in NYSE or AMEX. All the options have ten-year maturities. If we look at sample averages, vesting period is 1.96 years and exercise takes place at 5.83 years. Carpenter also reports some interesting correlations in her Table 1. It is surprising that the correlation of stock price (relative to strike) and time of exercise is only 0.14. This should be judged against the average stock price at exercise, which is 2.75 times the strike. A look at Carpenter's Figure 1 confirms that there is almost no association between time of exercise and stock price.

Finally, there is a survivorship issue that complicates interpreting these figures. All the published data concerns the sample of options that have finished in the money and not the full population. Hence it would be a great mistake to say that the average ESO holder in the US exercises her options at 2.75 times the strike price. A fair share of ESOs expires worthless, and because this amount is unknown, it is difficult to make conclusions on the behavior of the average employee endowed with options. Further, it is also possible that part of options in a single plan is exercised deep in the money and part of them expires worthless. Thus, we don't know the risk preferences of those who never exercise their options.

5. Discussion

IFRS 2 requires employee stock options to be expensed, decreasing reported profits as well as dividend payments. Further, in a case where period profit and stock price have a weak correlation an ESO plan does not automatically motivate managers to improve the operating performance of the reporting entity. According to agency theory, relatively long vesting period is preferable from the owner' point of view, as the risk-averse agent's commitment to the common goals is improved. If employee stock options form a substantial part of the manager's wealth, he may choose excessively conservative policies as a result of risk aversion. If the maturity of employee stock options is relatively short, the management may invest all its time and effort in maximizing short-term profits, at the expense of the owner's long-term goals.

The effect of exercise price on the shape of resulting utility is often overlooked. When shareholders (the principal) give options to the manager (the agent), it should be understood that the manager's utility function will take a different shape. If the shareholders would like to see the manager taking more risk, out-of-the-money options provide correct incentives. On the other hand, if shareholders prefer the agent to stay risk-averse, in-the-money options should be used in compensation. Shareholders should also keep track of the dynamic incentive effects of options as time evolves. It is fully possible that a risk-inducing incentive becomes a risk-reducing incentive. This materializes when an option was granted out-of-the-money, but has become in-the-money with increased share price (see figure 5).

Adoption of IFRS 2 reduces the wealth of the owner in cases where substantial expense entries from ESO plans are disclosed and the distributable retained earnings diminish. Thus, the interests of the principal are more secured after the adoption of IFRS 2 while the eventual loss of wealth does not come as a surprise to the owners and the owners may assess the use of their investment compared with other possible investment opportunities. However, the power of the agent to the ESO valuation method may result in ambiguous profit and loss statements, although additional disclosure already demanded by the IFRS 2 may help to overcome these dilemmas. Nevertheless, the adoption of IFRS 2 will usually improve the comparability between entities with varying employee incentive schemes, but the increased disclosure will cause the size of financial statements to grow. Thus, increased effort from owners and all those working in the fields of finance, auditing or management is needed in order to understand the facts and figures presented.

Expensing the value of ESO plan means that the consideration of new share capital is ultimately the work performed by the employee or employee's commitment to the company. However, in some EU countries, for example in Finland, the company legislation prevents the actual issuance of shares in consideration of work. Also, the gap between tax accounting and financial reporting will probably grow. When accounting rules are changed to secure the owner's interests, the entity's point of view becomes less important and there is a gap between the reported costs for the owner and for the firm. One solution to the fair presentation problem is to use fair market value as the indicator of ESO value which in light of this study is lower than a risk-neutral valuation model predicts. For example, in a case where an option plan has become worthless the true and fair view is not likely to convey from the profit and loss statement. Hence, if it is found out that the options will probably not be exercised; the decline in the value of the option plan could be recognized as a deduction of employee costs as this diminishes the dilution effect.

6. Conclusions

We argue that if the employee is risk-averse, her subjective value of the options is lower than the objective value given by standard option pricing models. Second impact of risk-aversion is that the expected value of compensation does not uniquely determine the subjective value of compensation, because the risk premium depends on variance as well. Because the employee has limited opportunities to diversify and hedge, it is likely that when she faces any probability of zero outcomes, she will exercise at least some of her options prior to maturity. Ignoring vesting conditions and risk-averse behavior may result in substantial overestimation of the option plan value. Consequently, giving options to employees is likely to result in some deadweight loss, because the employee's value of the plan is below fair value for reasons given above. Therefore, in order for the value expensed in profit or loss statement to reflect any objective value, fair value stated as an expense in the financial statements of the company should usually not be equal, but lower than the value suggested by a risk-neutral option pricing model.

