Is backdating executive stock options always harmful to shareholders?

Philippe Grégoire, R. Glenn Hubbard, Michael F. Koehn
Jimmy Royer, Marc Van Audenrode

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Abstract

Prior to 2005, accounting rules required corporations awarding employee stock options (ESOs) to expense their grant-date intrinsic value. Accordingly, only ESOs granted in the money would have a negative impact on accounting income. Backdating ESO grants in order to award in-the-money ESOs while reporting them as at-the-money would then eliminate an expense. However, whether an ESO has been granted in- or at-the-money, its dilutive impact on earnings per share only depends on its strike price, and diluted earnings per share are always communicated to shareholders. U.S. fiscal rules, on the other hand, treat incentive stock options (ISOs), which cannot be granted in the money, differently from non-qualifying stock options (NQOs). The profits an executive realizes with an ISO are taxed at a more favorable rate than an NQO but are not tax deductible for the firm. As a result, backdating an ESO grant in order to award ISOs instead of NQOs in the same quantity and with the same strike price would have a negative impact on a firm's cash flow while enriching executives. If, however, such substitution is done in a manner that leaves an executive's utility level unchanged, then fewer backdated options are needed to replace non-backdated ones. If, on top of that, we consider the non-transferability of ESOs and assume that the executive is risk averse, then backdating ESOs can reduce the cost to shareholders. It this paper, we show that this is the case when the underlying stock's expected return is equal to the risk-free rate and reasonable conditions are imposed on tax rates. A backdating arrangement that leaves an executive's utility level unchanged becomes costly to shareholders when the spread between the expected stock return and the risk-free rate exceeds a certain threshold, this threshold being positively related to the executive's level of risk aversion and negatively related to his or her non-option wealth.

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1 Introduction

Awarding employee stock options (ESOs) as part of compensation packages has been common practice for a number of years. In the late 1990s, academic studies started noticing the surprisingly good timing of ESO grants. Yermack (1997) showed that ESOs granted by compensation committees with flexible meeting schedules were often followed by positive abnormal returns, and suggested that this be due to compensation committee meetings taking place prior to good news announcements. Aboody and Kasznik (2000) and Chauvin and Shenoy (2001) proposed that the good timing of ESO grants be due to the manipulation of information before and after the grant dates. Lie (2005) offered a much simpler explanation for the too-good-to-be-true returns surrounding ESO grants: Backdating.

Backdating an ESO grant consists in selecting an earlier date with a stock price below the actual price as the grant date in order to effectively award in-the-money ESOs while reporting the award of at-the-money ESOs. This hypothesis is supported by Narayanan and Seyhun (2005a) to explain returns around ESO grants and backdating is positively correlated with CEO influence (Bebchuk *et al.*, 2010). A series of articles in The Wall Street Journal in 2006 unveiled many examples of ESO grants with "unusually propitious dates", all taking place before the implementation of the Sarbanes-Oxley Act (SOX) in 2002[1]. Regulators have been investigating the matter and lawsuits were brought against corporations that were allegedly engaging in backdating, based on the fundamental premise that backdating harmed shareholders[2][3].

From an economic perspective, a key question emerges: Does backdating indeed make shareholders worse off, or are corporations that engage in backdating acting in the best interest of shareholders and managers while avoiding accounting rules that treat ESOs as a corporate ex-

[1]Although the implementation of SOX made backdating less effective, Narayanan and Seyhun (2005b), Collins, Gong and Li (2005) and Heron and Lie (2007) claim that opportunistic behavior is still observed after the passage of SOX. Narayanan and Seyhun (2008) also suggest forward-dating, *i.e.* the selection of a grant date following the compensation committee meeting date, as a potential ESO-enhancing strategy.

[2]Evidence that firms under investigation for options backdating, as well as firms suspected of such practices, have been punished by the markets through lower stock returns seems to confirm that premise (Narayanan, *et al.*, 2007; Bernile and Jarrell, 2009; Carow, *et al.*, 2009) but the observed lower stock returns could be caused by the litigation itself.

[3]These lawsuits largely ignored that, regardless of whether the options had been granted at- or in-the-money, corporations are required to report information sufficient to estimate the potential dilution effect on shareholders of all options granted.

pense[4]? Prior to 2005, a corporation that granted executive options had to expense their intrinsic value, meaning that only in-the-money options would generate a cost[5]. In response, corporations may have issued in-the-money options, but backdated the awards to avoid altering their net income. Thus, regardless of the economic value of in-the-money versus at-the-money options, corporations may have chosen not to issue and report in-the-money options if doing so may have created an illusion that their earnings were below those of identical firms that issued at-the-money options. This would only be an illusion since, abstracting from taxes, the dilutive impact of ESOs only depends on their strike price, regardless of whether they have been granted at- or in-the-money. Moreover, shareholders are aware of this potential dilution since corporations are required to communicate diluted earnings per share.

U.S. tax rules, on the other hand, are such that awarding an ESO in- or at-the-money can have an impact on cash flow. ESOs can be classified as incentive stock options (ISOs) or non-qualifying stock options (NQOs). To qualify as an ISO under the Internal Revenue Code (IRC) Section 422, an option contract must specify performance goals to be attained and, most importantly, such option cannot be awarded in-the-money. An ISO cannot be expensed by the firm for tax purposes and thus does not provide any tax shield to the firm. The proceeds from the exercise of an ISO by an executive are taxed at the capital gains rate when the shares obtained through exercise are disposed of, conditional on the exercise taking place at least a year after the grant date and the share disposition taking place at least a year after the exercise date. In contrast, the proceeds from the exercise of an NQO are taxed as income in the hands of the executive and can be expensed for tax purposes by the firm, all on exercise date. The fiscal advantage from the firm's viewpoint of NQOs over ISOs is nevertheless limited. IRC Section 162(m) prevents a firm from claiming a tax deduction following the exercise of an NQO when the latter generates an income above $1,000,000 for the CEO or one of the four other highest-paid executives in the firm.

A backdating arrangement consists in awarding in-the-money options instead of at-the-money options or instead of in-the-money options with the same strike price but a different tax treatment. Seven scenarios must be considered: (1) In-the-money options are granted instead of at-the-money options with the same tax treatment, (2) "in-the-money" ISOs are granted instead of at-the-money

[4]See Calomiris (2005) and Hagopian (2006) for a full discussion regarding the problems related to treating ESOs as a corporate expense.

[5]Since 2006, all ESO awards have to be expensed at fair value.

NQOs under the \$1,000,000 limit, (3) “in-the-money” ISOs are granted instead of at-the-money NQOs over the \$1,000,000 limit, (4) in-the-money NQOs under the \$1,000,000 limit are granted instead of at-the-money ISOs, (5) in-the-money NQOs over the \$1,000,000 limit are granted instead of at-the-money ISOs, (6) “in-the-money” ISOs are granted instead of in-the-money NQOs under the \$1,000,000 limit with the same strike price and (7) “in-the-money” ISOs are granted instead of in-the-money NQOs over the \$1,000,000 limit with the same strike price.

In this paper, we show, using a binomial model, that a backdating arrangement can be Pareto-improving, simultaneously benefiting both shareholders and managers. Taking into account the non-transferability of ESOs (which implies that they must be exercised to realize their value) and the risk aversion of the recipient[6], a backdating arrangement as in scenario (1) above can always be Pareto-improving when the underlying stock return is equal to the risk-free rate. For scenarios (3) and (7), a backdating arrangement can always be Pareto-improving when the underlying stock return is equal to the risk-free rate and the capital gains tax rate is smaller than the income tax rate. A backdating arrangement as in (5) cannot be Pareto-improving when the capital gains tax rate is smaller than the income tax rate and tax conditions have to be imposed for scenarios (2), (4), and (6) to be Pareto-improving.

As Lambert, Larcker, and Verrecchia (1991) show, the value of an ESO from the point of view of a risk-averse manager is not the same as the option cost to the shareholders of the firm granting it. As a result, changing the strike price of an ESO will not have the same impact on its value from the manager's viewpoint as it does on its value from the shareholders' viewpoint. If increasing the moneyness of an ESO has a greater impact on the manager's valuation than on the shareholders' valuation, one can replace at-the-money options with fewer in-the-money options in a way that increases the manager's utility (or at least leaves it unchanged) while at the same time enhancing shareholders' value. If this is the case, then backdating ESOs in the sense of awarding in-the-money rather than at-the-money options does not necessarily harm shareholders. The same reasoning applies when in-the-money ESOs taxed at a more favorable tax rate in the hands of the manager are granted instead of in-the-money ESOs with a less favorable tax rate and when there are no tax consequences for the firm. However, if the difference between the expected return on

[6]The assumption of risk aversion precludes their valuation in a risk-neutral framework (Kulatilaka and Marcus, 1994; Huddart, 1994; Rubinstein, 1995).

the company's stock and the risk-free rate exceeds a certain threshold, then backdating is costly to shareholders so long as it does not make the manager worse off. This threshold is negatively related to the manager's tolerance for risk and to his or her non-option wealth.

The paper is structured as follows: The next section explains the model, Section 3 discusses accounting and tax rules that apply to ESOs, Section 4 analyzes backdating, Section 5 discusses the option Greeks and Section 6 concludes.

2 Model

Time is represented by $t = 1, \ldots, T$ and is measured in years. Consider a call option with time to maturity T and a strike price K on a stock with a current price of S_0, a dividend yield δ and a return volatility σ. The risk-free rate is r. The option is granted to a manager with non-option wealth w_0 and strictly increasing, strictly concave and continuous utility function over wealth $U(\cdot)$. The option is non-transferable. The manager can monetize its value only by exercising it and this decision is based on the expected utility of exercising versus keeping the option. Over the life of the option, the manager's non-option wealth grows at the risk-free rate r. The proceeds from exercising the option before maturity also grow at the risk-free rate following the exercise.

