Rev Deriv Res (2008) 11:41–59
DOI 10.1007/s11147-008-9023-0

Stock options and managers' incentives to cheat

Marc Chesney · Rajna Gibson

Published online: 15 November 2008

Abstract This paper develops a continuous-time real options' pricing model to study managers' incentives to cheat in the presence of equity-based compensation plans. It shows that managers' incentives to cheat are strongly influenced by the efficiency of the justice. The model's main result is that managers have greater incentives to commit fraudulent actions under stock options than under common stocks based compensation plans.

Keywords Executive compensation · Fraud · Incentives · Stock options

JEL Classifications G13 · G30

1 Introduction

Over the last decade, we have witnessed corporate scandals in which firms have used specific accounting mechanisms and financial engineering strategies to disguise their actual profits or leverage levels. These scandals have raised doubts about the ethical standards of corporate managers. More specifically, in the case of Enron, managers used off-balance sheet entities to improve the company's results and to hide its debt, overstating its net income by 744 million dollars. In the case of Waste Management Inc., managers falsified and misrepresented the company's financial results, which

M. Chesney
Swiss Banking Institute, University of Zurich, Zurich, Switzerland
e-mail: Chesney@isb.uzh.ch

R. Gibson (✉)
Swiss Finance Institute, University of Geneva, Geneva, Switzerland
e-mail: rajna.gibson@unige.ch

led to a restatement of the company's earnings of about 1.7 billion dollars. Even more dramatic is the case of Worldcom managers who falsified earnings by almost 10 billion dollars. Finally, by prematurely recognizing its revenues, Xerox overstated its pre-tax earnings by 1.5 billion dollars. As suggested by Degeorge et al. (1999), executives have both the incentives and the ability to manage earnings.

These corporate scandals suggest that some managers are willing to cheat about the true financial health of their firms in order to boost their performance figures. Is this tendency exacerbated when managers receive stock option rather than stock-based compensation plans? This is the main question addressed in this study with respect to the fraudulent accounting practices employed by some CEOs.

Contrarily to the remaining literature in the field, this study does not attempt to model the influence of performance-based remuneration policies on managers' effort levels and risk-taking behavior since these are widely explored research areas. The paper focuses on firms whose managers receive equity or stock options based compensations and examines their incentives to cheat within a continuous-time real options modelling framework. It characterizes managers' decision to engage in illicit—mostly, accounting—activities as an option to cheat. Indeed, the manager has the possibility to cheat and to manipulate the earnings if one abstracts from moral or ethical considerations guiding his actions. This decision to cheat can lead to a potential positive payoff in the form of a higher stock option value—due to the higher stock price—that more than compensates the manager's costs of cheating (i.e., the strike price associated with the exercise of that option to cheat). The value of the option to cheat is then derived and the manager's optimal exercise policy is analysed. In this model, the illicit activity of the manager leads to a short-term increase in the stock expected returns. However, engaging in that illicit activity is not free since we consider corruption costs as well as the possibility that the manager may lose part or all of his reputation—and future remuneration—if he is convicted. For pedagogical reasons, we first assume that the duration of the legal process leading to the manager's conviction is known with certainty. The model is then extended to the more realistic case of a non-fully predictable legal settlement process. This allows us to tackle our main objective, that is, to examine whether stock options exacerbate managers' incentives to cheat relative to stocks and thus, induce managers to exercise their option to cheat earlier.

The question of how to design an efficient remuneration contract that will induce the manager to exercise best efforts and thus to maximize shareholders' wealth is at the core of the compensation literature. In this context, an important stream of the literature has examined the impact of the form of the compensation contract on the managers' incentives (Holmstrom 1979) and argued that compensation should be linked to corporate performance (Smith 1996). There is still ample debate as to whether prevailing remuneration contracts are indeed efficient (for an excellent survey on the issue see Core et al. 2003) and consistent with the classical principal-agent efficient contracting model (see Dittmann and Maug 2003). Dittmann and Maug have shown that the latter model is unable to explain the high level of stock options in existing executive compensation contracts. Indeed, according to a study on 13,500 US executives active in all major industrial sectors during the year 2002, Watson Wyatt observe that these managers received a 3 million US dollars average stock option pay

in contrast to a 843,000 US dollars average total cash pay. The widespread use of stock options has also been advocated as a manner to add convexity to the manager's remuneration scheme and thus to induce him to behave in a less risk-averse manner (Carpenter 2000). This risk steering property of stock option contracts has been corroborated in a study by Guay (1999) but is challenged in the recent theoretical study by Ross (2004) who shows that the risk-taking behavior of the manager is, in particular, affected by the wealth effect induced by the stock options. A more technical stream of the literature is devoted to valuation issues and focuses in particular on the correct methodology to use in order to value stock options given that they have hedging restrictions (see Huddart 1994; Marcus and Kulatilaka 1994; Carpenter 1998) or that the manager holds an imperfectly diversified portfolio as a consequence of his equity-based remuneration (Ingersoll 2002). As shown by Lambert et al. (1991), a manager with a power utility function may, depending upon the structure of his remaining wealth, value his stock options for less than 50% of the Black and Scholes (1973) predicted value. Finally, and more closely related to our modelling framework, the paper by Cadenillas et al. (2004) examines, within a continuous-time setting, how shareholders should compensate managers and simultaneously select a leverage ratio that will provide optimal incentives to the managers. In their framework, the manager chooses both his optimal effort level and the volatility of the firm's projects. The authors' main conclusions are the following: the optimal policy is to grant stock with high leverage to "good managers" and stock with low leverage to "bad" managers.

All these studies have so far assumed that managers are honest and that they would not breach the legal environment in which the firms operate to increase their wealth. However, a more recent—and mostly empirical—stream of the accounting and finance literature focuses on the relationship between managerial compensation and earnings manipulation and in the extreme case, fraud. In this context, one can cite Burns and Kedia (2006) who examine the effect of CEO compensation contracts on firms' propensity to misreport. In particular, these authors are interested in studying the impact of stock options on firms' tendency to adopt aggressive accounting practices. They postulate that "CEO's with higher pay performance incentives from stock options are more likely to adopt aggressive accounting practices associated with restatements". They conduct an empirical study based on 266 restatement events and on a control sample of 8000 non-restatements which corroborates their null hypothesis. The authors explain the observed relationship through the convexity of stock options. The empirical study by Johnson et al. (2003) is the most closely related to our research question. These authors examine the relationship between equity-based executive compensation and accounting fraud. Their empirical results, based on a sample of 2,504 firms and a total of 43 fraud events during the period 1992–2001, suggest that managers who engage in illegal accounting practices have significantly higher equity-based compensation than managers in control matching firms. Furthermore, they show that managers in fraudulent firms earn higher compensation by exercising a larger fraction of their vested options during the fraud period. These new empirical results highlight an important externality associated with equity-based compensation policies, namely their potential to induce managers to behave at the frontiers of the law and even beyond.

