An Indexed Executive Stock Option: Design, Pricing and Incentive Effects

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April 2008

ABSTRACT

The executive stock options indexed to the market are useful as a compensation scheme in that the indexed options protect shareholders from rewarding executives excessively during market upturns. Despite the usefulness of indexed options, most of the large firms in the US have not granted an indexed option. According to academic researches on executive stock options, the probability of expiring in the money is too small to offer risk-averse executives incentives to work more efficiently. This paper develops a new indexed option model and explores the incentive effects. While there is a similar indexation feature between the existing indexed options and the new one, a different payoff structure has a significant influence on option values and incentive effects. We show that the new indexed option has the higher probabilities of expiring in the money and increases incentive effects relative to the existing one.

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1 Introduction

One of the major issues in corporate finance is corporate compensation that provides incentives to align the executive's interests with the shareholders'. Among corporate compensation schemes, executive stock options have drawn attention to many corporations. Typically, executive stock options provide executives with the right to buy shares of stock at a price set to be the stock's market price. To the extent of her efforts, the executive can be rewarded as long as she performs better relative to the firm's performance on the grant date.

In contrast to providing a vehicle of increasing the executive's incentive effects and reducing the agency costs, executive stock options could be an inefficient tool as stated in Hall and Murphy (2000).

One of the problems with executive stock options is that they can provide much more rewards to executives relative to their efforts or their shareholders. For example, a financial press reports that '... CEO ... received a $2.1 million bonus and 200,000 new options last year even though net income fell by half and shareholder returns were flat at his company.'.[1]

In addition, because the exercise price of option is fixed at the grant date, executive stock options could generate enormous rewards for poor firm performances during market upturns. In order to make executive stock options more efficient in the case of excessive rewarding, many studies suggest that exercise prices of stock options should be made to be indexed to the market. Rapport (1999) and Meulbroek (2001a, 2001b) design an executive stock option based on relative performance. Johnson and Tian (2000b) design an indexed option model and derive an indexed option formula. Then by using the indexed option formula, they

[1] See BusinessWeek (April 19, 2002) as titled, 'An Answer to the Options Mess'.

investigate incentive effects implied through their model. In addition to Johnson and Tian (2000b), several papers carry out research on the indexed executive stock option. Johnson and Tian (2000a) explore the price and incentive effects of the traditional executive stock option (such as the Black and Scholes model) and nontraditional options including indexed options. Jørgensen (2002) derives the American indexed executive stock option formula and analyzes the characteristics of the option when there is a vesting period. Duan and Wei (2005) investigate the effects of systematic risk on the values and incentives of the indexed option as well as the nonindexed option under a GARCH option pricing framework.

The financial press also proposes executive stock options indexed to the market, for example, a BusinessWeek's report (April 19, 2002) subtitled, 'How to ensure that top execs aren't rewarded even when their outfits perform poorly? Index stock options to a benchmark like the S&P 500'.

However, despite the usefulness of indexed executive stock options, there were no large firms in the US that had an indexed option plan (See Hall and Murphy (2003)). The reason why indexed options almost never exist in practice is as follows. First, indexed option grants put the firm expense in accounting statements. Second, according to Hall and Murphy (2003), the values of indexed executive stock options are much lower than the corresponding traditional option values. They state that "... because stock returns are skewed to the right (since the minimum return is minus 100 percent but the maximum return is unbounded), and therefore less than half of the firms in an index will have returns that exceed the average. Thus, indexing reduces the company's cost of granting an option, but it reduces the executive's value even more because risk-averse executives attach very low values to options likely to expire worthless. Therefore, to deliver the same value to the executive, it costs the company more to grant indexed options rather than traditional options." Therefore, the differences in values between traditional executive stock options and indexed options may make indexed options provide risk-averse executives with weak incentives.[2]

This paper designs an indexed executive stock option model where the payoff structure is different from the existing indexed option model. The existing indexed option pays off only if the firm's stock price exceeds the benchmark price indexed to the market at the option's maturity date.[3] This implies that the firm evaluates the manager's performance only on the payment date of options. In this paper we consider that an indexed option pays off when an average of stock price from the grant date to the option's maturity date is greater than the index counterpart. Hereafter, we call this indexed option the averaging indexed option. An averaging indexed option has the following feature. Like the indexed option of Johnson and Tian (2000b) (hereafter, it is called as an indexed option), an averaging indexed option links the option values with only the firm performance after filtering out the market performance. This aspect does not allow executives to be rewarded excessively compared with their efforts.

After designing and pricing an averaging indexed option, we investigate the properties of an averaging indexed option. In contrast with indexed options, averaging indexed options have significantly higher probabilities that will expire in the money. Since the possibilities that the stock price on the option's maturity would exceed the indexed exercise price after many years (typically, ten years) are very low, the value incentive of the indexed option is small.

[2]Since the first reason why indexed options do not exist comes from the accounting rules proposed by the Financial Accounting Standards Board (FASB), this paper studies an indexed option from the standpoint of option design.