We calculate option values using a binomial tree with time steps represented by $\Delta t \leq 1$. A node in the binomial tree is represented by (i, j), where i is the number of up movements to node (i, j) and j represents time. The number of down movements to node (i, j) is then given by $j/\Delta t - i$. $S_{i,j}$ represents the stock price at node (i, j) and, from each node, the stock price may go up by a factor $u = e^{\sigma\sqrt{\Delta t}}$ or down by a factor $d = e^{-\sigma\sqrt{\Delta t}}$, yielding the risk-neutral probability of an up movement $p_{rn} = \frac{e^{(r-\delta)\Delta t} - d}{u-d}$. If we represent the expected return in the stock price by μ such that $p_s S_0 u + (1 - p_s) S_0 d = S_0 e^{(\mu-\delta)\Delta t}$, where p_s denotes the actual (or subjective) probability of an up movement in the stock price, then $p_s = \frac{e^{(\mu-\delta)\Delta t} - d}{u-d}$. Hence $p_s \leq 1$ implies that $\mu \leq \sigma/\sqrt{\Delta t} + \delta$.

2.1 Manager's decision to exercise an option

If, at node (i, T), the option has not yet been exercised by the manager, then it will be exercised if it is in-the-money, providing the manager with utility $U(w_0 e^{rT} + \max\{(1 - \tau_m)(S_{i,T} - K), 0\})$, where τ_m corresponds to the manager's tax rate. If, at node (i,$T - \Delta t$), the option has not yet been exercised, then it will be exercised if exercising provides the manager with greater utility than keeping the option. To compute expected utility, we must use the subjective probability of an upward movement represented by $p_s = \frac{e^{(\mu-\delta)\Delta t} - d}{u-d}$. The manager's decision at node $(i, T - \Delta t)$, given a stock price $S_{i,T-\Delta t}$ will be to exercise if $U(w_0 e^{rT} + (1-\tau_m)(S_{i,T-\Delta t} - K)e^{r\Delta t}) > p_s U(w_0 e^{rT} + \max\{(1-\tau_m)(S_{i+1,T} - K), 0\}) + (1-p_s)U(w_0 e^{rT} + \max\{(1-\tau_m)(S_{i,T} - K), 0\})$ and not to exercise otherwise[7][8]. Let $U^*_{i,T-\Delta t}$ denote the manager's expected time-T utility given the utility-maximizing decision at node $(i, T - \Delta t)$. At node $(i, T - 2\Delta t)$, the manager exercises if $U(w_0 e^{rT} + (1-\tau_m)(S_{i,T-2\Delta t} - K)e^{r(2\Delta t)}) > p_s U^*_{i+1,T-\Delta t} + (1-p_s)U^*_{i,T-\Delta t}$ and keeps the option otherwise. Proceeding in this manner until we reach time 0, the manager's decision at any node (i, j), $j < T$, is to exercise if $U(w_0 e^{rT} + (1-\tau_m)(S_{i,j} - K)e^{r(T-j)}) > p_s U^*_{i+1,j+\Delta t} + (1-p_s)U^*_{i,j+\Delta t}$, and to keep the option, otherwise.

2.2 Option cost to shareholders

The option is granted to the manager by a firm owned by shareholders who bear the cost of the ESO at the time of exercise through a reduction in their ownership of the firm determined by the difference between the stock price at the time of exercise and the option's strike price. The cost of the option to the firm at node (i, j) corresponds to its expected intrinsic value, given the manager's decision to exercise at subsequent nodes, discounted at the risk-free rate. At node $(i, T - \Delta t)$, the option cost to shareholders is $C^e_{i,T-\Delta t} = (1-\tau_c)(S_{i,T-\Delta t} - K)$ if exercised at that node, and $C^e_{i,T-\Delta t} = e^{-r\Delta t}\left(p_{rn}(1-\tau_c)\max\{S_{i+1,T} - K, 0\} + (1-p_{rn})(1-\tau_c)\max\{S_{i,T} - K, 0\}\right)$ if retained by the manager, where τ_c represents the firm's corporate tax rate that can be used to claim a tax deduction following the exercise of the option. Letting $V^*_{i,T-\Delta t}$ denote the option cost at node $(i, T - \Delta t)$ given the manager's decision, the option cost at node $(i, T - 2\Delta t)$ is given by $C^e_{i,T-2\Delta t} = (1-\tau_c)(S_{i,T-2\Delta t} - K)$ if exercised and $C^e_{i,T-2\Delta t} = e^{-r\Delta t}\left(p_{rn}V^*_{i+1,T-\Delta t} + (1-p_{rn})V^*_{i,T-\Delta t}\right)$, otherwise. We obtain the option value by processing as just described until time $j = 0$ is reached.

[7] We will assume that the manager exercises only if his or her time-T utility of doing so is strictly greater than her expected utility of keeping the option.

[8] It may be useful to point out that $S_{i+1,T} = uS_{i,T-\Delta t}$ and $S_{i,T} = dS_{i,T-\Delta t}$.

2.3 Value of the option from the manager's viewpoint

As in Lambert *et al.* (1991), the value of an option from the manager's viewpoint is given by the smallest sum of money the manager would accept in exchange of the option, which we refer to as the option's certainty equivalent. At node (i,j), the certainty equivalent, denoted $m_{i,j}$, is such that:

$$\text{Node } (i,j){:}\quad U\left(w_0 e^{rT} + m_{i,j} e^{r(T-j)}\right) \;=\; U^*_{i,j},$$

which gives $m_{i,j} = \left(U^{-1}(U^*_{i,j}) - w_0 e^{rT}\right) e^{-r(T-j)}$, where U^{-1} is the reciprocal of the manager's utility function.

2.4 Example

Figure 1 provides an example of the value of a typical American call option, denoted C, an executive call option from shareholders' and the manager's viewpoints, denoted C^e and m, respectively. The option has a strike price $K = 40$ and a time to maturity $T = 3$. The stock price at time 0 is $S_0 = 40$ with $\mu = 5\%$, $\delta = 2\%$ and $\sigma = 30\%$. The risk-free rate is $r = 5\%$ and the time step is $\Delta t = 1$. The manager has an initial non-option wealth is $w_0 = 100$ and a utility function $U(w) = w^{1-\gamma}/(1-\gamma)$, with $\gamma = 2$. Tax rates have been set to zero in this example. The combination of the non-transferability of the option and the risk aversion of the manager induces the latter to exercise at node (2,2), thus reducing the option's cost to the firm compared to a typical American call option. In a risk-neutral setting, the value of the option (conditional on the risk neutral probability of an upward movement being $p_{rn} = (e^{.05-.02} - e^{-.3})/(e^{.3} - e^{-.3}) = .4756$) is:

$$C \;=\; 58.38 \times .4756^3 e^{-3(.05)} \;+\; 3 \times 13.99 \times .4756^2 (1 - .4756) e^{-3(.05)} \;=\; \$9.69.$$

From shareholders' viewpoint, the value of the ESO is given by

$$C^e \;=\; 32.88 \times .4756^2 e^{-2(.05)} \;+\; 2 \times 13.99 \times .4756^2 (1 - .4756) e^{-3(.05)} \;=\; \$9.59.$$

As of time 0, the manager's expected time-T utility (conditional on the subjective probability of an upward movement being $p_s = (e^{.05-.02} - e^{-.3})/(e^{.3} - e^{-.3}) = .4756$) is given by

$$\begin{aligned} U^* \;&=\; -.4756^2 \left(32.88 e^{.05} + 100 e^{3(.05)}\right)^{-1} \;-\; 2 \times 4756^2 (1 - .4756) \left(13.99 + 100 e^{3(.05)}\right)^{-1} \\ &\quad -\; \left(3 \times 4756 (1 - .4756)^2 + (1 - .4756)^3\right) \left(100 e^{3(.05)}\right)^{-1} \\ &=\; -0.00794, \end{aligned}$$

yielding a certainty equivalent $m = e^{-3(.05)}\left(.00794^{-1} - 100e^{3(.05)}\right) = 8.39$ for the ESO. In general, the value of a typical American call option corresponds to the upper limit of the cost of an ESO from the firm's viewpoint. The option's certainty equivalent, on the other hand, will be smaller than the firm's cost as long as μ is not too large. If μ exceeds a certain level, then the certainty equivalent is greater than the option's cost to the firm.

3 ESOs, accounting rules and fiscal rules

Prior to 2005, accounting rules required that the intrinsic value of an ESO on its grant date be subtracted as an expense on the income statement. A firm awarding at-the-money ESOs would then avoid an accounting expense and this may explain why most ESOs have historically been granted at-the-money. From a shareholder's perspective, however, an ESO is a non-cash expense when granted, having an impact on cash flow to shareholders, through dilution of the firm's assets, only when exercised. At the time an ESO is exercised, dilution of ownership depends on the option strike price only, regardless of whether the option has been issued in-, at- or out-of-the-money. Moreover, diluted earnings per share, calculated using in-the-money ESOs that have not yet been exercised, are always communicated to the public and thus shareholders are always aware of the dilutive impact of the ESOs held by the company's executives. Therefore, given an option's strike price, shareholders focusing on cash flow should not pay attention to whether the option has been granted in- or at-the-money.

Fiscal rules, on the other hand, may create some distortions with regards to employee stock option awards. An option that qualifies as an incentive stock option (ISO) under the Internal Revenue Code (IRC), Section 422, is not subject to the same tax treatment as a non-qualifying option (NQO). To qualify as an ISO, specific performance goals have to be attached to the option and, most importantly, such an option cannot be granted in-the-money.

When an NQO is exercised, tax rules consider the intrinsic value of the option as an income for the manager exercising it and as an expense for the firm. The manager is then taxed at his or her personal income tax rate on the exercise-date intrinsic value of the option while the firm benefits from a tax shield against the corporate tax rate based on the same amount. If, however, the manager is the CEO or one of the four other highest-paid executives of the firm and exercising the

ESO generates an annual income above $1,000,000 for the manager, then the exercise-date intrinsic value of the ESO cannot be claimed as an expense by the firm for tax purposes (IRC Section 162 (m)).

When an ISO is exercised, there are no immediate tax consequences for the manager nor the firm. Rather, the entire difference between the disposition-date stock price and the ESO strike price is treated as capital gain for the manager, where the disposition date refers to the date when a share obtained through exercise of an ESO is sold. For this rule to apply, the option has to be exercised at least one year after its grant date and the shares obtained through exercise have to be held at least a year as well, otherwise the disposition is said to disqualify the ISO. An ISO cannot be claimed as an expense by a firm for tax purposes.