The main finding of our study can be summarized as follows: for an equivalent dollar amount of stock and stock options, the stock options will exacerbate the managers incentives to cheat.[1] In this respect, this model is the first one to offer theoretical support for the empirical results described above. Indeed, the model shows that the option to cheat associated with a stock option compensation package will always be exercised sooner than the one associated with a stock based compensation package. The model also highlights the importance of the legal framework in place. Indeed, in the more elaborate version of the model, two regions can be observed: an honesty region—in which the manager never engages in illicit activities. This honesty region can be associated with an efficient legal system. When the legal system is inefficient, the manager has incentives to engage in illicit activities. This is a very important result since it suggests that proper corporate governance, especially in inefficient jurisdictions should favor the issuance of stocks rather than stock options. As expected, managers' incentives to cheat will be higher for a manager with a low reputation or a low future compensation and/or in the presence of low corruption costs.

The structure of the paper is the following: Sect. 2 presents the main assumptions of the model. The third section is primarily of pedagogical interest, it derives the manager's optimal decision to engage in illicit activities when his compensation consists of stock options in an "artificial economy" in which the legal settlement process is fully predictable. Section 4 present our main results in the more realistic case of an economy whose legal settlement process is not fully predictable. Section 5 compares the managers incentives to cheat under both remuneration policies. Finally, Sect. 6 concludes the paper by highlighting its main results.

2 Main assumptions

Let us consider an all-equity financed firm run by a risk neutral manager.[2] The manager has received m stock options at time t_0 that he cannot exercise before date t_1 to account for the fact that most options contracts specify a vesting period during which the manager cannot exercise or sell his options. In order to simplify the analysis, we chose to initiate his decision making period at date t_1 which corresponds to the end of this vesting period. His stock options are of the American type, have a strike price equal to K and, for simplicity, we will assume that they have a perpetual maturity.[3] Let T_1 denote the date at which the manager will engage in illicit activities. Until date T_1, this firm manager undertakes a perfectly licit activity and the value of the firm's stock S_t is characterized by the following dynamics:

[1] Given the lack of observable data on the subject, we rely on numerical simulations to illustrate our model's predictions.

[2] The model can be extended to the case of a risk-averse manager although this can only be achieved at the cost of additional mathematical complexity.

[3] There are three main reasons for using perpetual options. First, it makes the model more tractable without affecting our main results. Secondly, we know that longer maturity options are supposed to better align managers and shareholders incentives in the absence of fraud. Finally, the perpetual option provides a reasonable approximation to those long-term options.

$$\frac{dS_t}{S_t} = (\mu_1 - \delta)dt + \sigma dW_t, \quad t \in [t_1, T_1], \tag{1}$$

where $(W_t, t \geqslant 0)$ is a P-Brownian motion and P denotes the historical probability. The parameters μ_1 and σ, respectively, denote the instantaneous expected total return and volatility of the stock returns and are constant. The continuously compounded dividend yield δ on the stock is also assumed to be constant.

The manager has the option to engage in an illicit activity that will alter the stochastic process followed by the stock price. We will assume that by pursuing an illicit activity, the manager can fool the market by issuing a stream of news that leads to an increased drift of the stock price process.[4]

One can thus write the modified stock price process in the illicit economy as follows:

$$\frac{dS_t}{S_t} = (\mu_2 - \delta)dt + \sigma dW_t, \quad t \in [T_1, T_1 + \Delta T], \tag{2}$$

where $\mu_2 \geqslant \mu_1$ and $T_1 + \Delta T$ denotes the date at which the manager is convicted.[5] Thus, ΔT represents the total length of time it takes for justice[6] to settle the fraudulent case associated with the manager's behavior. It is a measure of the inefficiency of the judiciary system prevailing in a specific country.

In reality, ΔT is not known with certainty and the main model presented in Sect. 4 clearly accounts for this feature. However, for pedagogical reasons, we first consider a simpler version of the model in which ΔT is constant and thus the date at which the manager is convicted is known. Indeed, it will allow us to already define the main features of the option to cheat in a simple framework.

At date $T_1 + \Delta T$, the manager's conviction by the justice leads to an immediate significant drop in the stock price as well as to a decrease in the drift of the stock. In their study, Palmrose et al. (2001) document a two-day stock excess return of -20% following fraud based restatements which is consistent with our stock price jump assumption. We can thus write the modified stock price process when the manager is convicted as follows:

$$\frac{dS_t}{S_t} = (\mu_3 - \delta)dt + \sigma dW_t, \quad t \in [T_1 + \Delta T, +\infty\,]. \tag{3}$$

Given that in the illicit economy, the stock price experiences an immediate jump defined as follows:

$$S_{T_1+\Delta T} = (1 - \beta)S_{T_1+\Delta T^-}.$$

[4] Johnson et al. (2003) provide an interesting Appendix illustrating the variety of fraudulent accounting mechanisms that US firms in their sample used to artificially inflate their stock prices.

[5] An alternative perpective could have been pursued by assuming that this date represents the moment when the fraud becomes publicly known.

[6] Justice is here broadly defined and also encompasses the control and auditing mechanisms prevailing in a given country.

The new drift parameter μ_3 is such that $\mu_2 \geqslant \mu_1 \geqslant \mu_3$ and the constant $\beta \in (0, 1)$, denotes the size of the instantaneous relative jump in the stock price at the date when the manager is convicted.