[3]Both Jørgensen (2002) and Duan and Wei (2005) adopt the indexed exercise price proposed by Johnson and Tian (2000b).

For example, although a firm performance has been good before the option's maturity, the firm performance could become bad slightly near the option's maturity. In this case it is very difficult for an executive to be rewarded through the indexed option. In contrast to indexed options, a compensation using an averaging indexed option lays less burden on an executive relative to an indexed option. Because an executive with an averaging indexed option can be rewarded on average performance, she does not need to concentrate her efforts on the stock price at option's maturity.

We also show that the difference in value between traditional and averaging indexed options is smaller than the difference of traditional and indexed option values. We observe the significant difference in price patterns between indexed options and averaging indexed options.

Before we investigate the incentive effects of averaging indexed options, we analyze the Johnson and Tian method for exploring the incentive effects of indexed options. The analysis of incentive effects of indexed options allows us to provide the following implication. While the existing indexed option allows the shareholders to be protected from rewarding executives with poor performance in bull markets, executives with poor performance can be rewarded much more in bear markets.

Although indexed and averaging indexed options have the similar incentive to increase stock price for in-the-money options, the value incentive effects of averaging indexed options are greater than those of indexed options for out-of-the-money. Averaging indexed options could provide stronger effects to a poor performing executive.

Indexed and averaging indexed options have stronger risk incentives than traditional option counterparts. We also observe that the averaging option vega is almost greater than the indexed option counterpart for relatively shorter term options while for relatively longer term options, the indexed option vega is greater than the averaging indexed option vega. The risk-averse executives tend to avoid risky, however, positive net present value (NPV) projects when the option's maturity date is near. Because of the relatively high vega, averaging indexed options could be an efficient compensation scheme to mitigate this problem.

The organization of this paper is as follows: In Section 2 we set up a benchmark exercise price of the averaging indexed executive stock option and derive a closed-form formula for the averaging indexed executive stock option. In Section 3, we explore the incentive effects of the executive stock option. Section 4 concludes the paper.

2 An Averaging Indexed Executive Stock Option Model

We provide a simple executive stock option model where the option's strike price is indexed to a benchmark. There are no arbitrage opportunities in the economy. Suppose that under the physical probability measure P, the dynamics of the firm's stock price and the index are governed by as follows:

$$dS = (\mu_S - \delta_S)Sdt + \sigma_S S dW \tag{1}$$

and

$$dI = (\mu_I - \delta_I)Idt + \sigma_I I dZ \tag{2}$$

where both W and Z are the standard Brownian motions and ρ is the correlation coefficient of W and Z. Here, μ_S, μ_I, σ_S and σ_I are constants. Also, we assume that the riskless interest rate, r is a constant.

As in Johnson and Tian (2000b), we consider the relation between stock and index returns.

$$\mu_S = r + \beta(\mu_I - r) \tag{3}$$

Here, β is the same as that in the capital asset pricing model (CAPM):

$$\beta = \rho \frac{\sigma_S}{\sigma_I}. \tag{4}$$

If the index is the market portfolio, equation (3) is identical to the capital asset pricing model (CAPM). Equation (3) also states that the excess return on the firm's stock is zero. Since the excess performance $(\mu_S - r) - \beta(\mu_I - r)$ measures the executive's performance (e.g., Holmstrom and Milgrom (1987)), no excess return implies that the firm assesses executive's performance based on firm-specific performance.

To set up the benchmark exercise price that reflects only the firm's performance filtering out the market performance, Johnson and Tian (2000b) suggest that the benchmark exercise price, H_t is set to be the conditional expectation of the stock price on the market index, that is, $H_t = E[S_t|I_t]$. Johnson and Tian derive the benchmark exercise price

$$H_t = S_0 \left(\frac{I_t}{I_0} \right)^{\beta} e^{\eta t} \tag{5}$$

where

$$\eta = r - \delta_S - \beta(r - \delta_I) + \frac{1}{2}\rho\sigma_S\sigma_I(1 - \beta). \tag{6}$$

Under this assumption, the payoffs to the firm's executive at the option's maturity date, T are given by

$$\max(S_T - H_T, 0). \tag{7}$$

This implies that the possibility of the firm performance beating the market performance at the option's maturity is an important factor to determine the value of the option. Although the firm's performance is better than the market's before the option's maturity, the payoffs of the option can be very small if the firm's performance is bad near the option's maturity.

Contrary to the Johnson and Tian's assumption, we consider the benchmark exercise price as the average of executive's performance filtering out that of the market performance. The average of the executive and market performance from the grant date to the option's maturity date are calculated by

$$\exp\left(\frac{1}{T}\int_0^T \ln S_u du\right) \tag{8}$$

and

$$\exp\left(\frac{1}{T}\int_0^T \ln I_u du\right). \tag{9}$$

We define the new benchmark exercise price as follows.

$$B_T = E[A_T^S | A_T^I] \tag{10}$$

where A_T^S and A_T^I denote $\exp(\frac{1}{T}\int_0^T \ln S_u du)$ and $\exp(\frac{1}{T}\int_0^T \ln I_u du)$, respectively. Equation (10) represents the firm average performance against the market average performance if the index was the market portfolio. From equations (3) and (10), the firm rewards executives based on the idiosyncratic part of average performance after filtering out the market average performance.