Shareholders should recognize that giving call options to managers convexifies them, i.e. makes all DARA managers less risk-averse. We argue that the choice of strike price is a key decision variable of shareholders. If shareholders want only a modest convexifying effect, the strike price should be in the money. However, if shareholders want managers to accept higher risk, options with out of the money strikes should be used. Corporate boards should also monitor the level of option-based incentives after grants. As share price develops and options become in or out of the money, they may impose different incentives than originally thought.

When it comes to choosing an option pricing model, we think that the binomial framework is flexible enough to account for two major complications in ESO pricing: risk-averse preferences and trading constraints in the underlying asset. Correct choice and calibration of valuation model is crucial, since ESO-related expenses may have a material impact on reported earnings. Having recognized the intricacies of valuing employee stock options, we find that wrong valuation choices, as well as market fluctuations, limit in some cases the attainment of the true and fair view from the owner's point of view. The grant date value of an ESO plan disclosed in IFRS financial statements is only as valid as the underlying assumptions.

Nevertheless, the adoption of IFRS 2 may be considered as advancement in the financial statement disclosure: the use of resources affecting owners' wealth is better displayed. Also, IFRS 2 has justifiably raised many questions for further discussions, such as: what is the "fair value" of an option; what is value of work; what is a good design of an incentive scheme; and what are the costs of operations to the company and to the owner of the firm.

Notes

[1] "International Financial Reporting Standards" and "IFRSs" are trademarks of the International Accounting Standards Committee Foundation. IFRS 2 was issued in February 2004 by the International Accounting Standards Board (IASB) with an effective date of 1.1.2005.

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Appendix 1: Proof of Proposition 1a.

Proposition 1. (a) *Assume that the option holder has an increasing and concave utility function U(W). Then she applies a risk premium in valuing her wealth distribution given by the binomial grid. As a result her subjective value of the employee stock option is always lower than the market value calculated with risk-neutral option pricing model.*

We investigate the subjective valuation of employee stock option with risk-averse preferences. Our first assumption is that the employee has power utility given by equation (A7) with constant relative risk aversion γ.

$$\text{(A7)} \qquad U(W) = \begin{cases} \dfrac{W^{1-\gamma} - 1}{1-\gamma} & \text{if } \gamma > 1 \\ \log W & \text{if } \gamma = 1\,. \end{cases}$$

This utility function is differentiable, increasing and concave for all $W > 0$. Assume that the employee's terminal wealth is positive and bounded by the range $[a, b]$ of Figure A2. Expected utility, given by eq. (A8) is calculated by weighing the possible outcomes w_i with their probabilities, given by p_i. Values of these outcomes are found in the last period nodes of the binomial grid. Index i goes from 1 to $N + 1$, since the N-period binomial model has $N + 1$ different outcomes.

$$\text{(A8)} \qquad E[U(W)] = \sum_{i=1}^{N+1} p_i U(w_i) \le U(E[W]).$$

Equation (A8) says that the expected utility of wealth is less (or equal to) utility evaluated at mean point of wealth. This inequality is known as Jensen's inequality for concave functions and it is illustrated in Figure A2. A quick look at the Figure 1 shows that equality in eq. (A8) holds only when length of the interval $[a, b]$ approaches zero. We will assume that this interval is wider than zero as there is always some variance in the payoffs generated by the option.

To see the effect of risk neutrality, consider a linear utility function given by eq. (A9). Here it is only the mean of wealth distribution that matters.

(A9) $U^*(W) = W.$

(A10) $E[U^*(W)] = \sum_{i=1}^{N+1} p_i w_i = U^*(E[W]).$

As shown by eq. (A10), linear utility implies that expected utility is equal to utility of expected wealth. But Jensen's inequality says that this is the upper bound for expected utility in the concave case. Hence the linear expected utility is always equal or higher than the concave expected utility, if probabilities are unchanged (as is the case here). This point can be confirmed by comparing expected utility in the two cases.

Linear preferences: $E[U^*(W)] = U^*(E[W])$ and

Concave preferences: $E[U(W)] \leq U(E[W])$.