We are interested in valuing the option to cheat from the manager's perspective. Since, his option to cheat is not a tradable contingent claim, we cannot rely on the standard no-arbitrage argument to determine its value. Instead, we will rely on the manager's preferences in order to value the option to cheat and to determine his optimal exercise policy. Without loss of generality, we will assume that the manager is risk-neutral and that the riskless discount rate is equal to r with $\mu_2 - \delta \geqslant r \geqslant \mu_1 - \delta$. The first inequality is consistent with the fact that the expected rate of return of the stock net of the dividend yield after cheating be strictly greater than r which renders the stock option European. The second inequality is chosen so that the licit option can be treated as an American option.[7]

The manager's total wealth at date T_1 consists of his stock option in the licit world and of his option to cheat.[8] Since we are interested in studying the manager's incentives to engage in illicit activities, we will consider a reduced-form optimization problem focusing on the maximization of the expected discounted utility of the payoff generated by the manager's option to cheat. At date $t \in [t_1, T_1]$, the latter can be viewed as an exchange call option. Indeed, this exchange call gives the manager the right to exchange his "licit" stock option for an "illicit"[9] stock option. The value of the exchange call option at date T_1 depends on the value of the m stock options SOI_{T_1} he will own provided that he engages in illicit activities less the costs of exercising his exchange option. These costs consist of three components: first, the value of those m perpetual American stock options had he pursued a licit activity $(m \cdot SOL_{T_1})$,[10] second, the total costs of corruption C[11] and finally the expected discounted reputational loss $EDRL$ that he incurs when he will be convicted.[12]

[7] The valuation problem can however be solved without imposing those restrictions on the two drifts of the stock returns.

[8] Note that considering other sources of wealth in our model will not change its main results due to the fact that we assume that the manager maximizes the expected discounted utility of his wealth differential in order to focus more precisely on the valuation of the option to cheat.

[9] The terms "licit" and "illicit" refer, respectively, to the case where the manager does not engage in a fraudulent activity and the one where he engages in a fraudulent activity in order to increase the payoff of his stock options.

[10] We have for tractability reasons ignored the case where the manager also foregoes additional future options grants if he cheats and is caught by the justice. The latter foregone option grants would have increased the strike price of the option to cheat without fundamentally altering the conclusions made in the paper.

[11] Such costs are for instance dedicated to the creation of illegal off-shore SPV's or trusts, or associated with false communication to the analysts or to the auditors, or costs associated with bribery, etc. We will assume that the discounted stream of all corruption costs denoted by C is constant.

[12] Thus, we only consider the costs borne by the manager and not those borne by the other stakeholders of the firm which are exogeneously specified in the model and captured mainly by the drop in the stock price and the decline of its drift.

Theoretically, an individual's reputation is neither a quantifiable nor, in general, a tradable asset (see, in particular, Tadelis 2001).[13] However, for the purpose of this study, we shall assume that reputation has an agent specific monetary value and that the manager is endowed with a reputational capital A at date t_0. This reputational capital results from his capitalized good behavior in previous jobs and is supposed to be constant thereafter. The expected discounted reputational loss $EDRL$ at date T_1 that arises when he engages in illicit activities[14] and is convicted is equal to $\eta A e^{-r\Delta T}$. In other words, he loses a constant fraction of his reputational capital when he is convicted at date $T_1 + \Delta T$.

Thus, one can write

$$EDRL = \eta A e^{-r\Delta T},$$

with $1 \geqslant \eta \geqslant 0$ denoting the reputational cost fraction that reduces his reputational capital when he is convicted. The loss parameter η consists of two components, an external one that is driven by the market for this specific type of managerial positions and a second one which is specific to the agent and determined by his ethical values.

Assuming that the manager is risk-neutral, his optimization problem can be written as follows:[15]

$$\sup_{T_1} E_{t_1}\left[e^{-r(T_1-t_1)}\left(mSOI_{T_1} - \left(mSOL_{T_1} + C + \eta A e^{-r\Delta T}\right)\right)\right]. \tag{4}$$

The argument in the utility function is the discounted value of the option to cheat. This leads to a non-standard aspect in the formulation of the model, namely that "the utility function is defined over the gain from engaging in illicit activities at T_1 instead of the absolute level of wealth".

3 The manager's optimal decisions in the presence of stock options

This section characterizes the manager's decision to engage in an illicit activity, that is to exercise his option to cheat and to subsequently exercise his stock options in the case where the legal settlement date is known. Since the option to cheat is an American perpetual option, the decision to cheat corresponds to the first passage time of the underlying stock price at a level L_1:

[13] Tadelis (2001) examines the conditions that guarantee long-term incentives through an active market for reputation.

[14] We could have easily incorporated other costs—such as the one related to the fact that his accounts can be blocked or the cost associated with a jail sentence—related to the manager's conviction into the managers's optimisation problem simply by adding other constants representative of these costs into the strike price of the option to cheat. The reputational cost also accounts for any future foregone salary payments that are lost due to the manager's conviction. All of these costs have the same impact which is to raise the exercise price of the option to cheat and thus to lower the probability that managers may cheat.

[15] Note that the choice of T_1 as the reference date for the manager's optimization problem does take into account the flows that occur when the manager's illicit activity is discovered. Indeed, as will be clear from the next section, the definitions of SOL and of $EDRL$ integrate the monetary consequences of his conviction at date $T_1 + \Delta T$.

$$T_1 = inf\,\{t > 0;\, S_t \geqslant L_1\}\,.$$

The illicit and licit stock option values respectively, SOI_{T_1} and SOL_{T_1}, in Eq. 4 are manager specific and thus cannot be valued using standard no-arbitrage arguments but rather invoking the risk preferences of the manager.[16]

3.1 The case where early exercise of the stock option is not optimal in the illicit economy

While μ_2 can in principle take on any value higher than μ_1, we will cast the model in the case where the expected rate of appreciation of the stock price process $(\mu_2 - \delta)$ is higher than r which, in the classical real options literature, would suggest that the owner of the perpetual stock options never exercises his calls. However, due to the fact that the manager will be convicted, the exercise policy of these perpetual stock options is de facto constrained by the legal risk incurred by the manager. It is sub-optimal for him to exercise his options after date $T_1 + \Delta T$. Indeed, after date $T_1 + \Delta T$, that is, once the manager is convicted, the dynamics of the stochastic process characterizing S are altered by the presence of a large decline in the stock price as well as by a reduction of its drift. Thus, the optimal exercise date T_2 occurs just an instant before he is convicted, that is to say at date $T_2 = T_1 + \Delta T^-$.

