

More Manipulation, Less Risk Taking?

Sharon Hannes¹ and Avraham Tabbach^{1*}

¹ Faculty of Law, Tel Aviv University, Israel

*Correspondence: Avraham Tabbach, Faculty of Law, Tel Aviv University, Israel. E-mail: adtabbac@post.tau.ac.il; Tel: +972 3 6408108

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Abstract

Executive stock options are a dominant component of managers pay in the United States. This common compensation feature entails two perverse side effects: driving managers to engage in manipulative practices, and generating excessive risk-taking. Tellingly, some scholars blame the first side effect for the wave of Enron-style fraud in 2001-2002 and the second for the 2007-2010 financial crisis. To date, however, no one has investigated the interaction between these two types of adverse incentives, for manipulation and risk-taking. In this paper, we study the effects of manipulation practices on risk-taking decisions of managers holding large amounts of stock options. We first show that *sufficient* manipulation restrains excessive risk-taking but it does not impede managers from taking beneficially risky projects. We then show that mild levels of manipulation have complex effects on managers' preference for risk taking, but they too tend to decrease risk taking. Our analysis suggests that when regulation improves disclosure and impedes manipulative practices, excessive risk taking may erupt. Policy-wise, we recommend that anti-manipulative regulatory policies be accompanied by measures designed to prevent excessive risk taking.

JEL Classifications: G18, G32, G38, J33, K22

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1. Introduction

Executive stock options (ESOs) have become since the 1990s a major component of managers' compensation package in the United States (Murphy, 1999, 2013). While in 1985, the value ESOs grants amounted to only 8% of the average total CEO compensation in the largest U.S. companies (Barris, 1992), in the 1990s it grew rapidly and steadily, peaking at 78% in 2000 and 76% in 2001 (Bebchuk & Grinstein, 2005; Hall, 2003). One of the widely accepted economic justifications of this phenomenon is that equity ownership in general and stock options in particular may mitigate the agency problems between shareholders and managers in public firms resulting from the separation of ownership and control.

In recent years, however, there is a growing theoretical and empirical evidence that large amounts of ESOs may not align the interests between shareholders and managers but rather induce two perverse behavioral effects. Particularly, it may drive managers to engage in all sorts of manipulative practices that inflate stock prices in the short run, and it may encourage managers to take excessively risky decisions, that is, risk beyond the level desirable by shareholders.

Tellingly, some researchers, regulators and the popular press blame, at least partially, the first perverse incentive for the wave of Enron-style fraud in 2001-2002 and the second perverse incentive for the 2007-2010 financial crisis. Interestingly, however, to date, no one has investigated the interaction between these two types of adverse incentives, for manipulation and risk-taking, and the relationship between the two crises. This is the task of the present paper.

Manipulation: The popular press and regulators have for a long time blamed the compensation packages bestowed on managers for some of the high-profile corporate scandals in the U.S. in the turn of the Century, scandals that allegedly contributed to the 2001-2002 financial crisis. Recently, academic studies provided solid support to these popular views (Hannes, 2010). These studies demonstrate that ESOs induce managers to manipulate corporate earnings and commit accounting fraud so as to boost market valuations and enrich themselves by exercising options at inflated stock prices (Cheng & Warfield, 2005; Bergstresser & Philippon, 2006; Burns & Kedia, 2006, 2008; Efendi, Srivastava, & Swanson, 2007; Peng & Roel, 2008; Johnson, Ryan Jr., & Tian, 2009). Other studies also show a rather widespread backdating of ESOs (Lie, 2005; Heron & Lie, 2007, 2009; Narayanan & Seyhun, 2008), which again benefit managers usually at the expense of shareholders who suffer tremendous damage when such practices are exposed (Jensen, 2005; Narayanan, Schipani, & Seyhun, 2007; Bernile & Jarrell, 2009).

Risk Taking: Similarly, the popular press and regulators have held the compensation packages of managers at financial institutions that heavily relies on ESOs a contributing factor to the financial crisis of 2007-2009.¹ According to these views, large amounts of ESOs encourage managers to take excessive risk taking, including excessive levels of leveraging. From an academic, scientific perspective, the story is more complex because stock options with their convex payoff structure were used in the first place to encourage risk taking. Many studies provide evidence that managers do respond to ESOs incentives and take more risks. (Guay, 1999; Knopf, Nam, & Thornton, 2002; Rajgopal & Shevlin, 2002; Chen, Steiner, & Whyte, 2006; Coles, Daniel, & Naveen, 2006). What is harder to establish is whether the induced risk taking by managers is excessive, that is, beyond the optimal level desired by shareholders. Recently, however, there is a growing theoretical and empirical evidence that ESOs may indeed sometime induce too much risk (Lambert, 1986; Ju, Leland, & Senbet, 2003; Raviv & Landskroner, 2009; Romano & Bhagat 2009; Dong, Wang, & Xie, 2010; Bebchuk & Fried 2010).

In this paper, we take these perverse incentives as a starting point and study the effects of manipulative practices, and in particular stock price manipulation and backdating, on risk-taking decisions of managers holding large amounts of stock options. While the relationship between manipulation and risk taking is complex, our analysis shows, perhaps counter-intuitively, that manipulation tends to restrain risk taking. The explanation for this outcome is that a manipulative manager will not want to jeopardize the fruits of her manipulative wrongdoing by taking on too much risk that may drive her stock options out of the money and thus prevent her from benefiting fully from the manipulation.