4 Backdating

Backdating executive stock options consists in retroactively selecting a grant date with a low stock price in order to grant in-the-money options but report the award of at-the-money options, an apparently widespread practice in the late 1990s (Lie, 2005; Narayanan and Seyhun, 2005; Bebchuk, *et al.*, 2010). This opportunistic behavior seems to have persisted after the passage of SOX (Narayanan and Seyhun, 2005b; Collins, Gong and Li, 2005; Heron and Lie, 2007) even though the new reporting rules imposed by SOX significantly altered backdating possibilities[9]. Empirical evidence confirms that firms under investigation for option backdating, as well as firms suspected of such practices, have experienced lower stock returns (Narayanan, *et al.*, 2007; Bernile and Jarrell, 2009; Carow, *et al.*, 2009), but these lower returns could be a reaction to these litigations rather than an anticipation of lower future cash flows.

Walker (2007) and Fleischer (2007) argue that the objective of backdating is to compensate a manager with in-the-money options carrying the same tax advantages for the manager as ISOs, which cannot be granted in the money. When doing so, however, the firm loses the tax shield provided by NQOs but this tax shield may be out of reach anyway if the manager's compensation exceeds a certain limit ($1,000,000 under IRC Section 162 (m))[10]. But even if the NQO limit

[9]Prior to SOX, firms had to report ESO grants at the latest 45 days after the fiscal year-end when the grants took place. Since SOX, ESO grants have to be reported at most two days after they take place.

[10]Backdating also has an impact on the time to maturity of an option as the latter sees its life being reduced by the difference between the true grant date and the back date. As backdating prior to the Sarbanes-Oxley act involved

has been reached, why grant "in-the-money" ISOs instead of in-the-money NQOs or at-the-money ISOs? One can also ask whether granting in-the-money ISOs instead of at-the-money NQOs could make any sense for a firm. This section provides some answers to these questions.

When backdating a stock option grant, two scenarios are possible:

1. In-the-money options are awarded (and reported as being awarded at-the-money at an earlier date) instead of at-the-money options using today's stock price as the exercise price. Both options are either NQOs or ISOs.

2. In-the-money ISOs are awarded (and reported as being awarded at-the-money at an earlier date) instead of in-the-money NQOs with the same strike price as the ISOs.

4.1 In-the-money options are awarded instead of at-the-money options

To take into account the possibility that in-the-money options be taxed differently than at-the-money options, let τ_m^a and τ_c^a denote the tax rates (for the manager and the firm, respectively) associated with at-the-money options and let τ_m^i and τ_c^i denote the tax rates (for the manager and the firm, respectively) associated with in-the-money options. We are aware that ISOs only trigger a tax liability once the shares obtained through exercise are disposed of. To simplify the analysis, however, we assume that all taxes are paid when options are exercised.

Consider a manager being granted an at-the-money option with certainty equivalent m_0^a and a time-T expected utility of $U\left((w_0 + m_0^a)e^{r\times T}\right)$. If offered to replace the at-the-money option with n in-the-money options with certainty equivalent m_0^i, the manager will accept if

$$U\left((w_0 + nm_0^i)e^{r\times T}\right) \;\geq\; U\left((w_0 + m_0^a)e^{r\times T}\right), \tag{1}$$

i.e., if $n \geq \frac{m_0^a}{m_0^i}$. Let $C_0^{e,a}$ and $C_0^{e,i}$ denote the cost to shareholders of granting the at-the-money option and the in-the-money option, respectively. For shareholders to agree to grant n in-the-money options instead of one at-the-money option, it is necessary that

$$nC_0^{e,i} \;\leq\; C_0^{e,a}. \tag{2}$$

picking a date within at most a year of the true grant date and since executive stock options usually come with a maturity of ten years, the maturity reduction caused by backdating is likely to have had a small impact on the option values and, as such, we do not consider this aspect of the problem in the present paper.

To benefit both the manager and shareholders, the quantity n of in-the-money options to be granted instead of one at-the-money option must be such that

$$\frac{m_0^a}{m_0^i} \;\leq\; n \;\leq\; \frac{C_0^{e,a}}{C_0^{e,i}}. \tag{3}$$

If condition (3) is not satisfied, then backdating cannot benefit both parties, meaning that if it benefits the manager, then shareholders are made worse off and vice versa. We prove the following proposition in the appendix.

Proposition 1 *If $(1-\tau_m^a)(1-\tau_c^i) \leq (1-\tau_c^a)(1-\tau_m^i)$, then granting in-the-money options rather than at-the-money options can always simultaneously benefit shareholders and the manager when the latter is risk-averse and the expected return on the underlying stock is equal to the risk-free rate ($\mu = r$).*

Proposition 1 states that awarding in-the-money options rather than at-the-money options can always be done in a manner that benefits both shareholders and the manager when $\mu = r$, regardless of the strike price of the in-the-money options. This result is intuitive as it corresponds to a shift in risk from a risk-averse manager to risk-neutral shareholders. A sufficient (but not necessary) condition for this result to hold is

$$(1-\tau_m^a)(1-\tau_c^i) \;\leq\; (1-\tau_c^a)(1-\tau_m^i). \tag{4}$$

Table 1 shows all possible cases of option classifications for tax purposes when backdating involves granting in-the-money options rather than at-the-money options. In this table, τ_c denotes the corporate tax rate, τ_m represents the manager's personal income tax rate and τ_{cg} denotes the capital gains tax rate. When both options have the same tax treatment, then it is always possible to grant fewer in-the-money options instead of at-the-money options in a way that improves welfare when $\mu = r$. This is also true when the in-the-money options are ISOs and the at-the-money options are NQOs above the $1,000,000 limit as long as the capital gains tax rate is smaller than the personal income tax rate, which is generally the case.

If, however, the in-the-money options are ISOs and the at-the-money options are NQOs under the $1,000,000 limit, then condition (4) holds only if the personal income tax rate is sufficiently large, as shown in Table 1. For example, with a capital gains tax rate $\tau_{cg} = 15\%$ and a corporate tax rate $\tau_c = 35\%$, condition (4) holds in this case when the personal income tax rate exceeds 44.75%.

Always referring to Table 1, if the in-the-money options are NQOs under the \$1,000,000 limit and the at-the-money options are ISOs, then condition (4) holds only if the personal income tax rate is sufficiently small, i.e. below 44.75% when the capital gains tax rate is $\tau_{cg} = 15\%$ and the corporate tax rate is $\tau_c = 35\%$. Replacing at-the-money ISOs with NQOs above the \$1,000,000 limit does not provide any benefit to either party unless $\tau_{cg} \geq \tau_m$, which is usually not the case.

ITM option (backdated)	**ATM option**	$\boldsymbol{\tau_c^i}$	$\boldsymbol{\tau_c^a}$	$\boldsymbol{\tau_m^i}$	$\boldsymbol{\tau_m^a}$	**Condition** (4)
NQO	NQO	τ_c	τ_c	τ_m	τ_m	Holds
ISO	ISO	0	0	τ_{cg}	τ_{cg}	Holds
ISO	NQO under limit	0	τ_c	τ_{cg}	τ_m	Holds if $\tau_m \geq \tau_{cg} + (1-\tau_{cg})\tau_c$
ISO	NQO over limit	0	0	τ_{cg}	τ_m	Holds if $\tau_{cg} \leq \tau_m$
NQO under limit	ISO	τ_c	0	τ_m	τ_{cg}	Holds if $\tau_m \leq \tau_{cg} + (1-\tau_{cg})\tau_c$
NQO over limit	ISO	0	0	τ_m	τ_{cg}	Holds if $\tau_{cg} \geq \tau_m$

Table 1: Satisfaction of condition (4) depending on option classifications for tax purposes when the backdated option is in-the-money (ITM) and the non-backdated option is at-the-money (ATM). ISO stands for incentive stock option and NQO stands for non-qualifying stock option. NQO over limit means the option cannot be deducted by the firm for tax purposes whereas an NQO under limit can be deducted for tax purposes. τ_c corresponds to the corporate tax rate, τ_m corresponds to the manager's personal income tax rate and τ_{cg} corresponds to the capital gains tax rate.

Proposition 2 *Suppose a backdating arrangement involves granting in-the-money options instead of at-the-money options. If $(1-\tau_m^a)(1-\tau_c^i)$ is not too small compared to $(1-\tau_c^a)(1-\tau_m^i)$, then the likelihood that a backdating arrangement benefits both shareholders and the manager vanishes when μ is sufficiently larger than r.*

This proposition states that if $(1-\tau_m^a)(1-\tau_c^i)$ is not too small, then there exists a $\mu^* > r$ such that $\frac{m_0^a}{m_0^i} \geq \frac{C_0^{e,a}}{C_0^{e,i}}$ for all $\mu \geq \mu^*$ and $\frac{m_0^a}{m_0^i} < \frac{C_0^{e,a}}{C_0^{e,i}}$ for all $\mu < \mu^*$. That is, awarding in-the-money options instead of at-the-money options cannot benefit both shareholders and the manager when the expected return on the underlying stock is sufficiently large relative to the risk-free rate. This result arises because increasing μ increases the certainty equivalent. Increasing μ also increases the option cost to shareholders but at a lower rate than the certainty equivalent, the consequence being that the certainty equivalent eventually becomes less sensitive to a reduction in the strike price than the option cost to shareholders when μ is sufficiently large.

The following proposition, which is proved in appendix, states that the more risk-neutral the manager's behavior, which can arise from either a higher initial non-option wealth w_0 or a smaller γ when $U(x) = \frac{x^{1-\gamma}}{1-\gamma}$, the smaller the range of expected stock returns $[r, \mu^*)$ such that backdating executive stock options can benefit both shareholders and the manager. This result is sensitive to tax rates and can be shown to hold when $\tau_c^a = \tau_c^i$ and $\tau_m^a = \tau_m^i$.

Proposition 3 *Suppose a backdating arrangement involves granting in-the-money options instead of at-the-money options. Given the assumptions on the function U, then, when $\tau_c^a = \tau_c^i$ and $\tau_m^a = \tau_m^i$ (same tax treatment for both options),*

1. *μ^* is negatively related to w_0–that is, the larger the manager's initial non-option wealth w_0, the smaller μ^*;*
2. *if $U(x) = \frac{x^{1-\gamma}}{1-\gamma}$, then μ^* is positively related to γ, i.e., the greater the coefficient of relative risk aversion γ, the greater μ^*,*

where μ^* is as defined in Proposition 2.