Based on the above considerations, the illicit stock option SOI_{T_1} in Eq. 4 can thus be priced as a European option owned by a risk-neutral manager:

$$\begin{aligned} SOI_{T_1} &= E_{T_1}[(S_{T_1+\Delta T^-} - K)^+ e^{-r\Delta T}] \\ &= L_1 e^{-(r-\mu_2+\delta)\Delta T} N(d_1) - K e^{-r\Delta T}\, N(d_2), \end{aligned} \tag{5}$$

where K denotes the exercise price of the stock option and where

$$d_1 = \frac{\ln(L_1/K) + (\mu_2 - \delta + \sigma^2/2)\Delta T}{\sigma\sqrt{\Delta T}}$$

and

$$d_2 = \frac{\ln(L_1/K) + (\mu_2 - \delta - \sigma^2/2)\Delta T}{\sigma\sqrt{\Delta T}}.$$

In the case of the licit stock option, SOL_{T_1}, we know that when $r \geqslant \mu_1 - \delta$, it might be optimal to exercise this American option prematurely.[17] Thus, the licit stock option

[16] In a different context, Ingersoll (2002) recognizes and values explicitly the subjective value of stock options to managers who hold sub-optimally diversified portfolios and who exercise their stock options prematurely.

[17] When this inequality is reversed, we can easily value the stock option with a simpler European option valuation model.

in Eq. 4 can be priced as an American option when the critical exercise boundaries of the option to cheat and the licit stock options respectively satisfy $L_1 < L_3^*$:

$$SOL_{T_1} = \sup_{L_3} E_{T_1}[e^{-r(T_3-T_1)}(L_3 - K)]$$

with

$$T_3 = \inf\{t > 0; S_t \geqslant L_3\},$$

which reduces to

$$SOL_{T_1} = (L_3^* - K) \cdot (L_1^*/L_3^*)^{\theta_1},$$

where L_3^* is the level at which the licit stock option is optimally exercised.

$$L_3^* = \frac{\theta_1}{\theta_1 - 1} K \tag{6}$$

and

$$\theta_1 = \frac{-\nu_1 + \sqrt{\nu_1^2 + 2r}}{\sigma} \tag{7}$$

with

$$\nu_1 = \frac{\mu_1 - \delta}{\sigma} - \frac{\sigma}{2},$$

and where L_1^* denotes the stock price at which the manager will optimally exercise his option to cheat.

Thus, relying on the definition of the expected discounted reputational loss, we can now rewrite the maximization problem of the risk-neutral manager in Eq. 4 as follows:

$$\begin{aligned}\sup_{L_1} \left(\frac{S_{t_1}}{L_1}\right)^{\theta_1} \Big[& m\left(L_1 e^{-(r-\mu_2-\delta)\Delta T} N(d_1) - K e^{-r\Delta T} N(d_2)\right) \\ & - \left(m(L_3^* - K) \cdot (L_1/L_3^*)^{\theta_1}\right) 1_{L_1 \leqslant L_3^*} \\ & - (m(L_1 - K))\, 1_{L_1 > L_3^*} - C - \eta A e^{-r\Delta T} \Big]\end{aligned}$$

Indeed, when $L_3^* < L_1$, the value of the licit stock option at time T_1 is simply $(L_1 - K)$ since the licit stock option is now equal to its intrinsic value.

The maximization problem of the manager is solved under the budget constraint imposed by the shareholders which in turn determines m, the number of options granted to the manager. The shareholders are risk averse and value the options from

the shareholders' accounting perspective[18] using their the specific discount rate ρ. Knowing that the amount of cash distributed by the shareholders at date t_0 is a constant, D, the number of shares m given to the manager satisfies the following budget constraint:

$$mCA(S_{t_0}) = D, \tag{8}$$

where $CA(S_{t_0})$ the value of the licit American perpetual stock option at time t_0 from the perspective of the risk averse shareholders with standard well behaved utility function U is given by

$$CA(S_{t_0}) = e^{-\rho(t_1-t_0)} E_{t_0}(U\ ((L_3^* - K)(S_{t_1}/L_3^*)^{\theta_1})).$$

Note that in the simulations, we will for tractability assume that the shareholders are risk-neutral. In this case, the latter equation can be explicitly written as follows:

$$\begin{aligned} CA(S_{t_0}) &= e^{-r(t_1-t_0)}(L_3^* - K)(E_{t_0}(S_{t_1}/L_3^*)^{\theta_1}) \\ &= e^{-r(t_1-t_0)}(L_3^* - K) S_{t_0}^{\theta_1} e^{(\theta_1(\mu_1-\delta)+\theta_1(\theta_1-1)\sigma^2/2)(t_1-t_0)}/L_3^{*\theta_1}. \end{aligned} \tag{9}$$

The following proposition summarizes the main property of the exercise boundary of the option to cheat that stems from numerically solving the maximization problem of the manager defined in Eq. 4 under the budget constraint (8).

Proposition 1 *When the settlement date of the legal procedure is known with certainty, the manager always faces incentives to cheat (when ΔT is a constant, the optimal exercise boundary of the option to cheat L_1^* is finite). In our case where the maturity of the option to cheat is infinite, the probability to cheat is equal to one.*

This first statement is intuitive since certainty about the legal settlement date eliminates the legal dimension of the risk faced by the cheating manager. The second part of this proposition, which is numerically verified in the following section, follows from the fact that the drift of the stochastic process characterizing the stock price dynamics is strictly positive. Thus, the process characterizing the stock price will, with probability one, hit the critical level L_1^* when the maturity of the option to cheat is infinite.[19] This proposition illustrates the properties of the limiting case behaviour of the manager when the efficiency of a country's legal system is fully predictable. This assumption has, as stated in the introduction, been made for pedagogical reasons and will be relaxed in the next section.

[18] We assume that for accounting purposes, the shareholders value the stock options in the licit traditional economy.

[19] A similar methodology can be used in order to analyse the incentives to cheat of the manager who receives common stocks. The derivation of the exact results for this case are available from the authors upon request.