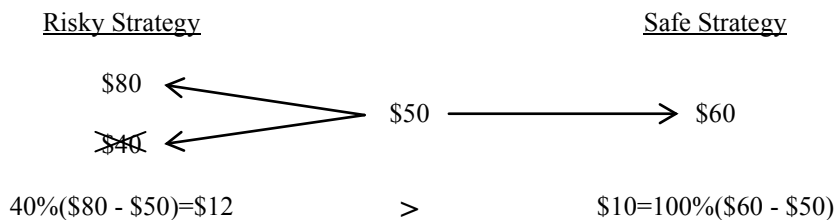
Our argument that manipulation restrains risk taking has empirical content. It predicts a link between the financial crisis of 2001-2002, the regulation adopted in response to it, and the financial crisis of 2007-2010. According to our theoretical argument, in a lax environment concerning manipulative practices, managers holding large amounts of ESOs will engage in manipulative behavior (such as inflating stock prices and backdating) but will restrain their risk taking decisions.

¹ See, for example, Press Release, U.S. Dep't of the Treasury, Statement by Treasury Secretary Tim Geithner on Compensation (June 10, 2009), *available at* <http://www.treasury.gov/press-center/press-releases/Pages/tg163.aspx> ("This financial crisis had many significant causes, but executive compensation practices were a contributing factor. Incentives for short-term gains overwhelmed the checks and balances meant to mitigate against the risk of excess leverage.").

This may lead to the wave of Enron-style fraud cases culminating in the crisis of 2001-2001. As a response to this crisis, the regulator in the US and elsewhere imposed severe anti-manipulation measures, including an overhaul of the accounting industry, which has effectively constrained managers ability to engage in manipulative practices (Dyck, Morse, & Zingales, 2010). This led, in accordance with our argument, to greater risk taking on the part of managers, which eventually resulted in the 2007-2010 mega-crisis. Thus, according to our view, the regulation that was meant to tackle the manipulation problem and that did so successfully contributed to the excessive risk-taking problem.

To illustrate our main argument consider the following numerical example ignoring considerations of the time value of money and risk-adjusted returns. Suppose that a firm's manager should decide on her business strategy between two alternative strategies: a conservative, safe strategy that would, with certainty, increase the firm's share prices by \$10, from \$50 to \$60 a share, and a risky strategy that would with 40% chance increase share prices by \$30 from \$50 to \$80 a share and with 60% chance would reduce share prices by \$10 from \$50 to \$40 a share (as illustrated in Table 1). Under such circumstances, shareholders clearly prefer that the manager would select the safe strategy over the risky one, since the former increases share prices by \$10 a share, while the latter increases average share prices from \$50 to \$56 a share ($0.4 \times 80 + 0.6 \times 40$), that is, by only \$6 a share. However, option-based compensation may push the manager towards the undesirable risky strategy, since options allow her to benefit from the upside of a risky decision without suffering the consequences of its downside. In this example, and assuming the manager can exercise her options at the baseline price of \$50 per share, the value of the safe strategy for the manager is \$10 per option ($\$60 - \50). On the other hand, the value of the risky strategy for the manager is \$12 (40% ($\$80 - \50)).

Table 1. Classical effects of stock option on risk taking



This familiar story about the possible risk-inducing nature of call options does not account, however, for the possibility that managers may engage in manipulative practices. If managers can manipulate share prices or change favorably the exercise price of their option (e.g., engage in backdating of their option) sufficiently, they will, perhaps counter-intuitively, forego their preference for excessive risk. To illustrate this, suppose that the manager can either inflate by 10% or more the stock prices or reduce the exercise price on her option by \$4 or more. These possibilities turn the outcome of our example on its head, and reverse the manager's preference for the risky strategy. With stock price manipulation, if the manager opts for the safe strategy she could exercise her options for a profit of \$16 per option ($\$60 \times 110\% - \50), while if she chooses the risky strategy, the manager could earn an expected profit of only approximately \$15 (40% ($\$80 \times 110\% - \50)) (Table 2). Similarly, if the exercise price is reduced (through backdating) by \$4 and set at \$46, the safe strategy would offer now a gain of \$14 per option ($\$60 - \46), whereas the risky strategy would offer a profit of approximately \$13 (40% ($\$80 - \46)) to the manager (Table 3). Greater manipulation or a more aggressive backdating would merely intensify the manager's changed preference for the safe strategy.