Figure 2 shows whether the relation in (3) is satisfied for different values of the risk aversion coefficient γ, assuming a utility function $U(x) = \frac{x^{1-\gamma}}{1-\gamma}$ for the manager, and different values of the manager's initial non-option wealth w_0. In each case the stock price is $S_0 = 40$ and the in-the-money option has an exercise price $K = 36$. The option has a ten-year maturity, a three-year vesting period and option values are computed with binomial trees with 1-month time steps. Other parameters are $r = 5\%$, $\sigma = 30\%$ and tax rates are all equal to zero. On these graphs, both the manager and shareholders can benefit from backdating (granting the in-the-money rather than the at-the-money option) when the line, which depicts $\frac{C_0^{e,a}}{C_0^{e,i}} - \frac{m_0^a}{m_0^i}$, is above zero. The figure shows that the greater the expected stock return relative to the risk-free rate, the less likely backdating can be beneficial to both shareholders and the manager. The upper graph of Figure 2 shows that the less risk averse is the manager, the less likely backdating can benefit both parties. The lower graph of Figure 2 shows that a rising initial non-option wealth w_0 reduces the likelihood that backdating benefit both shareholders and the manager.

4.2 Backdated ISOs instead of in-the-money NQOs with the same strike price

Backdating could also be used to replace in-the-money NQOs by ISOs with the same strike price but reported as being granted at-the-money, thus entailing a favorable tax rate for the manager. The following proposition is proved in appendix.

Proposition 4 *If backdating involves granting "in-the-money" ISOs instead of at-the-money NQOs with the same strike price, then there always exists a welfare-improving arrangement when $\mu = r$, when $\tau_{cg} \leq \tau_m$, and when the firm cannot deduct the NQOs as an expense for tax purposes. If the firm can deduct the NQOs as an expense for tax purposes, then a welfare-improving backdating arrangement exists if the corporate tax rate is sufficiently small.*

If backdating involves granting in-the-money ISOs, reported as at-the-money, instead of in-the-money NQOs with the same strike price, then a backdating arrangement can benefit both shareholders and the manager if the corporate tax rate that applies on the NQOs is equal to zero, i.e. when the NQOs exceed the $1,000,000 limit in compensation to the manager, as long as the capital gains tax rate is smaller than the manager's personal income tax rate. Otherwise, a backdating arrangement that benefits both shareholders and the manager may not exist if the corporate tax rate is too large.

5 Greeks

Option greeks for in-the-money options may not align manager's interests with those of the firm as strongly as at-the-money options do, especially when we consider Vega, the sensitivity of the option value from the manager's viewpoint relative to stock return volatility. As demonstrated in Lambert et al. (1991), an increase in the stock return volatility may reduce the value of the certainty equivalent of an ESO when the manager is highly risk averse and when the option is deeply in-the-money, which translates into a negative Vega from the manager's viewpoint. As can be seen in Table 2, Vega from the manager's viewpoint is negative when the utility function is $U(x) = \frac{x^{1-\gamma}}{1-\gamma}$ with $\gamma = 4$ and when the option is deep in the money (a strike price of 20 when $S_0 = 40$).

Similarly, Vega can be negative when the manager's non-option wealth is small compared to the value of the ESOs. As can be seen in Table 3, Vega rapidly becomes negative when $w_0 = 10$ instead of $w_0 = 100$ given the parameters chosen for the exercise. Note, however, that the parameters used in Table 3 give a value of around 10 for one option, meaning that the manager's option wealth would then represent half of his or her wealth.

6 Conclusion

We show in this paper that the non-transferability of employee stock options (ESOs), combined with the risk aversion of the managers receiving them, may generate situations in which issuing in-the-money ESOs can simultaneously benefit the firm (through lower dilution to shareholders), and the manager (through higher utility). We show that the more risk-averse the manager, the more likely that doing so can benefit both parties. We also show that reducing the manager's non-option wealth has a similar effect to increasing risk aversion, thus increasing the likelihood that backdating, when it consists of awarding in-the-money options rather than at-the-money options, benefits both the manager and shareholders.

A Proof of Proposition 1

Consider two call options on a firm's stock with the same time to maturity, T. One option is at-the-money, its characteristics being identified with the superscript a, and the other is in-the-money, its characteristics being identified with the superscript i. Let $N^a = \left\{n_1^a, n_2^a, \ldots, n_g^a\right\}$ denote the exercise frontier of the at-the-money option–that is, the set of exercise nodes that can be reached through a sequence of non-exercise nodes. Let $\left\{S_1^a, S_2^a, \ldots, S_g^a\right\}$ denote the stock price at each node in N^a, and let $\left\{T_1^a, T_2^a, \ldots, T_g^a\right\}$ be the time left until the expiration of the option at each node in N^a. Let $\left\{\pi_1^{s,a}, \pi_2^{s,a}, \ldots, \pi_g^{s,a}\right\}$ represent the subjective probability of reaching each node in N^a through sequences of non-exercise nodes only, and let $\left\{\pi_1^a, \pi_2^a, \ldots, \pi_g^a\right\}$ represent the risk-neutral probability of reaching each node in N^a through sequences of non-exercise nodes only. Let $N^i = \left\{n_1^i, n_2^i, \ldots, n_h^i\right\}$, $\left\{S_1^i, S_2^i, \ldots, S_h^i\right\}$, $\left\{T_1^i, T_2^i, \ldots, T_h^i\right\}$, $\left\{\pi_1^{s,i}, \pi_2^{s,i}, \ldots, \pi_h^{s,i}\right\}$ and $\left\{\pi_1^i, \pi_2^i, \ldots, \pi_h^i\right\}$ represent similar sets for the in-the-money option. Note that $h \geq g$–that is, the in-the-money option is exercised at least as often as the at-the-money option. The certainty-equivalent value and cost to shareholders of each option are then given by

$$
\begin{aligned}
m_0^a &= e^{-rT}U^{-1}\left(\sum_{j=1}^{g}\pi_j^{s,a}U\left((1-\tau_m^a)(S_j^a-S_0)e^{rT_j^a}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{g}\pi_j^{s,a}\right)U\left(w_0e^{rT}\right)\right)-w_0\\
m_0^i &= e^{-rT}U^{-1}\left(\sum_{j=1}^{h}\pi_j^{s,i}U\left((1-\tau_m^i)(S_j^i-K)e^{rT_j^i}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{h}\pi_j^{s,i}\right)U\left(w_0e^{rT}\right)\right)-w_0\\
C_0^{e,a} &= e^{-rT}\sum_{j=1}^{g}\pi_j^a(1-\tau_c^a)(S_j^a-S_0)e^{rT_j^a}\\
C_0^{e,i} &= e^{-rT}\sum_{j=1}^{h}\pi_j^i(1-\tau_c^i)(S_j^i-K)e^{rT_j^i},
\end{aligned}
$$

where $0 \leq K < S_0$ and where U is a continuous, strictly increasing and strictly concave function. If an option is an ISO (backdated in the case of the in-the-money option), then τ_m corresponds to the capital gains tax rate and $\tau_c = 0$. If an option is an NQO, then τ_m corresponds to the manager's ordinary income tax rate, and τ_c corresponds to the corporate tax rate if the manager's compensation does not exceed a pre-determined limit (currently \$1 million per year for some executives) and $\tau_c = 0$ if the limit has been reached.

If $\mu = r$, then $\pi_j^{s,a} = \pi_j^a$, and $\pi_j^{s,i} = \pi_j^i$ for all j, and granting in-the-money options instead of at-the-money options can benefit both the firm and shareholders if:

$$
\begin{aligned}
\frac{m_0^a}{m_0^i} &= \frac{U^{-1}\left(\sum_{j=1}^{g}\pi_j^aU\left((1-\tau_m^a)(S_j^a-S_0)e^{rT_j^a}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{g}\pi_j^a\right)U\left(w_0e^{rT}\right)\right)-w_0e^{rT}}{U^{-1}\left(\sum_{j=1}^{h}\pi_j^iU\left((1-\tau_m^i)(S_j^i-K)e^{rT_j^i}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{h}\pi_j^i\right)U\left(w_0e^{rT}\right)\right)-w_0e^{rT}}\\
&< \frac{\sum_{j=1}^{g}\pi_j^a(1-\tau_c^a)(S_j^a-S_0)e^{rT_j^a}}{\sum_{j=1}^{h}\pi_j^i(1-\tau_c^i)(S_j^i-K)e^{rT_j^i}} = \frac{C_0^{e,a}}{C_0^{e,i}}.
\end{aligned}
\tag{5}
$$

To determine whether condition (5) is satisfied, we will separate the analysis in two:

(i) *Same tax rates for both options ($\tau_c^a = \tau_c^i = \tau_c$ and $\tau_m^a = \tau_m^i = \tau_m$)*
In this case, condition (5) is satisfied if

$$
\begin{aligned}
A &= \frac{U^{-1}\left(\sum_{j=1}^{g}\pi_j^aU\left((1-\tau_m)(S_j^a-S_0)e^{rT_j^a}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{g}\pi_j^a\right)U\left(w_0e^{rT}\right)\right)-w_0e^{rT}}{\sum_{j=1}^{g}\pi_j^a(S_j^a-S_0)e^{rT_j^a}}\\
&< \frac{U^{-1}\left(\sum_{j=1}^{h}\pi_j^iU\left((1-\tau_m)(S_j^i-K)e^{rT_j^i}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{h}\pi_j^i\right)U\left(w_0e^{rT}\right)\right)-w_0e^{rT}}{\sum_{j=1}^{h}\pi_j^i(S_j^i-K)e^{rT_j^i}} = B.
\end{aligned}
\tag{6}
$$

Due to the strict concavity of U,

$$
U\left(\sum_{j=1}^{g}\pi_j^a(1-\tau_m)(S_j^a-S_0)e^{rT_j^a}+w_0e^{rT}\right) > \sum_{j=1}^{g}\pi_j^aU\left((1-\tau_m)(S_j^a-S_0)e^{rT_j^a}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{g}\pi_j^a\right)U\left(w_0e^{rT}\right)
$$

and thus $A < 1-\tau_m$ for all $\tau_m \in [0,1)$.