4 The option to cheat under a random legal settlement date

In reality, it is unlikely that a manager will always cheat and that a manager who engages in illicit activities knows the date $T_1 + \Delta T$ at which he will be convicted. Indeed, courts are known for engaging in lengthy legal procedures whose final settlement dates are unknown ex ante. In order to account for these legal impediments, we now extend the model to account for a more realistic setting that accounts for the randomness in the duration of the legal procedure. We also assume, as in the previous sections, that the manager will wait as long as possible to exercise his stock options—since $\mu_2 - \delta \geqslant r \geqslant \mu_1 - \delta$—in the absence of any legal threats.

Relying on a similar framework as the one developed in Sect. 3, the manager's optimization problem can be written as follows:

$$\sup_{T_1} E_{t_1}\left[e^{-r(T_1-t_1)}\left((mSOI_{T_1}) - mSOL_{T_1} - C - EDRL\right)\right]. \tag{10}$$

The stock option's payoff $(mSOI_{T_1})$ is only perceived if the manager can exercise his options before being convicted, that is if T_2, the optimal exercise date of the stock options, is strictly smaller than $T_1 + \Delta T$. Like in the previous case, SOL, is the value of the perpetual American stock option in the licit environment and therefore its exercise policy is not constrained by the efficiency of the justice.

ΔT is now assumed to be a random variable with a uniform distribution[20] and therefore its distribution function is defined as follows:

$$p(\Delta T < u) = \frac{u}{\Pi}, \quad u \in [0, \Pi], \tag{11}$$

where Π denotes the maximal length of time it takes for justice to discover and rule over the criminal case.

Unlike in the deterministic case, the manager cannot exercise his stock option just before being convicted, that is at $T_1 + \Delta T^-$. Indeed, the length of the legal settlement process is now unknown to the manager. Hence, due to the random nature of the justice efficiency, the manager has incentives to exercise the stock options prematurely. Indeed, if he waits too long, he will be convicted and lose the proceeds from exercising his stock options.[21] Due to legal uncertainty, his stock options thus become American with a finite maturity $T_1 + \Pi$. We therefore need to determine the exercise boundary for the exercise of these American finite maturity stock options and will assume, as in

[20] We would like the distribution of ΔT to be bounded and thus chose the simplest possible distribution, namely the uniform one.

[21] One could have introduced a prescription period after which the condemnation of the manager is not possible anymore We thus adopt a very conservative approach that lowers the manager's incentives to cheat sooner by ignoring the existence of this prescription period.

Omberg (1987),[22] that this boundary S^* is a decreasing exponential function of time:

$$S_t^* = \exp(-\gamma(t - T_1))S_{T_1}^*, \quad t \in [T_1, T_1 + \Pi]. \tag{12}$$

Note that the positive coefficient γ is defined in such a way that $S_{T_1+\Pi}^* = K$. Thus, $\gamma = \ln(S_{T_1}^*/K)/\Pi$. One can now rewrite the manager's optimization problem stated in expression (10) as

$$\sup_{L_1}\left(\frac{S_{t_1}}{L_1}\right)^{\theta_1}\left[m \sup_{S_{T_1}^*}\int_0^{\Pi} e^{-rt}\left(\exp(-\gamma t)\, S_{T_1}^* - K\right)\left(1 - \frac{t}{\Pi}\right) p\left(T_2' \in dt\right)\right.$$
$$\left. - \left(m\,(L_3^* - K)(L_1/L_3^*)^{\theta_1} 1_{L_1 \leqslant L_3^*} + m\,(L_1 - K)1_{L_1 > L_3^*} + C + \frac{\eta A}{r\Pi}\left(1 - e^{-r\Pi}\right)\right)\right], \tag{13}$$

where L_3^* denotes the critical stock price level at which the licit option is optimally exercised as defined in Eq. 7 and

$$T_2 = \inf\left\{t \geqslant T_1,\ S_t \geqslant S_t^*\right\}, \quad T_2' = T_2 - T_1.$$

In expression (13), $e^{-rt}(\exp(-\gamma t)\, S_{T_1}^* - K)$ represents the illicit stock option's payoff at date $T_1 + t$, discounted at date T_1. This payoff is granted provided that two independent conditions are simultaneously met. First, the exercise of the stock option takes place at date $T_1 + t$, and secondly the manager is not convicted before exercising his stock options.

The density at time T_1 of T_2', the first passage time of S at the exercise boundary is given by:

$$p\left(T_2' \in dt\right) = \frac{a}{\sqrt{2\pi t^3}} e^{-\frac{(a-bt)^2}{2t}} dt$$

with $a = \ln(S_{T_1}^*/L_1)/\sigma$ and $b = [\mu_2 - \delta + \gamma - \sigma^2/2]/\sigma$. The maximization problem of the manager is again solved under the budget constraint of the firms' shareholders. The latter stipulates that the manager receives m stock options at date t_0 where m satisfies $mCA(S_{t_0}) = D$, where $CA(S_{t_0})$ the value of the licit stock option from the shareholders perspective[23] at time t_0 satisfies Eq. 9.

[22] This analytical specification of the exercise boundary generates good approximation for exercise boundaries and option prices, as demonstrated by Omberg (1987). A similar specification of the default boundary has furthermore also been used in some structural credit risk models.

[23] Like in the previous section, it is assumed that shareholders are, for accounting purposes, using the value of the perpetual stock options in the licit world $SOL_{T_1}(S_{t_0})$ in order to determine the total number of options m granted to the manager. The shareholders are assumed to be risk-neutral to assure tractability for the numerical simulations.

4.1 Base case parameters and numerical results

This section is intended to examine the sensitivity of the manager's decision to cheat to the key parameters of the model which are described in the table below.