Table 2. Effects of stock price manipulation on risk taking

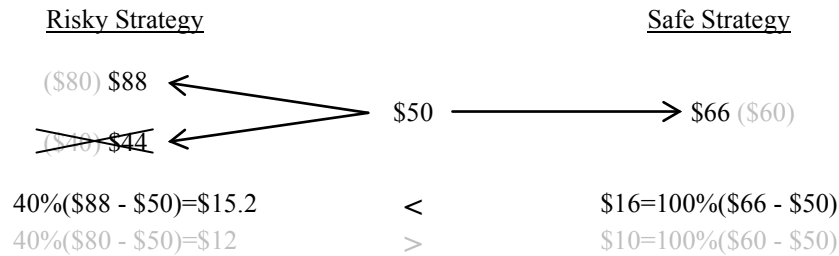
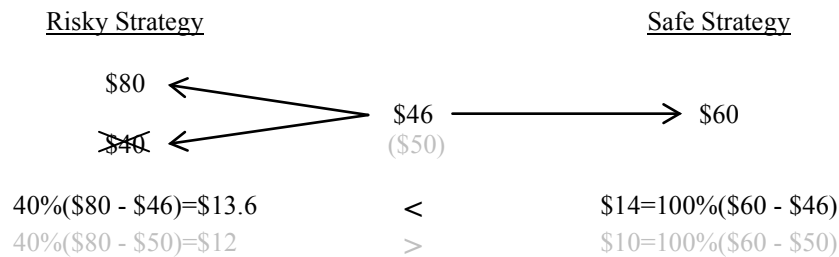


Table 3. Effects of backdating on risk taking



As we show in the paper the outcome of the above examples regarding stock price manipulation and backdating are generalizable, applying to any two business strategies out of which one is riskier but less valuable than the other, to any affine transformation of stock prices, and taking into consideration the time value of money and risk-adjusted returns. As we demonstrate, there always exists a threshold level of stock price manipulation or backdating, for which managers who originally prefer a risky strategy, contrary to shareholders' desire, would reverse their preference and choose the safer strategy (Proposition 1). As we also show, in the opposite scenario, in which shareholders prefer the riskier strategy among alternative business strategies, stock price manipulation and backdating would not cause a manager who also originally prefers the riskier strategy, to opt for a safer strategy than that favored by the shareholders (Proposition 2). Thus, while manipulation of both types pushes managers away from excessively risky business strategies, it does not reverse their preference for beneficially risky business strategies. The explanation for these results is that manipulation increases the likelihood that stock options will be exercised, and therefore it causes the manager to behave more like a shareholder. The ironic result is that reprehensible practices, such as stock price manipulation and backdating, better align managers' risk-taking preferences with those of shareholders.

While manipulation above some threshold level causes the manager to behave like a shareholder, it does not follow that manipulation below the threshold level will push the manager towards the strategy that shareholders prefer. This point is important because other factors, besides the holdings of stock options, may influence the manager's risk-taking decision. For instance, risky business strategies may endanger the manager's position or her salary and harm her reputation and human capital. Hence, if mild manipulation can enhance the manager's stock option-driven preference towards the riskier strategy, it may tilt the relative value of the strategies to a degree that would reverse the manager's overall preference for the efficient and safer strategy. Therefore, we analyze the influence of stock price manipulation and backdating on the relative value of different business strategies prior to the threshold level where such influence reverses managers' preference towards the safer and efficient strategies. We derive complex and subtle results that depend on the form of the manipulative practice. As per stock price manipulation, we show that it unambiguously pushes

the manager away from the excessively risky strategy only when the safer strategy is sufficiently safe (i.e., its volatility is lower than a cutoff value defined in the paper) or much more valuable to shareholders than the riskier strategy. Otherwise, mild levels of stock price manipulation may actually increase the relative preference of the manager towards the excessively risky strategy, although higher levels of manipulation reverse this trend (Proposition 4).² In contrast, backdating always pushes the manager away from the excessively risky strategy, even before it reaches the threshold level that reverses her taste for risk (Proposition 3).

The explanation for these subtle results is due to two conflicting effects. The first effect stems from the fact that higher volatility increases the probability that at the money options will end up out of the money. This tends to reduce the relative value of riskier strategies vis-à-vis safer ones in the presence of stock price manipulation or backdating, since it reduces the likelihood that the manager will reap the fruits of her action. We call this effect the "out of the money" effect or figuratively the "rocking the boat" effect, since it means that managers will not want to endanger the fruits of their manipulation by taking more risks. The second contradicting effect follows because volatility increases future stock prices in "good states" of the world, while reducing it in "bad states" of the world. This tends to increase the relative value of stock price manipulation (but not of backdating) on riskier strategies as long as stock price manipulation inflates stock prices proportionally. This is because a stock-option holder enjoys the increase in future stock prices, without suffering from the decrease. We call this effect the "upside inflation" effect. Unless the safer strategy is completely safe or sufficiently more valuable than the riskier strategy, with increasing volatility, the upside inflation effect dominates the rocking the boat effect (although again more manipulation would eventually cause the rocking the boat effect to reverse this trend).³

All the above – regarding the effects of manipulation on the relative preference of managers – holds for the case in which options are granted at (or in) the money, which for various reasons we discuss in the paper has been the common case in practice. To complete the analysis we study a currently rare case, but a possibly more typical one in the future, in which options are granted out of the money. Interestingly, the results we obtain are in a sense a mirror image of the case where options are granted at or in the money. In particular, focusing on beneficially risky business strategies, we show that stock price manipulation always increases the relative value of the riskier strategy vis-à-vis the safer one, while backdating has this effect provided that the safer strategy is sufficiently safe or the riskier strategy is much more valuable than the safer one (Propositions 5 and 6). We shall leave the explanation for these subtle results for the text.