Then the payoff to the executive at the option's maturity is

$$\max(S_T - B_T, 0). \tag{11}$$

Since $\ln A_t^S$ and $\ln A_t^I$ follow a bivariate normal distribution, the conditional expectation of A_t^S on A_t^I, $E[A_t^S|A_t^I]$ becomes

$$S_0\left(\frac{A_t^I}{I_0}\right)^{\beta} e^{\phi t} \tag{12}$$

where

$$\phi = \frac{1}{2}\{r - \delta_S - \beta(r - \delta_I) - \frac{1}{6}(\sigma_S^2 - (3 - 2\beta)\beta\sigma_I^2)\}. \tag{13}$$

In order to make the design of an option grant flexible, we introduce an additional parameter, λ into the exercise price as follows

$$\lambda S_0 \left(\frac{A_t^I}{I_0}\right)^{\beta} e^{\phi t}. \tag{14}$$

The payoff of the averaging indexed executive stock option at maturity T is

$$\max\left(S_T - \lambda S_0 \left(\frac{A_T^I}{I_0}\right)^{\beta} e^{\phi T}, 0\right). \tag{15}$$

Generally, in practice, the executive stock option is at-the-money on the date of grant. If λ is set to be one, then one can check easily that by construction, the option defined in equation (15) is at-the-money at the grant date. If λ is greater (smaller) than one, then the option is out-of-the-money (in-the-money) initially.

Now we proceed to the valuation of the averaging indexed executive stock option with payoffs of equation (15) at maturity. Because of no arbitrage opportunities, there exits the equivalent martingale measure Q with respect to the probability measure P. Under Q measure the firm's stock and index processes are as follows.

$$dS = (r - \delta_S)Sdt + \sigma_S S dW^Q \tag{16}$$

and

$$dI = (r - \delta_I)Idt + \sigma_I I dZ^Q \tag{17}$$

where W^Q and Z^Q are standard Brownian motions under Q.

In order to determine the time t value of the indexed executive stock option, we need to calculate the following discounted expectation.

$$C_t = e^{-r(T-t)} E_t^Q \left[\max \left(S_T - \lambda S_0 \left(\frac{A_T^I}{I_0} \right)^{\beta} e^{\phi T}, 0 \right) \right] \quad (18)$$

where $E_t^Q[\cdot]$ is the expectation operator at time t under Q. As in Johnson and Tian (2000b), this averaging indexed option can be considered as an option to exchange B_T for executive's stock, S_T. Thus, we can apply the exchange option formula of Margrabe (1978) to equation (18).

The value of the indexed option at time t with the time to maturity τ $(= T - t)$ is given by

$$C(t,T) = S_t e^{-\delta_S \tau} N\big(d_1\big) - \lambda \left(\frac{S_0}{I_0^{\beta}} \right) e^{-r\tau + \phi T + \beta m + \nu^2/2} N(d_2) \quad (19)$$

where

$$m = \frac{t}{T} \ln A_t^I + \frac{\tau}{T} \ln I_t + \frac{\tau^2}{2T}(r - \delta_I - \frac{\sigma_I^2}{2}) \quad (20)$$

$$\nu^2 = \frac{\tau^3}{3T^2} \rho^2 \sigma_S^2 \quad (21)$$

$$d_1 = \frac{\ln(\frac{S_t I_0^{\beta}}{S_0}) + (r - \delta_S + \frac{\sigma_S^2}{2})\tau - \phi T - \beta m - \frac{\tau^2}{2T}\rho^2 \sigma_S^2}{\sigma_s \sqrt{\tau + (\frac{\tau}{3T} - 1)\frac{\tau^2}{T}\rho^2}} \quad (22)$$

$$d_2 = d_1 - \sigma_s \sqrt{\tau + (\frac{\tau}{3T} - 1)\frac{\tau^2}{T}\rho^2} \quad (23)$$

and $N(\cdot)$ is a cumulative standard normal distribution.

2.1 Probability of Expiring In The Money

In this section we examine the probabilities of expiring in the money at the option's maturity, that is, the firm's payout probability. In order to obtain payout probabilities, we choose the parameter values used in Hall and Murphy (2002): no dividends ($\delta_S = \delta_I = 0$), $\beta = 1$,

$\sigma_S = 0.3$, the risk-free rate is 6% and an equity premium is 6.5%.[4] In addition, we need the value of the volatility of the market index, σ_I. We assume that σ_I is 0.15. This implies that the correlation coefficient between the firm and the market index returns is 0.75. Before we investigate the in-the-money probabilities for option's moneyness as in Hall and Murphy (2002), we need to consider the difference between traditional options and indexed (averaging indexed) options. While for each moneyness the in-the-money probabilities can be calculated in traditional options, by construction indexed (averaging indexed) options do not allow us to consider the moneyness of the options. Therefore, as the above manipulation of the exercise price of averaging indexed options, we add λ to equation (5) as follows

$$\lambda S_0 \left(\frac{I_t}{I_0} \right)^{\beta} e^{\eta t}. \tag{24}$$

This is the same exercise price as the equation (21) of Johnson and Tian when g is equal to zero in that equation.