Stock price at time zero, S_{t_0}	67.03
Stock price at time t_1, S_{t_1}	100
Strike price, K	67.03
Jump factor in the stock price, β	0.20
Risk-free rate, r	0.10
Stock price drift in the licit world, $\mu_1 - \delta$	0.08
Stock price drift in the illicit world, $\mu_2 - \delta$	0.20
Stock price drift after the justice intervenes, $\mu_3 - \delta$	0.02
Stock return volatility, σ	0.15
Initial reputational capital of the manager in dollars, A	500,000
Corruption cost in dollars, C	100,000
The remuneration budget constraint in dollars, D	5,000,000
The fraction of reputational loss, η	0.2
The reference date (in years after the options issuance date t_0), t_1	5

A few explanations on these base case parameters are required. First, note that the initial stock price S_0 is such that its expected future value at time t_1 when capitalized at the growth rate $\mu_1 - \delta$ is equal to S_{t_1}. Second, we assume that the stock options issued at date t_0 are at-the-money as is common practice in the industry. The manager's discount rate level r was chosen so that it be bounded by the expected rates of capital appreciation of the stock prevailing respectively before $(\mu_1 - \delta)$ and after $(\mu_2 - \delta)$ the manager engages in illicit activities in order to be consistent with the model setting developed in the previous section. The jump size in the stock price, β at date $T_1 + \Delta T$, is equal to 20%. The volatility of stock returns is characteristic of a moderate firm volatility observed on European and U.S. stock markets. The corruption costs represent an important parameter of the model on which we have only little public information. Thus, the model's predictions will be tested for alternative levels ranging from zero to 1 million dollars with the base case value set at 100,000 dollars. The reputational loss parameter η has been set at an arbitrary level of 0.2 to illustrate the case of a manager who does only moderately care about his reputation. Finally, the value of the initial reputational capital of the manager has been set at 500,000 dollars so that ηA be of the same order of magnitude as the corruption costs and we examine the model's predictions for alternative values of the reputational loss ranging from zero to 1 million dollars. The budget constraint of $D = 5$ million dollars allocated to the bonus pool is illustrative of a firm that yields a net annual profit of 50,000,000 dollars and distributes 10% of its net profit to its managers.[24] Finally, we assume that the

[24] This ratio is of realistic magnitude. For instance, in May 2006, British Airways announced an operating profit of 705 million pounds for the year ending in March 2006 coupled with a bonus pool for its staff of 48 million pounds driven by the fact that its staff had reached a net operating margin of 8.3%.

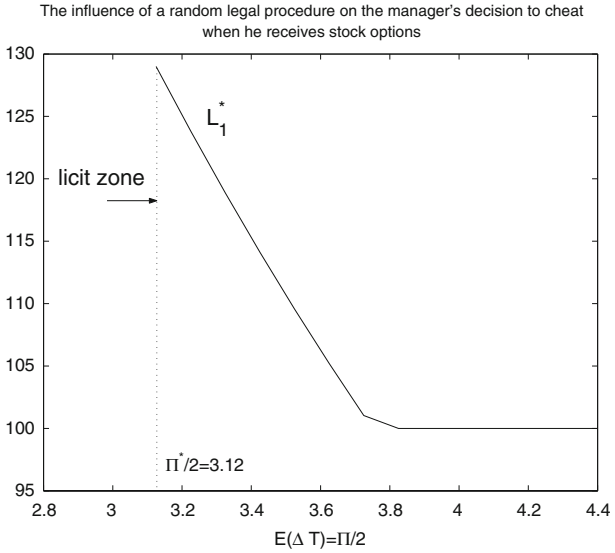

Fig. 1 The level of the stock price at which the manager will engage in illicit activities (L_1^*) as a function of the mean value of the length of the legal procedure ΔT, i.e., $E(\Delta T)$, when the manager receives stock options and when the legal procedure is random (with a uniform distribution over $[0, \Pi]$). The other parameters are: $S_{t_0} = K = 67.03$, $S_{t_1} = 100$, $r = 0.10$, $\mu_1 - \delta = 0.08$, $\mu_2 - \delta = 0.20$, $\mu_3 - \delta = 0.02$, $\sigma = 0.15$, $A = 500{,}000$, $C = 100{,}000$, $D = 5{,}000{,}000$, $\eta = 0.2$, $t_1 = 5$

analysis takes place 5 years after this specific option grant was issued to the manager.

The numerical simulations emphasize two main results: first of all, in the case of legal uncertainty, it can be seen in Fig. 1, that there is a region in which the manager stays honest. This occurs when the justice is "efficient" that is, for $E(\Delta T)$ smaller than 3.12 years under our set of base case parameters. Second, when the manager is in the illicit region, he will wait longer than under a fully predictable legal system[25] before engaging in illicit activities. Indeed, the manager may face the situation where he exercises the option to cheat without receiving full benefit of its proceeds. More precisely, he would pay the corruption costs, loose part of his reputation but would not be able to exercise his stock options due to the fact that he is convicted. Like any other real option, the option to cheat will be exercised later when uncertainty increases. The new feature characterizing this model is that the source of uncertainty considered is the legal uncertainty surrounding the conviction date of the manager.

These results can be summarized in the following proposition:

Proposition 2 *When the date of the legal settlement is not fully predictable (when ΔT is a uniformly distributed random variable), there are two regions characterizing the exercise policy of the manager. In the first region, called the licit region, defined by an efficient legal system (small Π), the manager never cheats (L_1^* is infinite). In the second region, called the illicit region, characterized by an inefficient legal system*

[25] The graph illustrating the mirror case for the fully predictable case is available upon request.

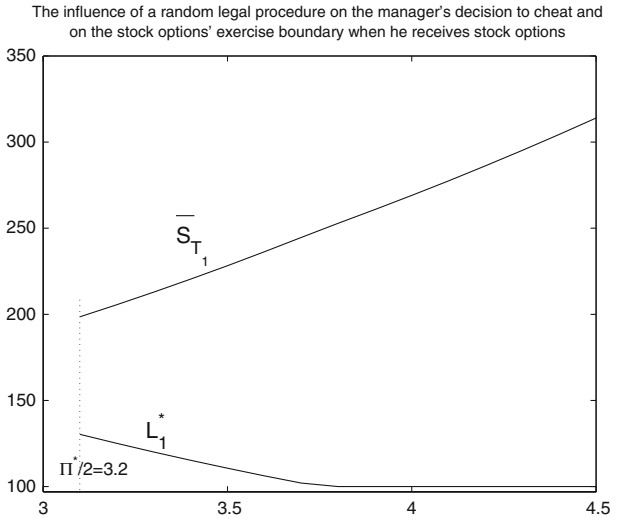

Fig. 2 The level of the stock price at which the manager will engage in illicit activities (L_1^*) and the level which defines the boundary at which the stock options are exercised ($\bar{S}_{T1}$) as a function of the mean value of the length of the legal procedure ΔT, i.e., $E(\Delta T)$, when the manager receives stock options and when the legal procedure is random (with a uniform distribution over [0, Π]). The other parameters are: $S_{t_0} = K = 67.03$, $S_{t_1} = 100$, $r = 0.10$, $\mu_1 - \delta = 0.08$, $\mu_2 - \delta = 0.20$, $\mu_3 - \delta = 0.02$, $\sigma = 0.15$, $A = 500{,}000$, $C = 100{,}000$, $D = 5{,}000{,}000$, $\eta = 0.2$, $t_1 = 5$

(large Π), the manager will always face incentives to engage in illicit activities (L_1^* is finite). In the case where the maturity of the option to cheat is perpetual, the probability that the manager effectively engages in illicit activities is equal to one in the illicit region. In the more realistic case where the maturity of the option to cheat is finite, the manager will not necessarily cheat even if he may be inclined to do so.