The remainder of the paper is organized as follows. Part 2 sets the model and analyzes the effects of sufficient stock price manipulation and backdating on the incentives of managers holding executive stock options to take risks. In Part 2.1, we examine the effects of both types of manipulation on excessive risk taking, that is, on risks that are undesirable from shareholders

² To illustrate this possibility, suppose in the example in the text, the existence of an even riskier strategy that has a 30% chance of increasing share prices by \$70 from \$50 to \$120 a share and a 70% chance of reducing share prices by \$30 from \$50 to \$20 a share. The NPV of this risky strategy is \$50 (30% 120+70% 20), which is lower than the NPV of the moderately risky strategy \$56 (40% 80 + 60% 40). For a manager holding a stock option, this riskier strategy is worth \$21 (30% (120-50)), far more than the (moderately) risky strategy, which was worth only \$12 (40% (80 - 50)). Now, a stock price manipulation that increases future stock prices by 25% would increase the value of a stock option with this riskier strategy from \$21 to \$30 (30% (125% 120 - 50)), that is, by \$9, while increasing the value of the stock option with the moderately risky strategy from \$12 to \$20 (40% (125% 80 - 50)), that is, by \$8. Thus, stock price manipulation increases the value of an option on a riskier strategy more than on a safer strategy.

³ In the previous example, even though a stock-option holder enjoys the fruits of her manipulation more often with the safer strategy (40% with the safer strategy versus 30% with the riskier strategy) – the rocking the boat effect – with the riskier strategy there are more fruits to inflate (30% with the riskier strategy versus 20% with the safer strategy) – the upside inflation effect.

perspective, while in Part 2.2, we examine the case of beneficially risk taking, that is, risks that are desirable for shareholders. Part 3 explores a slightly different question, namely, how mild levels of stock price manipulation and backdating affect the "relative value" of the different business strategies. Part 4 concludes the discussion. Some proofs are relegated to the appendix.

2. The Effects of Manipulation on Risk-Taking

To capture in a simple yet insightful way the effects of manipulation on risk taking decisions of managers holding large amounts of executive stock options consider the following scenarios. Suppose the manager of a firm should choose between two alternative business strategies that last for one period, say, a year, having the following characteristics:

Table 4. Profile of the different business strategies

Business Strategy	NPV	Rate of Return	Volatility
Safer Strategy	s^s	r_s	σ_s
Riskier Strategy	s^r	r_r	σ_r

We assume there is a one to one correspondence between the characteristics of the business strategies and the stock. Suppose the R strategy is riskier than the S strategy in both total and systematic risk. This means that the annual volatility of a business strategy is greater for the R strategy than for the S strategy, $\sigma_r > \sigma_s$, and also that the annual required rate of return is higher for the R strategy than for the S strategy, $r_r > r_s \geq r_f$, where r_f is the annual risk free rate of return. We assume that both business strategies have non-negative net present value (NPV), but we impose no restriction on their ranking, so that the R strategy may be more valuable, less valuable, or equally valuable to the S strategy from the perspective of shareholders. This assumption captures the notion that risk may be, but by no means is, bad for shareholders. We shall say that the R strategy is "excessively risky" if shareholders (weakly) prefer the S strategy over the R strategy, that is, if $s^s \geq s^r$. Otherwise, we shall say that the R strategy is "beneficially risky".

Ideally, shareholders would like the manager to choose the business strategy that maximizes share value, which means in the present framework, the strategy with the higher NPV. However, shareholders do not observe ex-ante the choices that are available to the manager. Instead, shareholders rely on the managers' decision, which is influenced by the compensation package they hold. For various tax and accounting reasons, executive stock options granted at the money have become the dominant element in managers' compensation package.⁴ We therefore assume the

⁴ Two of the most important driving forces in the design of executive pay are tax and accounting regulations (Scholes, Wolfson, Erickson, Maydew, & Shevlin, 2005, pp. 211-254). Both forces indeed drive firms to use options, in particular non-discounted options, vis-à-vis other instruments. As per accounting, until 2004 the traditional accounting standard (APB #25, 1972) did not require any charge against earnings for option grants unless issued in-the-money. Hence, options, in particular non-discounted options, offered a substantial accounting advantage. The rationale for this traditional accounting view was that the value of non-discounted options is hard to evaluate. The new accounting standard (SFAS 123R) required expensing of all options starting from 2004, but at the very same time the tax advantage of at-the-money options became increasingly important. Generally speaking, options as a compensation tool offer a tax advantage over restricted stock. While restricted stock is taxed when vested, options are not taxed at vesting but rather at the time of exercise (some qualified options are even taxed later upon the sale of the underlying shares, while their gains are taxed at preferential rates). However, preferential tax treatment for options has an important limitation. Under I.R.C. section 409A, enacted in 2004, discounted options are taxed upon vesting and not at the time of exercise. Moreover, the recipients of such options must pay an additional excise tax at the rate of 20%. Therefore, it is no wonder that discounted options are nonexistent in U.S. firms, even if they are considered optimal from a risk-taking standpoint. Interestingly, the tax legislation amendment of 2004 is representative of a general hostility of the tax code towards discounted options, which dates back 50 years (Walker, 2009).