We examine six values of the current stock price (10, 20, 30, 40, 50, 60). The exercise price, λS_0 is set to be \$30. Given the current stock prices and the fixed exercise price at the grant date, λ takes the values: 3, 1.5, 1, 0.75, 0.6 and 0.5.

Table 1 illustrates the probabilities that options with 10-year maturity will expire in-the-money. As stated in Johnson and Tian (2000b), the payout probabilities in their model are much lower than the corresponding probabilities implied in the Black and Scholes model.[5] The

[4] Here, the above risk-free rate and an equity premium values are (simply) compounded annual returns. Therefore, we calculate continuously compounded annual returns and then use these values to be applied in this model.

[5] Although Hall and Murphy (2002) do not use the Johnson and Tian model but use the certainty equivalent method to calculate the payout probability, they also obtain the similar results.

probability that an at-the-money indexed option ($S_0 = 30$) will expire in the money does not exceed 50%. Since recently many companies tend to grant out-of-the-money executive stock options on the grant date, we are interested in the probabilities that the options are in-the-money at the option's maturity when S_0 is less than 30. The lower the initial stock price is, the greater the differences of the in-the-money probabilities are.

Now we examine the probabilities that an averaging indexed option will expire in the money. For averaging indexed options the probability of expiring in-the-money is

$$N\left(\frac{\{6\beta(\mu_I - r) + 6(r - \delta_S) - (5 - 2\rho^2)\sigma_S^2 - \ln\lambda\}\sqrt{T}}{12\sqrt{\beta^2\sigma_I^2\frac{1}{3} + \sigma_S^2 - 2\rho^2\sigma_S^2\frac{1}{\sqrt{3}}}}\right). \tag{25}$$

From the above equation we find the following results. First, the probabilities that an averaging indexed option will be in-the-money after 10 years are much higher than the corresponding Johnson and Tian's probabilities. When S_0 is \$30, that is, the option is set at the money initially, the payout probability of the averaging indexed option is around 62% while the payout probability of the indexed option is around 34%. The averaging indexed option's payout probability is twice higher than the indexed option's. The lower S_0 is, the more significant differences are. Second, the differences between the payout probabilities of the traditional option and those of the averaging indexed option are not relatively great. For at-the-money options, the difference in payout probabilities between traditional and averaging indexed options is around 16%, while the difference in payout probabilities between traditional and indexed options is around 44%.

In sum, we show that the payout probabilities of indexed options are very low. Since this is not attractive to the executive, the firm would have to grant an amount of indexed options to increase executive's incentive effects. Granting an amount of indexed options may cost the firm additionally. We will discuss this problem again in the next chapter.

Also, the payout probabilities of averaging indexed options are higher than those of indexed options irrespective of moneyness. Since the difference in payout probabilities is not relatively great, granting traditional options can be replaced by granting averaging indexed options without additional costs.

2.2 Implications of Option Prices

Table 2 shows option prices of traditional, indexed and averaging indexed options on the date of grant ($t = 0$). We choose base parameter values as follows: Both the stock and index continuous dividend yield are 2%. The index volatility is 15%. The correlation between stock and index returns is 0.75. We examine option values at three stock prices (\$90, \$100, and \$110) and three values of stock return volatility (0.1, 0.2, and 0.3). For traditional options the strike price is \$100. Note that on grant date, stock price is the same as the strike price for indexed and averaging indexed options.

The traditional options have a higher value than the indexed and averaging indexed counterparts. This is consistent with Hall and Murphy (2002) where the traditional option values are too high. Also, the difference in value between the traditional and indexed options is larger than the difference in value between the traditional and averaging indexed options. For example, on the case where $S_0 = 100$ and $\sigma_S = 0.2$ the averaging indexed option value is \$28.35 or 70.3% of the traditional option counterpart (\$40.35) while the indexed option value is \$13.56 or 33.6% of the traditional option counterpart. The lower stock price and return volatility are, the larger difference in value is.

Next, we analyze option values with respect to correlation between stock and index returns. Johnson and Tian (2000b) also examine values of indexed options against the correlation. Therein, they plot the prices for an at-the-money option on the grant date. Therefore, λ is set to be one from here. When granted, the executive stock option is typically issued at-the-money. As time goes by, the executive stock option could be out of the money or in the money because the market price of stock changes. In order to investigate the price pattern for various stock prices, we plot both indexed and averaging indexed option prices with respect to the correlation at time $t = 5$. Since we focus on option values at some date not at the grant date, we need to select the value of $\ln A_t^I$ of equation (20) if we obtain prices of averaging indexed options. Since the value of A_t^I is known one at time t, we can choose an *ad hoc* value. However, in this paper, we select the value of $\ln A_t^I$ as the expected value of that under Q measure, that is, $\ln I_0 + (r - \delta_I - \sigma_I^2/2)t$. Even if A_t^I is given exogenously, the implications of option values in this section and incentive effects in the next section (unreported) do not change as long as we use the average value of I_0 and I_t as A_t^I.