(ii) *Different tax rates ($\tau_c^a \neq \tau_c^i$ and $\tau_m^a \neq \tau_m^i$)*

In this case, condition (5) is satisfied if

$$\begin{aligned} A &= \frac{U^{-1}\left(\sum_{j=1}^{g}\pi_j^a U\left((1-\tau_m^a)(S_j^a-S_0)e^{rT_j^a}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{g}\pi_j^a\right)U\left(w_0e^{rT}\right)\right)-w_0e^{rT}}{(1-\tau_c^a)\sum_{j=1}^{g}\pi_j^a(S_j^a-S_0)e^{rT_j^a}} \\ &< \frac{U^{-1}\left(\sum_{j=1}^{h}\pi_j^i U\left((1-\tau_m^i)(S_j^i-K)e^{rT_j^i}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{h}\pi_j^i\right)U\left(w_0e^{rT}\right)\right)-w_0e^{rT}}{(1-\tau_c^i)\sum_{j=1}^{h}\pi_j^i(S_j^i-K)e^{rT_j^i}} = B. \end{aligned} \tag{7}$$

In this case, the strict concavity of U implies that $A(1-\tau_c^a) < 1-\tau_m^a$ and $B(1-\tau_c^i) < 1-\tau_m^i$.

A.1 The in-the-money option is exercised at time 0

If the in-the-money option is exercised at time 0, then $h = 1$, $m_0^i = (1-\tau_m^i)(S_0-K)$ and $C_0^{e,i} = (1-\tau_c^i)(S_0-K)$. The at-the-money option has zero intrinsic value and thus is never exercised at time 0.

A.1.1 Same tax rates for both options ($\tau_c^a = \tau_c^i = \tau_c$ and $\tau_m^a = \tau_m^i = \tau_m$)

If tax rates are the same for both options, then

$$\frac{m_0^a/m_0^i}{C_0^{e,a}/C_0^{e,i}} = \frac{U^{-1}\left(\sum_{j=1}^{g}\pi_j^a U\left((1-\tau_m)(S_j^a-S_0)e^{rT_j^a}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{g}\pi_j^a\right)U\left(w_0e^{rT}\right)\right)-w_0e^{rT}}{(1-\tau_m)\sum_{j=1}^{g}\pi_j^a(S_j^a-S_0)e^{rT_j^a}} < 1$$

due to the strict concavity of U and thus condition (5) holds.

A.1.2 Different tax rates ($\tau_c^a \neq \tau_c^i$ and $\tau_m^a \neq \tau_m^i$)

In this case we have

$$\frac{m_0^a/m_0^i}{C_0^{e,a}/C_0^{e,i}} = \frac{(1-\tau_c^i)U^{-1}\left(\sum_{j=1}^{g}\pi_j^a U\left((1-\tau_m^a)(S_j^a-S_0)e^{rT_j^a}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{g}\pi_j^a\right)U\left(w_0e^{rT}\right)\right)-w_0e^{rT}}{(1-\tau_m^i)(1-\tau_c^a)\sum_{j=1}^{g}\pi_j^a(S_j^a-S_0)e^{rT_j^a}}.$$

Restrictions on the tax rates have to be imposed for this expression to be smaller than 1. A sufficient condition to have $\frac{m_0^a/m_0^i}{C_0^{e,a}/C_0^{e,i}} < 1$ is $(1-\tau_m^i)(1-\tau_c^a) \geq (1-\tau_m^a)(1-\tau_c^i)$. If the in-the-money option is an ISO and the at-the-money option is an NQO, then $\tau_c^i = 0$ and $\tau_m^i < \tau_m^a$, and $(1-\tau_m^i)(1-\tau_c^a) \geq (1-\tau_m^a)(1-\tau_c^i)$ is difficult to obtain with actual tax rates[11]. However, if the at-the-money option is an NQO that cannot be expensed to tax purposes because the compensation limit has been reached, then $\tau_c^a = 0$ and $(1-\tau_m^i)(1-\tau_c^a) = 1-\tau_m^i \geq (1-\tau_m^a)(1-\tau_c^i) = 1-\tau_m^a$ will hold if the capital gains rate is smaller than the ordinary income tax rate, which is usually the case. If, on the other hand, the in-the-money option is an NQO and the at-the-money option is an ISO, then $\tau_c^a = 0$ and $\tau_m^a < \tau_m^i$, and $(1-\tau_m^i)(1-\tau_c^a) \geq (1-\tau_m^a)(1-\tau_c^i)$ is usually satisfied with actual tax rates. However, executive stock options are generally granted with a vesting period and thus are never exercised at time 0.

[11] 40% ordinary income tax rate for the manager, 15% capital gains rate for the manager and 35% corporate tax rate.

A.2 The in-the-money option is not exercised at time 0

If the in-the-money option is not exercised at time 0 and if Δt is sufficiently small, then h will be large enough to perform the following operation: Take the values in $\{S_1^i, S_2^i, \ldots, S_h^i\}$ and reduce each of them to construct a set of h stock prices $\left\{\hat{S}_j\right\}_{j=1}^h$ such that (τ_c^i and τ_m^i most not be too large compared to τ_c^a and τ_m^a, respectively, for these three conditions to be met):

(1) $\hat{S}_j \leq S_j^i$ for $j = 1, \ldots, h$,

(2) $(1-\tau_c^i)\sum_{j=1}^h \pi_j^i(\hat{S}_j - K)e^{rT_j^i} \;=\; (1-\tau_c^a)\sum_{j=1}^g \pi_j^a(S_j^a - S_0)e^{rT_j^a},$

(3) and

$$U^{-1}\left(\sum_{j=1}^h \pi_j^i U\left((1-\tau_m^i)(\hat{S}_j - K)e^{rT_j^i} + w_0e^{rT}\right) + \left(1 - \sum_{j=1}^h \pi_j^i\right) U\left(w_0e^{rT}\right)\right)$$
$$= \; U^{-1}\left(\sum_{j=1}^g \pi_j^a U\left((1-\tau_m^a)(S_j^a - S_0)e^{rT_j^a} + w_0e^{rT}\right) + \left(1 - \sum_{j=1}^g \pi_j^a\right) U\left(w_0e^{rT}\right)\right).$$

That is, the set $\left\{\hat{S}_j\right\}_{j=1}^h$ replaces the prices in $\{S_1^i, S_2^i, \ldots, S_h^i\}$ by prices lower enough to equate the values of the in-the-money option and the at-the-money option from both the manager and shareholders' viewpoints. Note that we need $h \geq 2$ for the set $\left\{\hat{S}_j\right\}_{j=1}^h$ to exist, which requires a sufficiently small Δt.

A.2.1 Same tax rates for both options ($\tau_c^a = \tau_c^i = \tau_c$ and $\tau_m^a = \tau_m^i = \tau_m$)

In this case we have

$$\frac{U^{-1}\left(\sum_{j=1}^h \pi_j^i U\left((1-\tau_m)(\hat{S}_j - K)e^{rT_j^i} + w_0e^{rT}\right) + \left(1 - \sum_{j=1}^h \pi_j^i\right) U\left(w_0e^{rT}\right)\right) - w_0e^{rT}}{\sum_{j=1}^h \pi_j^i(\hat{S}_j - K)e^{rT_j^i}} \;=\; A,$$

which can be rearranged as

$$\sum_{j=1}^h \pi_j^i U\left((1-\tau_m)(\hat{S}_j - K)e^{rT_j^i} + w_0e^{rT}\right) + \left(1 - \sum_{j=1}^h \pi_j^i\right) U\left(w_0e^{rT}\right) \;=\; U\left(A\sum_{j=1}^h \pi_j^i(\hat{S}_j - K)e^{rT_j^i} + w_0e^{rT}\right).$$

If we replace each $\hat{S}_j$ by its corresponding S_j^i in the last equation, we obtain

$$\sum_{j=1}^h \pi_j^i U\left((1-\tau_m)(S_j^i - K)e^{rT_j^i} + w_0e^{rT}\right) + \left(1 - \sum_{j=1}^h \pi_j^i\right) U\left(w_0e^{rT}\right) \;>\; U\left(A\sum_{j=1}^h \pi_j^i(S_j^i - K)e^{rT_j^i} + w_0e^{rT}\right)$$

due to $\hat{S}_j \leq S_j^i$ for all $j = 1, \ldots, h$, due to $A < 1 - \tau_m$ and due to the properties of U. Since B is such that

$$\sum_{j=1}^h \pi_j^i U\left((1-\tau_m)(S_j^i - K)e^{rT_j^i} + w_0e^{rT}\right) + \left(1 - \sum_{j=1}^h \pi_j^i\right) U\left(w_0e^{rT}\right) \;=\; U\left(B\sum_{j=1}^h \pi_j^i(S_j^i - K)e^{rT_j^i} + w_0e^{rT}\right),$$

and because U is strictly increasing, it must be the case that $B > A$, meaning that (6) holds. This completes the proof of Proposition 1 for the case with identical tax rates.

A.2.2 Different tax rates ($\tau_c^a \neq \tau_c^i$ and $\tau_m^a \neq \tau_m^i$)

In this case we have

$$\frac{U^{-1}\left(\sum_{j=1}^{h}\pi_j^i U\left((1-\tau_m^i)(\hat{S}_j-K)e^{rT_j^i}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{h}\pi_j^i\right)U\left(w_0e^{rT}\right)\right)-w_0e^{rT}}{(1-\tau_c^i)\sum_{j=1}^{h}\pi_j^i(\hat{S}_j-K)e^{rT_j^i}} = A,$$

which can be rearranged as

$$\sum_{j=1}^{h}\pi_j^i U\left((1-\tau_m^i)(\hat{S}_j-K)e^{rT_j^i}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{h}\pi_j^i\right)U\left(w_0e^{rT}\right) = U\left(A(1-\tau_c^i)\sum_{j=1}^{h}\pi_j^i(\hat{S}_j-K)e^{rT_j^i}+w_0e^{rT}\right).$$

From (7), we know that $A(1-\tau_c^a) < 1-\tau_m^a$. Therefore, if $\frac{1-\tau_m^a}{1-\tau_c^a}\,(1-\tau_c^i) \leq 1-\tau_m^i$ (which is equivalent to condition (4)), replacing each $\hat{S}_j$ by its corresponding S_j^i in the last equation gives

$$\sum_{j=1}^{h}\pi_j^i U\left((1-\tau_m^i)(S_j^i-K)e^{rT_j^i}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{h}\pi_j^i\right)U\left(w_0e^{rT}\right) > U\left(A(1-\tau_c^i)\sum_{j=1}^{h}\pi_j^i(S_j^i-K)e^{rT_j^i}+w_0e^{rT}\right)$$

due to $\hat{S}_j \leq S_j^i$ for all $j=1,\ldots,h$ and due to the properties of U. Since B is such that

$$\sum_{j=1}^{h}\pi_j^i U\left((1-\tau_m^i)(S_j^i-K)e^{rT_j^i}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{h}\pi_j^i\right)U\left(w_0e^{rT}\right) = U\left(B(1-\tau_c^i)\sum_{j=1}^{h}\pi_j^i(S_j^i-K)e^{rT_j^i}+w_0e^{rT}\right),$$

and because U is strictly increasing, it must be the case that $B > A$, meaning that (7) holds. This completes the proof of Proposition 1 for the case with different tax rates.