Figure 2, displays the two trigger values associated, respectively, with the decision to cheat and to exercise the stock options afterwards. One can see that when the justice efficiency decreases (i.e., $\Pi/2$ increases), the managers will engage sooner in illicit activities but will wait longer before exercising their stock options. Indeed, a higher value of $\Pi/2$ reduces the manager's probability to be convicted sooner and thus leads him to cheat sooner and to wait longer before exercising his stock option in order to further profit from the differential in the stock return drift.

5 A comparison between both remuneration policies

In this section, we address the main question raised in this study, namely does the type of equity-based compensation affect the manager's incentives to engage in illicit activities? For that purpose, let us assume that the distribution rule of the shareholders is defined in such a way that, at date t_0, when the options are distributed, shareholders are indifferent between giving x shares or m stock options to the managers. Let one denote by y the ratio of m/x. The shareholders would like to distribute a number of

stock options such that the dollar value of both compensation packages be equal to D. More precisely, at date t_0, m and x should satisfy:[26]

$$x S_{t_0} = mCA(S_{t_0}) = D.$$

Thus, following the same line of reasoning as in the previous sections, this constraint can be rewritten as follows:

$$\begin{aligned} S_{t_0} &= y\, e^{-r(t_1-t_0)} E_{t_1}(e^{-r(T_1-t_1)} SOL_{T_1}) \\ &= y\, e^{-r(t_1-t_0)} E_{t_1}\left(e^{-r(T_1-t_1)}(L_3^* - K)(S_{t_1}/L_3^*)^{\theta_1}\right). \end{aligned}$$

Finally, the above equation reduces to

$$y = e^{r(t_1-t_0)} S_{t_0}^{-\theta_1+1} L_3^{*\theta_1} e^{-(\theta_1(\mu_1-\delta)+\theta_1(\theta_1-1)\sigma^2/2)(t_1-t_0)}/(L_3^* - K). \tag{14}$$

We now numerically compare the incentives to cheat associated, respectively, to stock and stock option compensation plans under a random maturity legal process. Figure 3 clearly shows that, from the shareholders perspective, stocks are preferable to stock options. Indeed, stocks display a wider licit region which finishes at 11.5 years as opposed to 3.2 years for the stock options and, in the illicit region, the trigger value for cheating is higher with stocks than with stock options unless the legal system is clearly inefficient (that is $E(\Delta T)$ greater than 13.5 years).

The main result obtained in this study, and illustrated in Fig. 3, can be summarized in the following proposition:

Proposition 3 *When the legal settlement date is not fully predictable, and for an equal dollar of initial compensation, the stock option compensation package generates higher incentives to cheat than the dollar equivalent stock based compensation package.*

Intuitively, the fact that the option to cheat has a lower exercise boundary in the case of the stock option based compensation package is due to the fact that its underlying—namely the stock option—presents greater convexity than the common stock. Furthermore, the difference between incentives to cheat under, respectively, stock options and stock grants is largest when out-of-the money calls are distributed to the managers.

This comparison between both equity-based compensation forms emphasizes an important externality of stock option compensation plans. Indeed, we have shown that stock options can exacerbate fraudulent incentives of managers operating in inefficient legal systems relative to stocks. According to our results, stock based compensation plans should thus offer more security to the shareholders since they are more likely to reduce managers' incentives to engage in illicit activities for an equal dollar compensation package. This conclusion is consistent with the empirical findings by

[26] Note that in this cash-neutral comparison, we once again assume that, for accounting purposes, the shareholders value the newly issued stock options in the licit world.

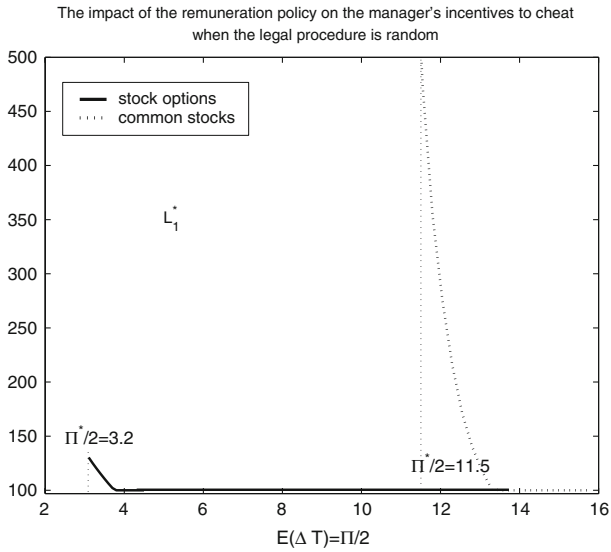

Fig. 3 The level of the stock price at which the manager will engage in illicit activities (L_1^*) as a function of the mean value of the length of the legal procedure ΔT, i.e., $E(\Delta T)$, under different remuneration policies: (i) when the manager receives stock options, and (ii) when the manager receives common stocks, and when the legal procedure is random (with a uniform distribution over [0, Π]). Capitalizations of stock options and common stocks are both equal to 5 millions. The other parameters are: $S_{t_0} = K = 67.03$, $S_{t_1} = 100$, $r = 0.10$, $\mu_1 - \delta = 0.08$, $\mu_2 - \delta = 0.20$, $\mu_3 - \delta = 0.02$, $\sigma = 0.15$, A =500,000, C =100,000, D =5,000,000, $\eta = 0.2$, $t_1 = 5$

Burns and Kedia (2006) who document, based on a study of U.S. firms accounts' restatements, that stock options sensitivity is positively related to firms' misreporting practices while such a relationship is not statistically significant for pure equity-based compensation plans. This conclusion is also consistent with the observation that several large corporations such as Credit Suisse have over the recent years—and before the regulation on expensing options has even been changed—modified their compensation plans and now distribute common stocks rather than stock options.