Figure 1 illustrates the prices of traditional, indexed and averaging indexed options for various values of the correlation between stock and index returns. We assume that the ratio of I_t to I_0 is 1. Each panel plots the option values against the level of the current stock price S_t. There are several interesting observations.

First, for the averaging indexed option, the price is an increasing function of the correlation between stock and index returns except for the deep-out-of-the-money option ($S_t = 60$). The executives with averaging indexed options have strong incentives to increase the systematic risk. For deep-out-of-the-money options, we can see a slightly inverted u-shaped relation between the averaging indexed option prices and the correlation.

Second, for indexed options, the difference in the price pattern is significant in each panel. Figure 1 (p. 47) of Johnson and Tian (2000b) shows that the indexed option value decreases with the correlation. Contrary to Johnson and Tian, Figure 1 in this paper illustrates that the indexed option value is an increasing function of the correlation when the option is in the money. When stock price at time $t = 5$ is higher than the stock price on the grant date, the executive has an incentive to increase systematic risks. The higher current stock price allows the risk-averse executives to bear more risks because it plays a buffer role in accepting a risky, however, positive NPV project.

Third, when options are out of the money or at the money, the difference in price between indexed options and averaging indexed options increases with the correlation. The difference in price for at-the-money options is more significant than that for in-the-money options. However, the price difference is a decreasing function of the correlation when options are in the money. As stated above, these patterns of difference in prices come from the fact that incentive effects of the indexed option to increase systematic risks grows stronger as the option goes in the money.

3 Incentive Effects

In this section we explore the pay-performance sensitivity of the averaging indexed option. We also compare incentive effects of traditional and indexed options with those of averaging options. In doing so, we follow the Jensen and Murphy (1990) approach to the pay-performance sensitivity that used by Johnson and Tian (2000b), and Duan and Wei (2005). Therein, the pay-performance is measured by the partial derivatives of the executive stock option price with respect to the firm's stock price and volatility and so on. Before we investigate the implications of the incentive effects (i.e., value incentive (delta) and risk incentive (vega) effects) of averaging indexed options, we first discuss the analysis method for investigating incentive effects in Johnson and Tian.

3.1 Discussion on Value Incentive Effects in Johnson and Tian

As described above, the prices of indexed options are much lower than the corresponding traditional options. To control the difference in option values, Johnson and Tian investigate the incentive effects of indexed options under the assumption that the firm grants indexed options adjusted by an amount that makes the value of the indexed option equal to the corresponding traditional option value. After adjustments, Johnson and Tian show that the delta of the indexed option is greater than that of the traditional option except when options are out of the money.

It is worthwhile to discuss the Johnson and Tian's method to investigate the incentive effects. First, the incentive effects of the indexed option are dominated by the adjustment amount above that makes the value of the indexed option equal to the corresponding traditional option value. Second, in fact, Johnson and Tian analyze the option's delta at time 0, that is, on grant date. By construction, however, this implies that they examine the delta of at the money indexed option irrespective of the current stock price.

Therefore, in order to gain implications of value incentive effects for various stock prices, we need to calculate the indexed option delta on some time after the grant date. We compute and examine the indexed option prices and deltas at $t = 5$. Also, we choose the parameter values used by Johnson and Tian (2000b). The base parameters are as follows: The market price of stock is $100 on the date of grant, the firm's stock volatility 20%, index volatility 15%, dividend yields for the stock and index are 2%, the riskless interest rate is 8%, and the correlation between the firm's stock and index is 0.75. The option's maturity is ten years. Table 3 provides the prices and the delta values of the traditional option and the indexed option.

The Panel A in Table 3 illustrates the prices and deltas of traditional and indexed options when a 50 percent rise in level of the market index would occur compared with on the grant date. The difference in price between traditional and indexed options is significant. The indexed option delta is smaller than the traditional option delta except in the money options. The deeper options are in the money, the greater the delta of indexed options relative to the delta of traditional options.

In the Panel B in Table 3 we can see the prices and deltas of traditional and indexed options when a 50 percent drop in level of the market index would occur relative to on the grant date. In contrast with Panel A, both prices and deltas for the indexed option are higher for all moneynesses. Although the firm performance is poorer than the market, it is important to observe that the indexed option price is higher than the traditional option. In this case indexed option grants are very inefficient for the firm.

In fact, the usefulness of indexed options is to protect shareholders from compensating executives with poor performance during market upturns. This effect appears in the Panel A in Table 3. However, in bear markets, indexed option could excessively reward executives with poorer performance relative to the market performance. Moreover, like the assumption of Johnson and Tian, if the firm grant executives a large number of indexed option to give the same value to executives with indexed options as with traditional options, then granting indexed options could cost the firm too much relative to traditional options.