manager of the firm holds a significant amounts of European call options on the stock with a strike price k and an exercise date of one period, that is, a year, where $k < s^i$. However, for the sake of completeness we shall at times relax this assumption and differentiate between $k \leq e^{r_f} s^s$ and $k > s^s e^{r_f}$, where $s^s e^{r_f}$ is the one year forward price of the stock with the S strategy. The significance of this assumption will become clear later. For simplicity and tractability reasons, we shall also assume, as is not atypical in the literature, that the manager values her stock options according to Black-Scholes option pricing model.⁵ However, our main argument, that manipulation generally restrains risk taking should carry to other valuation methods. Under Black-Scholes option pricing model, the option value with strategy $i \in \{s, r\}$ is.

$$c^i = \gamma s^i N(d_1^i) - k e^{-r_f} N(d_2^i) \quad (1)$$

Where

$$d_1^i = \frac{\ln\left(\frac{\gamma s^i}{k}\right) + r_f + \sigma_i^2 / 2}{\sigma_i} \quad \text{and} \quad d_2^i = d_1^i - \sigma_i \quad (2)$$

and where γ , which is defined below, is equal to 1.⁶

Roughly speaking, the Black and Scholes formula says that the value of a call option can be decomposed to two elements $s^i N(d_1^i)$ and $k e^{-r_f} N(d_2^i)$. The former reflects the expected net present value of receiving the stock and the latter reflects the expected net present value of paying the strike price. The expectation for both terms reflect the risk adjusted probability that the option finishes in the money and both use the risk free rate of return as the discount factor. As it turns out, one beautiful aspect of the Black and Scholes formula is that instead of using the real probability that the option finishes in the money and the real discount factor that should apply to the option payoff (which is hard and tricky to measure since options are riskier than the underlying asset on which they are written and therefore require a higher discount factor than the one applied to the underlying asset), one can adjust the probability distribution of stock prices in such a way that the present value of any stock-price contingent claim (including the value of the stock itself and of a call option) is equal to the expected future payoff, computed using the adjusted probabilities and discounted at the risk free rate of return. Therefore, $N(d_2^i)$ reflects the risk adjusted (or risk neutral) probability that the option finishes in the money. On the other hand, $s^i N(d_1^i)$ reflects the expected net present value of receiving the stock, but $N(d_1^i)$ ($> N(d_2^i)$) does not reflect the risk adjusted probability. The reason is that the value of receiving the stock is not independent from the

⁵ There are numerous studies both theoretical and empirical in the finance literature adopting the assumption that managers value their executive stock option compensation according to Black-Scholes option pricing model. Indeed, all the empirical studies we refer to in the Introduction use Black-Scholes option pricing model as the measure for valuing stock option held by managers. Moreover, executive stock options are regularly reported and valued in practice in accordance with Black-Scholes option value. On the other hand, in the last twenty years, there is a growing literature, arguing that Black-Scholes option pricing model (as well as other capital-asset pricing models) are not suitable to value executive compensation packages, because managers cannot fully diversify (see, for example, Lambert, Larcker, and Verrecchia (1991), Hall and Murphy (2002) and Carpenter (2000)). Notwithstanding the logic of this strand in the literature, we chose to adopt the standard assumption of Black-Scholes pricing, for two main reasons: first, it is a standard assumption in the finance literature; second, in contrast to other methods which require specific ad hoc assumptions regarding the degree of risk aversion, the composition of the compensation package, the wealth of the manager, and the availability of the manager to diversify unique or systematic risks, Black-Scholes option pricing do not require these assumptions and it allows derivation of relatively clear predictions. As pointed out, our main argument, that manipulation restrains risk taking carries over to other valuation methods.

⁶ We suppress the notation for T (time to expiration) since in our example the call option is for one year, so T=1.

probability of receiving the stock. In other words, the conditional expectation is that the value of the stock be greater than the strike price. As we will see below, these elements play an important role in our analysis.

It should be emphasized that the assumption that the manager values her stock options in accordance with the Black-Scholes option pricing model does not imply that the manager is risk neutral. Quite to the contrary, the Black-Scholes option price accounts for attitudes towards risks as well as for the time value of money, as it completely depends on the market value of stocks and bonds. Like other capital asset pricing models, it does, however, makes implicit assumptions about the functioning of the market and about the ability of investors to diversify.

We turn to analyze the manager's decision to adopt the S or R strategy and how it differs from the interests of shareholders. We conduct our analysis under two alternative scenarios. In the first scenario, we assume that stock prices can be manipulated; in particular, they can be inflated in all future states of the world proportionally, regardless of the strategy chosen by the manager (we defend and discuss the implication of this assumption in the concluding remarks, Part 4.1). We let $\gamma \geq 1$ be the "manipulation factor" that is the proportion of stock price increase, and assume, as seems realistic, that it does not change the required rate of return on the different strategies.

In the second scenario, we assume that the manager can affect (reduce) the strike price of the call option, as might be the case with the practice of backdating. We assume for now that the manager's choice is driven solely due to her holding of the call option. This is quite reasonable given the large amounts of ESOs bestowed on managers relative to other compensation component. Later we shall discuss how other parameters may affect her decision. For clarity, we analyze separately the case where the S strategy is more valuable to shareholders than the R strategy (i.e., Excessively Risky Strategy) and where the reverse is true (i.e., Beneficially Risky Strategy).