B Proof of Proposition 2

Suppose $r < \mu$. Using the same notation as in the proof of Proposition 1, we have $\frac{m_0^a}{m_0^i} \geq \frac{C_0^{e,a}}{C_0^{e,i}}$ if

$$\begin{aligned} A &= \frac{U^{-1}\left(\sum_{j=1}^{g}\pi_j^{s,a}U\left((1-\tau_m^a)(S_j^a-S_0)e^{rT_j^a}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{g}\pi_j^{s,a}\right)U\left(w_0e^{rT}\right)\right)-w_0e^{rT}}{(1-\tau_c^a)\sum_{j=1}^{g}\pi_j^a(S_j^a-S_0)e^{rT_j^a}} \\ &\geq \frac{U^{-1}\left(\sum_{j=1}^{h}\pi_j^{s,i}U\left((1-\tau_m^i)(S_j^i-K)e^{rT_j^i}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{h}\pi_j^{s,i}\right)U\left(w_0e^{rT}\right)\right)-w_0e^{rT}}{(1-\tau_c^i)\sum_{j=1}^{h}\pi_j^i(S_j^i-K)e^{rT_j^i}} = B. \end{aligned} \tag{8}$$

The subjective probability of an upward movement in the stock price is given by $p_s = \frac{e^{(\mu-\delta)\Delta t}-e^{-\sigma\sqrt{\Delta t}}}{e^{\sigma\sqrt{\Delta t}}-e^{-\sigma\sqrt{\Delta t}}}$ whereas the risk-neutral probability of an up movement is $p_{rn} = \frac{e^{(r-\delta)\Delta t}-e^{-\sigma\sqrt{\Delta t}}}{e^{\sigma\sqrt{\Delta t}}-e^{-\sigma\sqrt{\Delta t}}}$. If $\mu > r$, then $p_s > p_{rn}$, meaning that the subjective probabilities of reaching exercise nodes are higher than their risk-neutral counterparts. That is, $\pi_j^{s,a} > \pi_j^a$ and $\pi_j^{s,i} > \pi_j^i$ for all j.

B.1 A exceeds B when μ is large enough

To show that A is larger than B when μ is large enough, consider the limiting case where μ is such that $p_s \to 1$.

If μ is such that $p_s \to 1$, then subjective probabilities foresee a stock price that rises every period, which gives $m_0^i = (1-\tau_m^i)e^{-rT}(u^{T/\Delta t}S_0 - K)$. If exercised at time 0, the in-the-money option's certainty-equivalent value is $(1-\tau_m^i)(S_0-K)$. Therefore, if $u^{T/\Delta t}S_0 - K > e^{rT}(S_0-K)$, the in-the-money option is not exercised at time 0 when $p_s \to 1$. Because $u = e^{\sigma\sqrt{\Delta t}}$, this is the case when $\sigma > r\sqrt{\Delta t}$, a reasonable assumption when Δt is small.

B.1.1 The in-the-money option is exercised at time 0

If $p_s \to 1$ and σ is such that the in-the-money option is exercised at time 0, then $m_0^i = (1-\tau_m^i)(S_0-K)$ and $C_0^{e,i} = (1-\tau_c^i)(S_0-K)$. The at-the-money option has zero intrinsic value and thus is never exercised at time 0. As a consequence:

$$\frac{m_0^a/m_0^i}{C_0^{e,a}/C_0^{e,i}} = \frac{(1-\tau_c^i)U^{-1}\left(\sum_{j=1}^g \pi_j^{s,a} U\left((1-\tau_m^a)(S_j^a - S_0)e^{rT_j^a} + w_0 e^{rT}\right) + \left(1-\sum_{j=1}^g \pi_j^{s,a}\right) U\left(w_0 e^{rT}\right)\right) - w_0 e^{rT}}{(1-\tau_m^i)(1-\tau_c^a)\sum_{j=1}^g \pi_j^a (S_j^a - S_0)e^{rT_j^a}}$$

and

$$\lim_{p_s\to 1} \frac{m_0^a/m_0^i}{C_0^{e,a}/C_0^{e,i}} = \frac{(1-\tau_c^i)(1-\tau_m^a)(u^{T/\Delta t}S_0 - S_0)}{(1-\tau_m^i)(1-\tau_c^a)\sum_{j=1}^g \pi_j^a (S_j^a - S_0)}.$$

Since $\frac{u^{T/\Delta t}S_0 - S_0}{\sum_{j=1}^g \pi_j^a (S_j^a - S_0)} > 1$, restrictions on $\frac{(1-\tau_c^i)(1-\tau_m^a)}{(1-\tau_m^i)(1-\tau_c^a)}$ are needed when tax rates are different to have $\lim_{p_s\to 1} \frac{m_0^a/m_0^i}{C_0^{e,a}/C_0^{e,i}} > 1$ and thus $A > B$.

B.1.2 The in-the-money option is not exercised at time 0

In this case, we have:

$$\lim_{p_s\to 1} A = \frac{U^{-1}\left(U\left((1-\tau_m^a)(u^{T/\Delta t}S_0 - S_0) + w_0 e^{rT}\right)\right) - w_0 e^{rT}}{(1-\tau_c^a)\sum_{j=1}^g \pi_j^a (S_j^a - S_0)e^{rT_j^a}} = \frac{(1-\tau_m^a)(u^{T/\Delta t}S_0 - S_0)}{(1-\tau_c^a)\sum_{j=1}^g \pi_j^a (S_j^a - S_0)},$$

$$\lim_{p_s\to 1} B = \frac{U^{-1}\left(U\left((1-\tau_m^i)(u^{T/\Delta t}S_0 - K) + w_0 e^{rT}\right)\right) - w_0 e^{rT}}{(1-\tau_c^i)\sum_{j=1}^h \pi_j^i (S_j^i - K)e^{rT_j^i}} = \frac{(1-\tau_m^i)(u^{T/\Delta t}S_0 - K)}{(1-\tau_c^i)\sum_{j=1}^h \pi_j^i (S_j^i - K)}$$

and

$$\frac{\lim_{p_s\to 1} A}{\lim_{p_s\to 1} B} = \frac{(1-\tau_c^i)(1-\tau_m^a)(u^{T/\Delta t}S_0 - S_0)/(u^{T/\Delta t}S_0 - K)}{(1-\tau_c^a)(1-\tau_m^i)\sum_{j=1}^g \pi_j^a (S_j^a - S_0)/\sum_{j=1}^h \pi_j^i (S_j^i - K)}.$$

Because in this case the option is exercised at maturity only, $h > g$ and thus:

$$\sum_{j=1}^h \pi_j^i (S_j^i - K) = \sum_{j=1}^g \pi_j^a (S_j^a - K) + \sum_{j=g+1}^h \pi_j^i (S_j^i - K).$$

Consequently,

$$\frac{u^{T/\Delta t}S_0 - S_0}{u^{T/\Delta t}S_0 - K}\left(\frac{\sum_{j=1}^g \pi_j^a (S_j^a - K) + \sum_{j=g+1}^h \pi_j^i (S_j^i - K)}{\sum_{j=1}^g \pi_j^a (S_j^a - S_0)}\right)$$
$$> \frac{u^{T/\Delta t}S_0 - S_0}{u^{T/\Delta t}S_0 - K}\left(\frac{\sum_{j=1}^g \pi_j^a (S_j^a - K)/\sum_{j=1}^g \pi_j^a}{\sum_{j=1}^g \pi_j^a (S_j^a - S_0)/\sum_{j=1}^g \pi_j^a}\right) = \frac{u^{T/\Delta t}S_0 - S_0}{u^{T/\Delta t}S_0 - K}\left(\frac{\overline{S}_j^a - K}{\overline{S}_j^a - S_0}\right) > 1,$$

where $\overline{S}_j^a = \sum_{j=1}^{g} \pi_j^a S_j^a / \sum_{j=1}^{g} \pi_j^a$ gives the risk-neutral weighted average value of stock prices between S_0 and $u^{T/\Delta t} S_0$. The last inequality holds because $\overline{S}_j^a \in \left(S_0, u^{T/\Delta t} S_0\right)$ and $\frac{u^{T/\Delta t} S_0 - S_0}{u^{T/\Delta t} S_0 - K} \left(\frac{x-K}{x-S_0}\right) > 1$ for all $x \in \left(S_0, u^{T/\Delta t} S_0\right)$. Therefore, if $(1-\tau_m^a)(1-\tau_c^i)$ is not too small compared to $(1-\tau_c^a)(1-\tau_m^i)$,

$$\frac{\lim_{p_s \to 1} A}{\lim_{p_s \to 1} B} > 1$$

and thus $A > B$ when μ is sufficiently large and the in-the-money option is not exercised at time 0.