Therefore, when designing compensations using the existing indexed option, granting indexed options could be inefficient in bear markets while that makes executives enhance their incentives in bull market.

3.2 Value Incentive Effects

From equation (19) the pay-performance sensitivity (delta) of the averaging indexed option is as follows:

$$\frac{\partial C_t}{\partial S_t} = e^{-\delta_S \tau} N(d_1) \tag{26}$$

As stated in Johnson and Tian (2000b), it is not possible to compare the delta of traditional options with those of the indexed or averaging indexed options due to the index parameter. However, we can compare the delta of the averaging indexed option with that of the indexed option because both option models use the same the market index parameter.[6] In order to calculate deltas of options, we choose the parameter values used in Table 3.

Table 4 shows that the delta values of the averaging indexed option are higher than the corresponding indexed option. Since the option's delta expresses the sensitivity of the change in option price to the change in stock price, by definition the (positive) delta measures the executive's incentive to increase the firm's stock price. The higher option's delta, the greater incentive to increase stock price. In line with this, an executive with the averaging indexed

[6]Hereafter, we investigate incentive effects of options when we do not adjust the number of indexed and averaging indexed options on the date of grant.

option have stronger incentive than an executive with the indexed option.

The incentive effect's differences between the averaging indexed option and the indexed option grow stronger as the current stock price (S_t) is smaller. When the option is deep out of the money ($S_t = 50$), the delta of the averaging indexed option is about ten times greater than that of the indexed option. In the case of the indexed option, the incentive effects disappear when the option is deep out of the money as stated in Johnson and Tian (2000b). Contrary to the indexed option, the incentive effects of the averaging indexed option relative to the indexed option remain despite of being deep out of the money. In other words, the averaging indexed option would provide an executive with the value incentive although she performed poorly before.

3.3 Risk Incentive Effects

In this part we explore the risk incentive effects of the averaging indexed option. It is straightforward to calculate the averaging indexed option vega:

$$\frac{\partial C_t}{\partial \sigma_S} = S_t e^{-\delta_S \tau} n(d_1)\sqrt{\tau + (\frac{\tau}{3T} - 1)\frac{\rho^2 \tau^2}{T}} - \lambda\left(\frac{S_0}{I_0^\beta}\right)\left\{(m - \ln I_0)\frac{\rho}{\sigma_I} + \frac{\nu^2}{\sigma_S} + \gamma T\right\} \tag{27}$$

where

$$\gamma = \frac{1}{2}\left(\frac{1}{2}\rho\sigma_S - (r - \delta_I)\frac{\rho}{\sigma_I} - \frac{1}{3}(2\rho^2 + 1)\sigma_S\right). \tag{28}$$

Table 5 illustrates the vegas of traditional, indexed and averaging indexed options. Panel A and Panel B of Table 5 provide vega when the systematic risk is low ($\rho = 0.3$) and high ($\rho = 0.75$), respectively. Each panel shows vega both for longer time to maturity ($t = 3$) and for shorter time to maturity ($t = 8$) options. We can obtain several results from Table 5.[7]

[7] Except the values of ρ and t, we select the parameter values used in Table 3.

First, irrespective of the systematic risk level, vega for longer time to maturity option is greater the corresponding vega of options for shorter time to maturity. In other words, the executive has the stronger incentive to increase the firm's risk when the option maturity remains longer. This is because she have more incentives to increase the option value by bearing higher risks.

Second, the lower the level of total volatility is, the higher vega of options is. Compared with higher level of volatility, the lower volatility leaves room for increasing firm volatility.

Third, for the same level of the firm volatility, both indexed and averaging indexed option vegas is higher when the firm systematic risk is higher. Especially, this effect is strongest for relatively shorter term indexed options. This comes from the fact that the executive with indexed options could make her option values more valuable if she can mark up the stock price near the option's maturity.

Fourth, for relatively longer term options, the indexed option vega is greater than the averaging indexed option vega. In contrast with longer term options, with minor exceptions, it can be shown that the averaging option vega is greater than its indexed counter part for relatively shorter term options. We note that the effects of incentives to increase risk on firms vary according to firms' situation and executives' characteristic. According to Guay (1999), granting options with stronger risk incentives can be of an advantage to firms with riskier investments while that can be of a disadvantage to firm with higher debt agency costs. Apart from firm's situation and executives' characteristic, it seems that risk-averse executives generally tend to avoid a risky project as time moves closer to the option's maturity. Greater vega of the averaging indexed option implies that the averaging indexed option may encourage better risk-taking behavior compared with the indexed option.