2.1. Excessively Risky Strategies

Suppose that the S strategy is (weakly) more valuable to shareholders than the R strategy, that is, $s^S \geq s^R$. Then the interests of shareholders and managers are not necessarily aligned; in particular, managers may prefer the R strategy over the S strategy, the S strategy over the R strategy, or may be indifferent between the strategies, all according to $c^R \geq \leq c^S$.

The explanation for the possible misalignment between managers and shareholders is straightforward and well known. Ceteris paribus, a call option is more valuable the higher is the price and the greater is the volatility of the underlying asset.⁷ Therefore, if the NPV of the S strategy is only slightly higher than the NPV of the R strategy, while the volatility of the R strategy is sufficiently greater than the volatility of the S strategy, the manager holding a call option will prefer the R strategy over the S strategy. If the reverse is true, and the NPV of the S strategy is sufficiently higher than the NPV of the R strategy, while the volatility of the R strategy is only slightly greater than the volatility of the S strategy, the manager like shareholders will prefer the S strategy.⁸

⁷ Formally, the delta (reflecting the derivative of a call option with respect to the current value of the underlying asset) and vega (reflecting the derivative of a call option with respect to the volatility of the underlying asset) of a call option are both positive.

⁸ To illustrate suppose that $s^S = 100$, $\sigma_S = 10\%$, $s^R = 95$, $\sigma_R = 40\%$, $k = 100$ and $r_f = 5\%$. Then $c^S = 6.8$ while $c^R = 15$, that is, $c^S < c^R$. On the other hand, if we increase the NPV of the S strategy to 105 and increase its volatility to 30% (i.e. $s^S = 105$, $\sigma_S = 30\%$) without changing the parameters of the R strategy, then $c^S = 17.5$, so that $c^S > c^R$.

Consider the effects on shareholders of backdating or possible manipulation of financial statements and reports resulting in a proportional increase in stock prices in all future states of the world. Backdating has no direct effect on stock prices. On the other hand, stock price manipulation may have a direct impact on stock prices. In particular, if changes in stock prices were real and known to shareholders, stock prices would immediately increase from s^i to γs^i .⁹ Therefore, from the perspective of shareholders, the S strategy not only remains more valuable than the R strategy but it actually becomes even more valuable. However, assuming that shareholders, on average, and at least in the long run, are not going to benefit from such stock price manipulations, all these changes are not real changes but only virtual ones. From the perspective of the manager, things are different, as stated in the following proposition:

Proposition 1

Suppose that the S business strategy is weakly more valuable than the R business strategy to shareholders $s^S \geq s^R$. Then

(1) If a manager holding a call option is indifferent between the strategies or if she prefers the S strategy over the R strategy, that is, if $c^S \geq c^R$, then any backdating or stock price manipulation will make the manager strictly prefer the S strategy.

(2) If the S strategy is less valuable to a manager holding a call option than the R strategy, $c^S < c^R$, then for manipulation levels γ exceeding a cut-off value $\bar{\gamma}$ defined implicitly by $c^S(\bar{\gamma}) = c^R(\bar{\gamma})$, and for backdating exceeding a cut-off value \bar{k} defined implicitly by $c^S(\bar{k}) = c^R(\bar{k})$, the manager will prefer the S strategy and maximize shareholders value.

To prove the first part we will show that, under its conditions, the rate of change of the option with respect to the strike price (in the case of backdating) and the manipulation factor (in the case of stock price manipulation) is greater for the S strategy than for the R strategy. The rate of change in the value of the option as γ increases and k decreases is $s^i N(d_1^i)$ and $e^{-rf} N(d_2^i)$ respectively (see Appendix 1). Now, by assumption $c^S \geq c^R$, or using (1) and rearranging, $s^S N(d_1^S) \geq s^R N(d_1^R) + ke^{-rf}(N(d_2^S) - N(d_2^R))$. From which it follows, as proven in Appendix 2, that $N(d_2^S) > N(d_2^R)$ and therefore that $s^S N(d_1^S) > s^R N(d_1^R)$, which proves part 1.

The proof of part (2) follows from the continuity of option prices with respect to γ and k . In particular, if $c^S < c^R$, then sufficiently small changes in γ and k will not alter managers' preference for the R strategy. At the same time, for a sufficiently large changes in γ and k , managers will switch their preference towards the S strategy, that is, c^S will become larger than c^R . The reason is that for a sufficiently large increase of γ or decrease of k , the call option becomes deep in the money, and therefore its value converges to the value of the stock minus the present value of the strike price

⁹ The reason for that is the following. Proportional increase in future stock prices in all the state of the world is equivalent to increasing the scale of the strategies by the proportion γ . In terms of holding stocks, it is equivalent to someone who increases her holding of shares by the proportion γ . Doing so should clearly not affect the required rate of return on the stock or on the strategies. Therefore, proportional increase in future stock prices is equivalent to increasing the expected value of the strategies by the proportion γ without affecting the discount factor. Alternatively, if future stock prices in all states of the world can be increased by some constant amount, say, $v > 0$, then arguably the required rate of return on v is different than the required rate of return on the stock. Indeed, it should be the risk free rate of return. Other forms of manipulation may be associated with different required rates of return.