B.2 There exists a μ^* such that $A(\mu) > B(\mu)$ for all $\mu \geq \mu^*$

As in the proof of Proposition 1, if Δt is sufficiently small, we can construct a set $\left\{\hat{S}_j\right\}_{j=1}^{h}$ such that:

(1) $\hat{S}_j \leq S_j^i$ for $j = 1, \ldots, h$,

(2) $(1-\tau_c^i) \sum_{j=1}^{h} \pi_j^i (\hat{S}_j - K) e^{rT_j^i} = (1-\tau_c^a) \sum_{j=1}^{g} \pi_j^a (S_j^a - S_0) e^{rT_j^a}$

(3) and

$$U^{-1}\left(\sum_{j=1}^{h} \pi_j^{s,i} U\left((1-\tau_m^i)(\hat{S}_j - K)e^{rT_j^i} + w_0 e^{rT}\right) + \left(1 - \sum_{j=1}^{h} \pi_j^{s,i}\right) U\left(w_0 e^{rT}\right)\right) - w_0 e^{rT}$$

$$= U^{-1}\left(\sum_{j=1}^{g} \pi_j^{s,a} U\left((1-\tau_m^a)(S_j^a - S_0)e^{rT_j^a} + w_0 e^{rT}\right) + \left(1 - \sum_{j=1}^{g} \pi_j^{s,a}\right) U\left(w_0 e^{rT}\right)\right) - w_0 e^{rT}.$$

As a result,

$$\sum_{j=1}^{h} \pi_j^{s,i} U\left((1-\tau_m^i)(S_j^i - K)e^{rT_j^i} + w_0 e^{rT}\right) + \left(1 - \sum_{j=1}^{h} \pi_j^{s,i}\right) U\left(w_0 e^{rT}\right) = U\left(B(1-\tau_c^i) \sum_{j=1}^{h} \pi_j^i (S_j^i - K) e^{rT_j^i} + w_0 e^{rT}\right)$$

and

$$\sum_{j=1}^{h} \pi_j^{s,i} U\left((1-\tau_m^i)(\hat{S}_j - K)e^{rT_j^i} + w_0 e^{rT}\right) + \left(1 - \sum_{j=1}^{h} \pi_j^{s,i}\right) U\left(w_0 e^{rT}\right) = U\left(A(1-\tau_c^i) \sum_{j=1}^{h} \pi_j^i (\hat{S}_j - K) e^{rT_j^i} + w_0 e^{rT}\right).$$

When replacing each $\hat{S}_j$ by its corresponding S_j^i in the last equation, A being sufficiently large ($A(1-\tau_c^i) > 1-\tau_m^i$) will give

$$\begin{aligned} &\sum_{j=1}^{h} \pi_j^{s,i} U\left((1-\tau_m^i)(S_j^i - K)e^{rT_j^i} + w_0 e^{rT}\right) + \left(1 - \sum_{j=1}^{h} \pi_j^{s,i}\right) U\left(w_0 e^{rT}\right) \\ &\qquad < U\left(A(1-\tau_c^i) \sum_{j=1}^{h} \pi_j^i (S_j^i - K) e^{rT_j^i} + w_0 e^{rT}\right) \end{aligned} \tag{9}$$

and hence $A > B$.

Because a change in μ may shift the exercise nodes, the terms A and B as defined above do not vary continuously with μ. Hence a μ^* such that $A(\mu^*) = B(\mu^*)$ may not exist. However, we can show that if $A(\hat{\mu}) > B(\hat{\mu})$ for some $\hat{\mu}$, then $A(\hat{\mu} + \epsilon) > B(\hat{\mu} + \epsilon)$ for any $\epsilon > 0$.

To show this, first note that $A(\mu)$ increases with μ. Therefore, if $\hat{\mu}$ is such that $A(\hat{\mu})$ is sufficiently large for (9) to hold, then (9) holds with $A(\hat{\mu}+\epsilon)$ for any $\epsilon > 0$. Similarly, if $\hat{\mu}$ is such that $A(\hat{\mu}) < B(\hat{\mu})$, then $A(\hat{\mu}-\epsilon) < B(\hat{\mu}-\epsilon)$ for all $\epsilon \in (0, \hat{\mu}-r)$. There must then exist a μ^* such that $A(\mu) \geq B(\mu)$ for all $\mu \geq \mu^*$ and $A(\mu) < B(\mu)$ for all $\mu < \mu^*$. This completes the proof of Proposition 2.

C Proof of Proposition 3

1. This proof uses the same notation as in the proofs of propositions 1 and 2 above. As before, we let:
$$A = \frac{U^{-1}\left(\sum_{j=1}^{g}\pi_j^{s,a}U\left((1-\tau_m^a)(S_j^a-S_0)e^{rT_j^a}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{g}\pi_j^{s,a}\right)U\left(w_0e^{rT}\right)\right)-w_0e^{rT}}{(1-\tau_c^a)\sum_{j=1}^{g}\pi_j^a(S_j^a-S_0)e^{rT_j^a}}$$
and
$$B = \frac{U^{-1}\left(\sum_{j=1}^{h}\pi_j^{s,i}U\left((1-\tau_m^i)(S_j^i-K)e^{rT_j^i}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{h}\pi_j^{s,i}\right)U\left(w_0e^{rT}\right)\right)-w_0e^{rT}}{(1-\tau_c^i)\sum_{j=1}^{h}\pi_j^i(S_j^i-K)e^{rT_j^i}}.$$
Suppose that $\mu > r$, let w_0 be such that $A < B$, let $\tilde{w}_0 > w_0$ and let $\tilde{A}$ and $\tilde{B}$ be the counterparts of A and B when the manager's initial non-option wealth is $\tilde{w}_0$. As $\tilde{w}_0 \to \infty$, the manager's valuation of an option approaches that of a risk-neutral agent, meaning that:
$$\lim_{\tilde{w}_0\to\infty}\tilde{A} = \frac{(1-\tau_m^a)\sum_{j=1}^{g}\tilde{\pi}_j^{s,a}(\tilde{S}_j^a-S_0)e^{rT_j^a}}{(1-\tau_c^a)\sum_{j=1}^{g}\tilde{\pi}_j^a(\tilde{S}_j^a-S_0)e^{rT_j^a}} > \frac{1-\tau_m^a}{1-\tau_c^a}.$$
when $\mu > r$. If $\tau_m^a = \tau_m^i$ and $\tau_c^a = \tau_c^i$, then $A > \frac{1-\tau_m^a}{1-\tau_c^a} = \frac{1-\tau_m^i}{1-\tau_c^i}$ and equation (9) holds, so that $A > B$. Therefore, when $\tau_m^a = \tau_m^i$ and $\tau_c^a = \tau_c^i$ and μ and w_0 are such that $A < B$, there exists a $\tilde{w}_0 > w_0$ such that $\tilde{A} > \tilde{B}$, meaning that the threshold μ^* is smaller with $\tilde{w}_0$ than with w_0.
2. If $U(x) = \frac{x^{1-\gamma}}{1-\gamma}$ and $\gamma \to 0$, the manager behaves as if he or she were risk neutral and the proof proceeds as in (1).

D Proof of Proposition 4

Suppose $\mu = r$. Let the superscript a denote the in-the-money NQO and i denote the in-the-money ISO. Let τ_m denote the personal income tax rate, let τ_c represent the corporate tax rate and let τ_{cg} denote the capital gains tax rate. In the present case, $\tau_c^i = 0$, $\tau_c^a = \tau_c$ if the \$1,000,000 limit has not been reached and $\tau_c^a = 0$ otherwise, $\tau_m^a = \tau_m$ and $\tau_m^i = \tau_{cg}$. For a backdating arrangement to benefit shareholders and the manager, we need
$$\begin{aligned} A &= \frac{U^{-1}\left(\sum_{j=1}^{g}\pi_j^aU\left((1-\tau_m)(S_j^a-K)e^{rT_j^a}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{g}\pi_j^a\right)U\left(w_0e^{rT}\right)\right)-w_0e^{rT}}{(1-\tau_c^a)\sum_{j=1}^{g}\pi_j^a(S_j^a-K)e^{rT_j^a}} \\ &< \frac{U^{-1}\left(\sum_{j=1}^{h}\pi_j^iU\left((1-\tau_{cg})(S_j^i-K)e^{rT_j^i}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{h}\pi_j^i\right)U\left(w_0e^{rT}\right)\right)-w_0e^{rT}}{\sum_{j=1}^{h}\pi_j^i(S_j^i-K)e^{rT_j^i}} = B. \end{aligned} \quad (10)$$

In general, $\tau_{cg} < \tau_m$ and this is what we will assume from now on. For the manager, the lower the tax rate that applies on his exercise income, the greater the risk and thus the earlier he or she is to exercise. Hence the manager will exercise earlier with τ_{cg} than with τ_m or, in other words, there will be more exercise nodes with τ_{cg} than with τ_m. For the manager, a lower tax rate translates into greater utility even though the option may be exercised earlier, i.e.

$$U^{-1}\left(\sum_{j=1}^{h}\pi_j^i U\left((1-\tau_{cg})(S_j^i-K)e^{rT_j^i}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{h}\pi_j^i\right)U\left(w_0e^{rT}\right)\right)$$
$$> U^{-1}\left(\sum_{j=1}^{g}\pi_j^a U\left((1-\tau_{m})(S_j^a-K)e^{rT_j^a}+w_0e^{rT}\right)+\left(1-\sum_{j=1}^{g}\pi_j^a\right)U\left(w_0e^{rT}\right)\right).$$

For the firm, earlier exercises reduces the cost before tax to shareholders, i.e.

$$\sum_{j=1}^{h}\pi_j^i(S_j^i-K)e^{rT_j^i} < \sum_{j=1}^{g}\pi_j^a(S_j^a-K)e^{rT_j^a}.$$

Therefore, if $\tau_c^a=0$, then equation (10) holds. Otherwise, equation (10) holds if τ_c is sufficiently small.