6 Conclusion

In this study, we have developed a continuous-time real options' model to analyse managers' incentives to cheat in the presence of stock or stock option based compensation plans. The manager who cheats is modifying the drift of the stock price process in order to benefit from a higher stock valuation. If he decides to cheat, he will face corruption costs as well as a reputational loss when he is convicted. The corruption costs and the reputational loss represent, respectively, explicit and implicit utility costs associated with the exercise of the option to cheat.

When the maturity of the legal settlement process is not fully predictable, we find that managers will, for specific values of the base case parameters and, especially when

justice is very efficient, remain honest. The model shows that higher reputational costs or higher corruption costs will delay managers' decision to cheat in the illicit region.

In light of the recent corporate scandals reported by the international press, it is clear that some managers were exploring the limits of accounting standards to hide losses, to reduce excess leverage ratios or to smoothen profits. This study demonstrates that such a behavior can be magnified under stock option remuneration packages and/or under less efficient legal systems. Indeed, the main message from this study is that the manager will always have incentives to engage in illicit activities sooner if he owns stock options rather than stocks. The exacerbated incentives to cheat provided by stock options result from the fact that such a compensation plan displays convexity unlike the stock based compensation package. Thus, from the perspective of the shareholders, stock compensation plans are preferable since they reduce managers' incentives to illicitly alter the drift of the stock returns. However, stock options grants have other well known benefits, namely they induce managers to take on more risky projects and from this perspective can benefit the shareholders who fear managers' excessive cautiousness. Ultimately, from the shareholders perspective, the respective benefits, in the form of enhanced risk—taking incentives, and costs, in terms of exacerbated fraud risks, associated with stock options grants have to be traded-off in order to reach a firm conclusion on behalf of their optimal choice of managerial compensation. This interesting subject remains however beyond the scope of this study and is thus left for future research.

In summary, this study provides a first attempt to apply the continuous-time real options' approach to analyse and value the impact of managers' compensation policies on their decisions to engage in illicit activities. The predictions of the theoretical model are consistent with the recent empirical study by Burns and Kedia (2006). This model corroborates their empirical findings in proving that stock options induce stronger incentives to cheat than stock based compensation packages. The model's predictions are rather conservative since we have ignored the prescription period that surrounds most corporate crimes and whose omission has in our case generated even lower managerial incentives to cheat.

Finally, a policy implication stemming from our theoretical insights into stock option grants is that the degree of convexity associated with equity-based compensation contracts should be monitored with scrutiny especially when these contracts are granted in countries with inefficient legal systems that thus better serve managerial fraud incentives.

Acknowledgements The authors would like to thank Andriy Demchuk, Benoit Metayer and Carsten Murawski from the University of Zurich for their excellent computer assistance as well as their valuable comments. We are also grateful to Michel Habib from the University of Zurich, to Ingolf Dittmann from Humboldt University as well as the participants to the EFMA 2004 Conference in Basel, to the Finrisk Research Day in Bern as well as to the participants of the AFFI 2004 Conference in Paris for their insightful comments. Financial Support by the National Centre of Conmpetence in Research "Financial Valuation and Risk Management" and the University of Zurich Research Priority Program in Finance are acknowledged.

References

Black, F., & Scholes, M. (1973). The pricing of options and corporate liabilities. *Journal of Political Economy, 81*, 637–654.

Burns, N., & Kedia, S. (2006). The impact of performance-based compensation on misreporting. *Journal of Financial Economics, 79*, 35–67.

Cadenillas, A., Cvitanic, J., & Zapatero, F. (2004). Leverage decision and manager compensation with choice of effort and volatility. *Journal of Financial Economics, 73*, 71–92.

Carpenter, J. (1998). The exercise and valuation of executive stock options. *Journal of Financial Economics, 48*, 127–158.

Carpenter, J. (2000). Does option compensation increase managerial risk appetite? *The Journal of Finance, 55*(5), 2311–2332.

Core, J. E., Guay, W. R., & Larcker, D. F. (2003). Executive equity compensation and incentives: A survey. *Federal Reserve Bank of New York Economic Policy Review, April*, 27–50.

Degeorge, F., Patel, J., & Zeckhauser, R. (1999). Earnings management to exceed thresholds. *Journal of Business, 72*(1), 1–33.

Dittmann, I., & Maug, E. (2003). *Lower salaries and no options: The optimal structure of executive pay*. Unpublished Working Paper. Humboldt University of Berlin.

Guay, W. (1999). The sensitivity of CEO wealth to equity risk: An analysis of the magnitude and the determinants. *Journal of Financial Economics, 53*, 43–71.

Holmstrom, B. (1979). Moral hazard and observability. *Bell Journal of Economics, 10*, 74–91.

Huddart, S. (1994). Employee stock options. *Journal of Accounting and Economics, 21*, 5–43.

Ingersoll, J. E. (2002). *The subjective and objective evaluation of incentive stock options*. Yale Working Paper No. 02-07.

Johnson, S. A., Ryan, H. E., & Tian, Y. S. (2003). *Executive compensation and corporate fraud*. Unpublished Working Paper, Louisiana State University.

Lambert, R., Larcker, D., & Verrecchia, R. (1991). Portfolio considerations in valuing executive compensation. *Journal of Accounting Research, 29*, 129–149.

Marcus, A., & Kulatilaka, N. (1994). Valuing employee stock options. *Financial Analysts Journal, 50*, 46–56.

Omberg, E. (1987). The valuation of American put options with exponential exercise policies. *Advances in Futures and Options Research, 2*, 117–142.

Palmrose, Z., Richardson, V., & Scholz, J. (2001). *Determinants of market eactions to restatement announcements*. Unpublished Working Paper, University of Southern California.

Ross, S. A. (2004). Compensation, incentives and the duality of risk aversion and riskiness. *The Journal of Finance, 59*(1), 207–225.

Smith, M. (1996). Shareholder activism by institutional investors: Evidence from CalPERS. *The Journal of Finance, 51*, 227–252.

Tadelis, S. (2001). *The market for reputations as an incentive mechanism*. Unpublished Working Paper, Stanford University.