(that is, $s^i - e^{-r_f}k$). In other words, for a sufficiently large increase of γ or reduction in k , a call option holder stands in the same position as a shareholder (but for the present value of the strike price). Since, by assumption, shareholders prefer the S strategy over the R strategy, managers will prefer the S strategy as well. Moreover, from part (1) it follows that once the manager is indifferent between the strategies further increase of γ or decrease of k will make him strictly prefer the S strategy and will also make the S strategy become relatively more and more valuable than the R strategy. Therefore there exists $\bar{\gamma}$ and \bar{k} such that $c^r = c^s$, which define cutoff values of stock price manipulation and backdating such that for minor manipulation (i.e., $\gamma < \bar{\gamma}$) or backdating (i.e., $k > \bar{k}$) the manager still prefers the R strategy over the S strategy, but for major manipulation (i.e., $\gamma \geq \bar{\gamma}$) and backdating (i.e., $k \leq \bar{k}$) the manager prefers the S strategy over the R strategy.¹⁰ This proves part (2).

Figures 1 and 2 illustrate proposition 1(2) for the case of stock price manipulation and backdating respectively, for the values $s^S = 100$, $\sigma_s = 10\%$, $s^r = 95$, $\sigma_s = 40\%$, $k = 100$ and $r_f = 5\%$. Without manipulation or backdating, the option values are $c^S = 6.8$ and $c^r = 15$. The critical value of misrepresentation is approximately $\gamma = 1.3$ and for backdating it is $k=77$. At these values the option prices are $c^S = c^r = 34.88$ ($\gamma = 1.3$) and $c^S = c^r = 27$ ($k=77$).

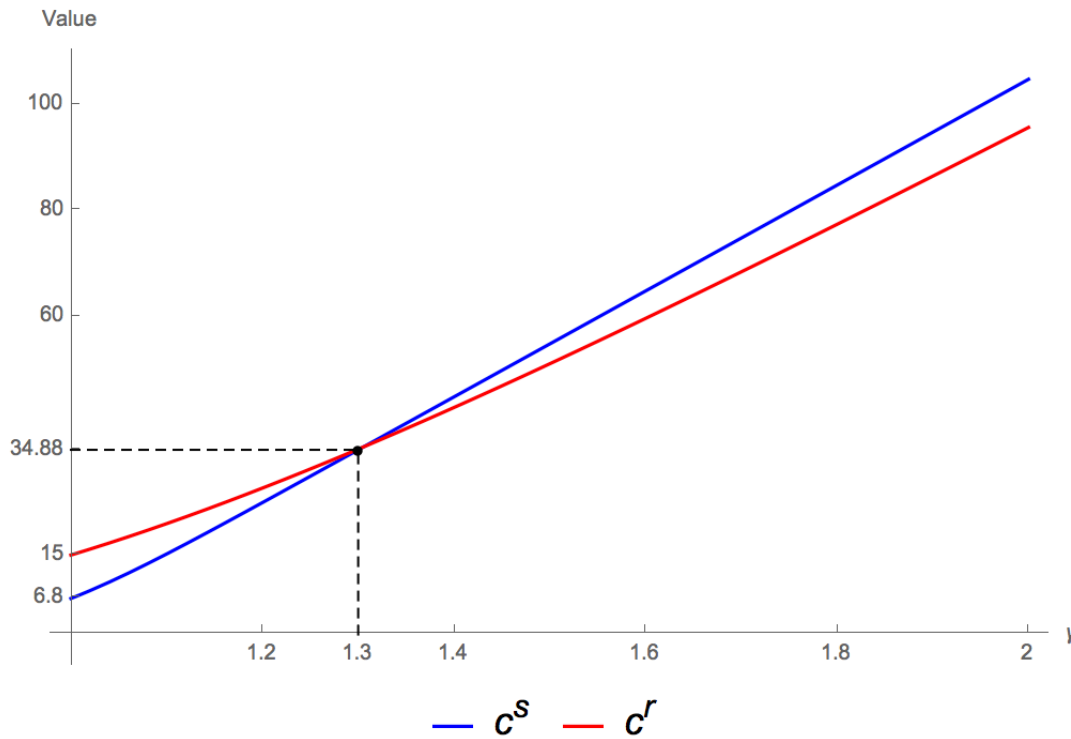


Figure 1. Value of stock options as γ changes

¹⁰ We assume here that in case of indifference, the manager chooses the strategy that is more valuable to shareholders.