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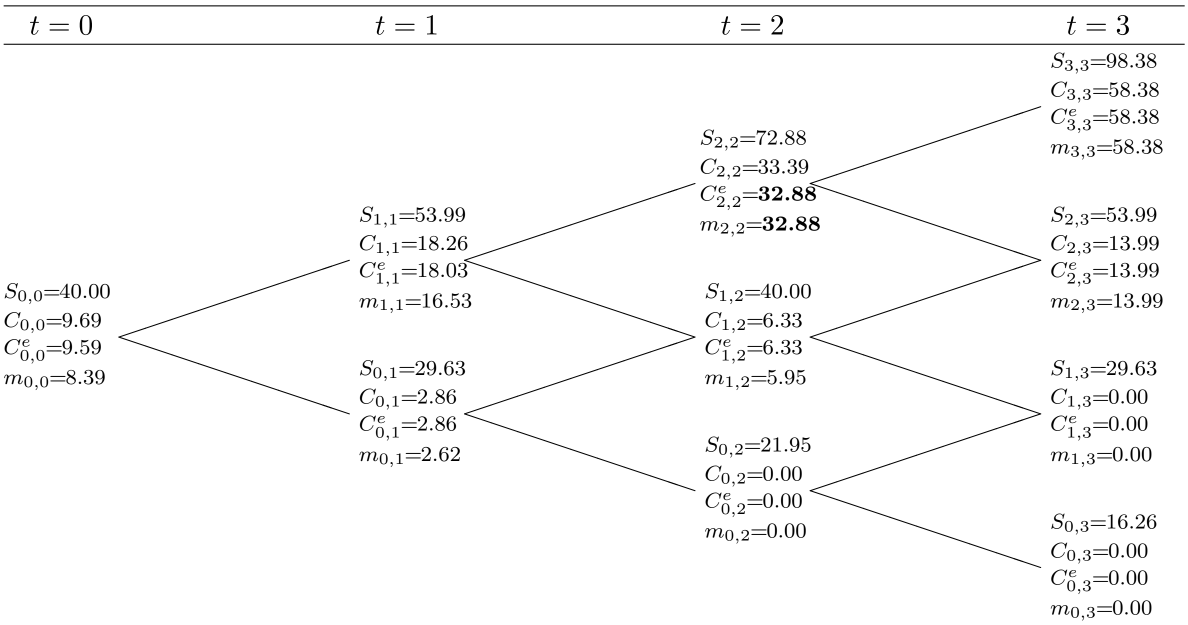

Figure 1: Value of a call option with strike price $K = 40$ and time to maturity $T = 3$ on a stock with $S_0 = 40$, $\mu = 5\%$, $\delta = 2\%$ and $\sigma = 30\%$. Tax rates are $\tau_m = \tau_c = 0$, the risk-free rate is $r = 5\%$ and a time step is $\Delta t = 1$, the manager's initial non-option wealth is $w_0 = 100$ and the manager's utility function is $U(w) = w^{1-\gamma}/(1-\gamma)$ with $\gamma = 2$. At each node, the tree gives the stock price ($S_{i,j}$), the value of a regular American call option ($C_{i,j}$), the value of an executive stock option from shareholders' viewpoint ($C^e_{i,j}$) and the value of an executive stock option from the manager's viewpoint ($m_{i,j}$).

Greeks for different strike prices ($w_0 = 100$)

	Firm's perspective							
	$\gamma = 2$				$\gamma = 4$			
Strike	Delta	Gamma	Vega	Theta	Delta	Gamma	Vega	Theta
40	0.5632	0.00998	0.3475	−0.3222	0.5545	0.01047	0.3106	−0.3697
38	0.5846	0.00994	0.2950	−0.2984	0.5743	0.01055	0.3276	−0.3556
36	0.6050	0.00998	0.3248	−0.2637	0.6006	0.01026	0.2951	−0.3086
34	0.6266	0.00973	0.3112	−0.2390	0.6210	0.01027	0.2950	−0.2888
32	0.6522	0.00934	0.2937	−0.1822	0.6476	0.00998	0.2586	−0.2401
30	0.6744	0.00913	0.2741	−0.1404	0.6730	0.00953	0.2611	−0.1773
20	0.8001	0.00610	0.1497	0.2552	0.8021	0.00622	0.1405	0.2434
	Manager's Perspective							
	$\gamma = 2$				$\gamma = 4$			
Strike	Delta	Gamma	Vega	Theta	Delta	Gamma	Vega	Theta
40	0.4553	0.00773	0.2017	−0.2830	0.3761	0.00617	0.1161	−0.0582
38	0.4744	0.00768	0.1925	−0.2569	0.3967	0.00614	0.1233	−0.0200
36	0.4952	0.00760	0.1825	−0.2265	0.4153	0.00610	0.1022	0.0209
34	0.5165	0.00749	0.1711	−0.1925	0.4356	0.00602	0.0915	0.0703
32	0.5387	0.00730	0.1530	−0.1507	0.4564	0.00589	0.0735	0.1255
30	0.5619	0.00706	0.1387	−0.1026	0.4785	0.00570	0.0583	0.1902
20	0.6858	0.00450	0.0134	0.2552	0.6002	0.00352	−0.0712	0.6520
	Bermudan							
	$\gamma = 2$				$\gamma = 4$			
Strike	Delta	Gamma	Vega	Theta	Delta	Gamma	Vega	Theta
40	0.5737	0.00968	0.3640	−0.2902	0.5737	0.00968	0.3640	−0.2902
36	0.6140	0.00941	0.3442	−0.2275	0.6140	0.00941	0.3442	−0.2275
32	0.6572	0.00898	0.3139	−0.1483	0.6572	0.00898	0.3139	−0.1483
20	0.7996	0.00665	0.1745	0.2741	0.7996	0.00665	0.1745	0.2741

Table 2: Greeks from the firm and the manager's viewpoint computed using binomial trees with $S_0 = 40$, $\mu = 3.5\%$, $\delta = 3.5\%$, $\sigma = 30\%$, $r = 3.5\%$, $w_0 = 100$, $T = 10$, $\Delta t = 1/12$, $v = 3$ and $U(w) = w^{1-\gamma}/(1-\gamma)$.

Greeks–Manager Perspective ($w_0 = 10$)

	$\gamma = 2$				$\gamma = 4$			
Strike	Delta	Gamma	Vega	Theta	Delta	Gamma	Vega	Theta
40	0.2430	0.00584	0.0310	0.1653	0.1290	0.00244	−0.0012	0.2085
36	0.2779	0.00639	0.0130	0.2661	0.1495	0.00274	−0.0207	0.2992
32	0.3215	0.00698	−0.0183	0.4101	0.1746	0.00309	−0.0445	0.4244

Table 3: Greeks from the manager's viewpoint computed using binomial trees with $S_0 = 40$, $\mu = 3.5\%$, $\delta = 3.5\%$, $\sigma = 30\%$, $r = 3.5\%$, $w_0 = 10$, $T = 10$, $\Delta t = 1/12$, $v = 3$ and $U(w) = w^{1-\gamma}/(1-\gamma)$.

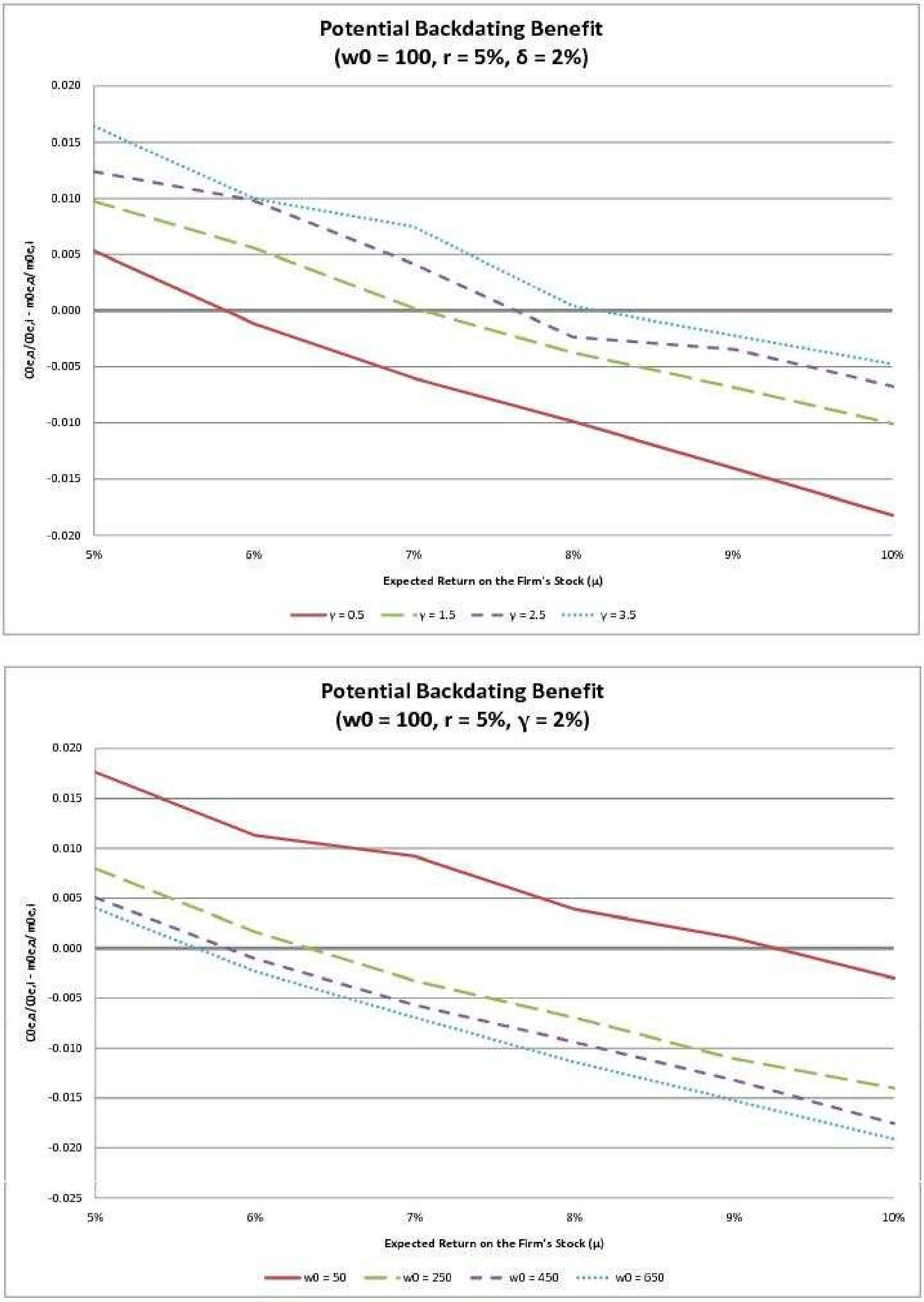

Figure 2: Potential benefit of issuing in-the-money options instead of at-the-money options for different values of the firm's expected stock return. The upper graph assumes $w_0 = 100$ and lets the coefficient of risk aversion vary. The lower graph assumes $\gamma = 2$ and lets w_0 vary. Other parameters are as follows: $S_0 = 40$, $r = 5\%$, $\delta = 2\%$, $\sigma = 30\%$, $T = 10$, $\Delta t = 1/12$, $v = 3$, $\tau_m = \tau_c = 0$ and $U(w) = w^{1-\gamma}/(1-\gamma)$. The strike price of the in-the-money option is $K = 36$.