4 Conclusion

The executive stock option plan is an important and good vehicle to alleviate the agency costs between the shareholders and the executive. Although many firms have granted executive stock options until now, the problems with executive stock option are brought up in academic studies. One of the problems is that in 1990s' bull market there were many executives that were rewarded excessively relative to their performance. To settle this problem, several studies propose that the strike price of executive stock options be indexed to the market. This indexed option plan protects the shareholders from compensating the executive too much because the option is worth at maturity only when the firm performance is better than the market's. However, as opposed to our expectation, almost all large firms in the US have not granted these indexed options. This is because the indexed option values are much lower than the traditional option counterparts and then indexed options may not be attractive to risk-averse executives.

In this paper we design a new indexed option model and explore the incentive effects. The strike price of this indexed option is set to be the firm's averaging performance relative to the market's averaging performance. Using this indexation scheme, we compare values and incentive effects of an averaging indexed option with those of traditional and existing indexed options.

As stated in Hall and Murphy (2000), a payout probability of indexed option is too small to offer risk-averse executives incentives. In contrast, averaging indexed options have significantly higher payout probability than indexed options. In line with a higher probability, the difference in value between traditional and averaging indexed options is smaller than the difference of traditional and indexed option values.

Our analysis of incentive effects gives some new implications on existing indexed options. While the existing indexed option allows the shareholders to be protected from rewarding executives with poor performance in bull markets, executives are highly likely to be rewarded excessively in bear markets.

Indexed and averaging indexed options have the similar incentive to increase stock price for in-the-money options. In case of out-of-the-money options, the value incentive effects of averaging indexed options are greater than those of indexed options. We think that averaging indexed options could provide a poorly performing executive with stronger value incentives than indexed options.

Risk incentives of indexed and averaging indexed options are greater than traditional option counterparts. This also holds although we do not adjust the number of indexed and averaging indexed options granted. We show that the averaging option vega is almost greater than the indexed option counterpart for relatively shorter term options while for relatively longer term options, the indexed option vega is greater than the averaging indexed option vega. Since risk-averse executives tend to avoid risky, however, positive net present value projects as time moves closer to the option's maturity, averaging indexed options with the relatively high vega could be an efficient compensation scheme to mitigate this problem.

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Table 1: Probabilities that will be in-the-money at the option's maturity

Stock price	traditional	indexed	averaging indexed
10.00	0.3480	0.0402	0.1582
20.00	0.6330	0.1829	0.4277
30.00	0.7785	0.3406	0.6169
40.00	0.8578	0.4758	0.7381
50.00	0.9042	0.5835	0.8163
60.00	0.9329	0.6674	0.8680

Table 1 describes probabilities of expiring in the money at the option's maturity with respect to stock price. We examine payout probabilities using the following parameter values: $r = 8\%$, $\delta_S = \delta_I = 0$, $\sigma_S = 30\%$, $\sigma_I = 15\%$, and $\rho = 0.75$. The time to maturity is ten years. The risk-free rate is 6% and an equity premium is 6.5%.

Table 2: Prices of traditional, indexed and averaging indexed options on grant date

Stock price	volatility	traditional	indexed	averaging indexed
90	0.1000	29.2086	3.1859	15.4861
90	0.2000	33.1372	9.1931	21.8746
90	0.3000	38.6094	15.3228	28.8533
100	0.1000	37.1516	6.8194	22.6373
100	0.2000	40.3530	13.5648	28.3549
100	0.3000	45.5975	20.1643	35.3187
110	0.1000	45.2252	11.9815	30.3215
110	0.2000	47.8027	18.6991	35.2668
110	0.3000	52.7731	25.5018	42.0824

Table 2 describes values for traditional, indexed and averaging indexed options on grant date. In order to calculate option prices, the values of parameters are as follows: Both the stock and index continuous dividend yield are 2%. The index volatility is 15%. The correlation between stock and index returns is 0.75. For traditional options the strike price is $100.

Table 3: Prices and Deltas of Traditional and Indexed Options

Panel A

	Price		Delta	
S_t	traditional	indexed	traditional	indexed
50	2.5308	0.0006	0.2317	0.0005
60	5.5087	0.0068	0.3639	0.0043
70	9.7779	0.0429	0.4873	0.0204
80	15.1902	0.1754	0.5915	0.0646
90	21.5361	0.5281	0.6741	0.1539
100	28.6064	1.2718	0.7369	0.2980
110	36.2209	2.5911	0.7836	0.4950
120	44.2357	4.6453	0.8176	0.7324
130	52.5410	7.5400	0.8421	0.9919
140	61.0555	11.3169	0.8598	1.2543
150	69.7199	15.9586	0.8724	1.5041

Panel B

	Price		Delta	
S_t	traditional	indexed	traditional	indexed
30	0.1500	0.1760	0.0327	0.1539
40	0.8328	1.5484	0.1123	0.7324
50	2.5308	5.3195	0.2317	1.5041
60	5.5087	11.4418	0.3639	2.0932
70	9.7779	19.0979	0.4873	2.4244
80	15.1902	27.5457	0.5915	2.5808
90	21.5361	36.3500	0.6741	2.6477
100	28.6064	45.3023	0.7369	2.6746
110	36.2209	54.3136	0.7836	2.6851
120	44.2357	63.3477	0.8176	2.6892
130	52.5410	72.3905	0.8421	2.6908
140	61.0555	81.4368	0.8598	2.6914
150	69.7199	90.4843	0.8724	2.6916

Table 3 describes prices and deltas of traditional and indexed options. The base parameters are as follows: The market price of stock is $100 on the date of grant, the firm's stock volatility 20%, index volatility 15%, dividend yields for the stock and index are 2%, the riskless interest rate is 8%, and the correlation between the firm's stock and index is 0.75. The option's maturity is 5 years.

Table 4: Deltas of Options with respect to Current Stock Prices

S_t	traditional	indexed	averaging indexed
50.00	0.2317	0.0127	0.1237
60.00	0.3639	0.0517	0.2394
70.00	0.4873	0.1313	0.3682
80.00	0.5915	0.2462	0.4906
90.00	0.6741	0.3778	0.5953
100.00	0.7369	0.5056	0.6791
110.00	0.7836	0.6161	0.7430
120.00	0.8176	0.7036	0.7902
130.00	0.8421	0.7688	0.8243
140.00	0.8598	0.8150	0.8485
150.00	0.8724	0.8465	0.8655

Table 4 describes the default probability of the investment grade firm with respect to different counterparty risks. We choose the following parameters: The market price of stock is $100 on the date of grant, the firm's stock volatility 20%, index volatility 15%, dividend yields for the stock and index are 2%, the riskless interest rate is 8%, and the correlation between the firm's stock and index is 0.75. The option's maturity is 5 years.

Table 5: Vega of Traditional, Indexed and Averaging Indexed Options

Panel A ($\rho = 0.3$)

	$t = 3$			$t = 8$		
σ_S	traditional	indexed	averaging indexed	traditional	indexed	averaging indexed
0.2	52.4147	98.1614	95.4930	46.1919	43.0522	69.6144
0.4	59.7660	89.2279	87.0583	47.9570	87.9946	86.7927
0.6	52.4147	73.0784	68.5348	46.1919	85.6192	85.9775
0.8	41.6582	55.5710	47.5345	43.2579	72.8584	75.1707

Panel B ($\rho = 0.75$)

	$t = 3$			$t = 8$		
σ_S	traditional	indexed	averaging indexed	traditional	indexed	averaging indexed
0.2	52.4147	99.7745	100.5248	46.1919	162.4067	94.7986
0.4	59.7660	95.2474	91.0030	47.9570	180.8730	116.8979
0.6	52.4147	78.1376	69.1058	46.1919	99.3098	104.9447
0.8	41.6582	58.0448	45.1066	43.2579	42.8776	76.5337

Table 5 describes vegas of traditional, indexed and averaging indexed options. The base parameters are as follows: The market price of stock is \$100 on the date of grant, index volatility 15%, dividend yields for the stock and index are 2%, and riskless interest rate is 8%.

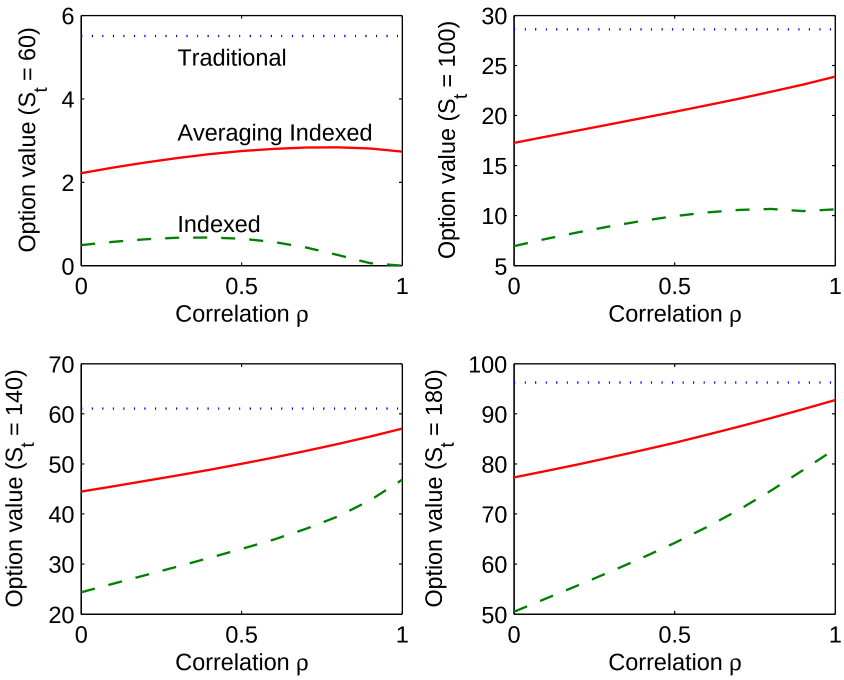

Figure 1: Traditional (dotted line), indexed (dashed line) and averaging indexed (solid line) option values with respect to the correlation between firm and index returns