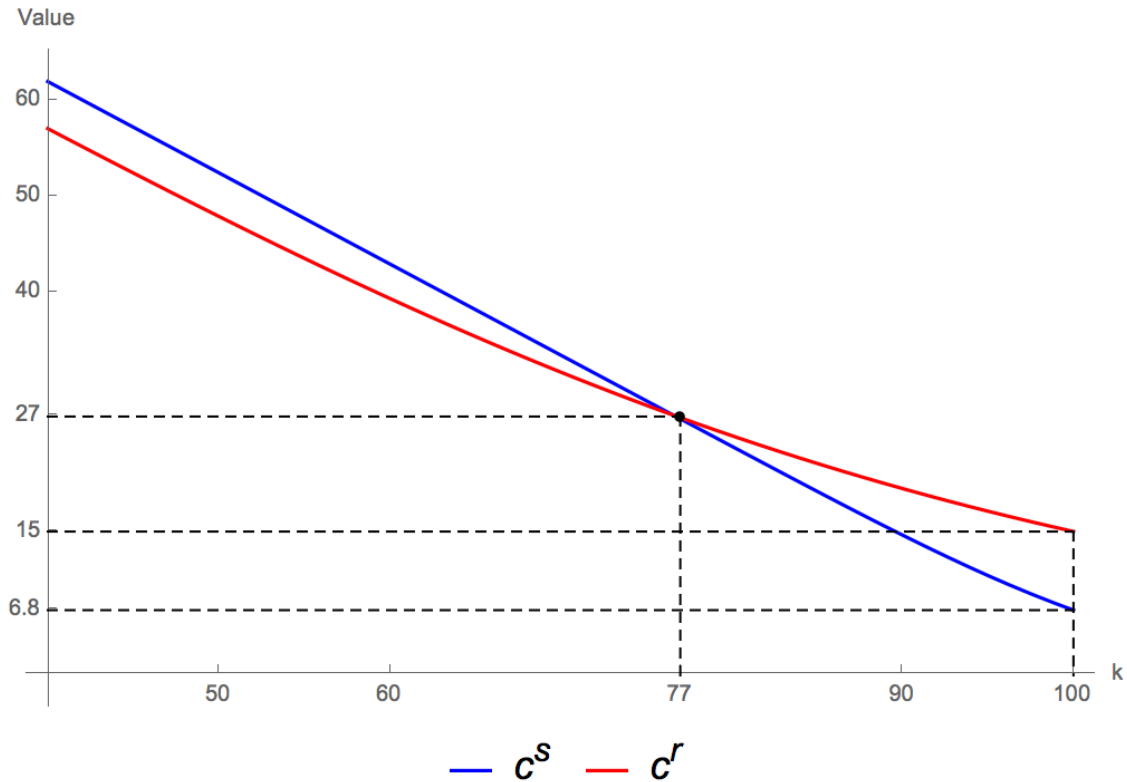


Figure 2. Value of stock options as k changes

2.2. Beneficially Risky Strategies

Suppose alternatively that the R strategy is weakly more valuable to shareholders than the S strategy, that is, $s^r \geq s^s$. Then the interests of shareholders and managers are aligned in the sense that the manager never prefers a strategy that the shareholders oppose. Indeed, concentrating on the effects of holding a call option, the manager will prefer the R strategy. The explanation is simple. As pointed above, ceteris paribus, a call option is more valuable the higher is the price and the greater is the volatility of the underlying asset. Since the R strategy has a higher NPV and greater volatility than the S strategy, its value for a manager holding a call option is greater than the value of the S strategy.

Consider again the (virtual) effects of stock price manipulation or backdating on shareholders. Backdating again does not affect shareholders preference for the R strategy, while stock price manipulation makes the R strategy even more valuable than the S strategy. As a result, managers will maintain their preferences for taking the R strategy. We state this in the following proposition without proof.

Proposition 2

If the R strategy is (weakly) more valuable than the S strategy for shareholders, then a manager holding a call option on the stock always prefers the R strategy over the S strategy even if stock prices can be manipulated or strike prices can be backdated.

3. Backdating, Manipulation and the Relative Value of the Strategies

Thus far we analyzed the decision of a manager to adopt a riskier or a safer business strategy assuming that she cares solely about the value of a call option she holds and assuming she values the call option according to Black and Scholes option-pricing model. In this part, we explore a slightly different question, namely, how stock price manipulation and backdating affect the “absolute value difference” between or the “relative value” of the different strategies. Does the R strategy become relatively more or less valuable than the S strategy to the manager? This question is important because, a manager's decision to take the R or S strategy may be influenced not merely by her holding of call options but by other parameters as well, such as the human capital the manager has in the corporation and other components of his compensation package such as non-contingent salary. These parameters tend to make the manager less inclined to take risks than shareholders. Therefore understanding how the “relative value” of the strategies is influenced as a result of stock price manipulation and backdating can help us understand better the overall effects of stock price manipulation and backdating on risk taking.

From a manager’s perspective, the relative value of the strategies is determined by a comparison between the rate of change of the option price with respect to changes in the manipulation factor and the strike price when the S and R strategies are taken. That is, by a comparison between $s^S N(d_1^S)$ and $s^R N(d_1^R)$ in the case of stock price manipulation, and between $N(d_2^S)$ and $N(d_2^R)$ in the case of backdating. We shall say that the S strategy becomes relatively more valuable than the R strategy in the case of stock price manipulation if $s^S N(d_1^S) > s^R N(d_1^R)$ and in the case of backdating if $N(d_2^S) > N(d_2^R)$ and vice versa.

From the analysis in the previous section it follows that the S strategies becomes relatively more valuable than the R strategy if the manager (weakly) prefers the S strategy over the R strategy, that is, if $c^S \geq c^R$. This is because $c^S \geq c^R$ implies that $N(d_2^S) > N(d_2^R)$ and $s^S N(d_1^S) > s^R N(d_1^R)$. In this trivial case, then, backdating and stock price manipulation increase the relative value of the S strategy over the R strategy.

The harder and more interesting case is when the manager prefers the R strategy over the S strategy, that is, $c^S < c^R$. As Proposition 1(2) proves for stock price manipulation and backdating not exceeding the cut-off values $\bar{\gamma}$ or \bar{k} respectively, the manager will still prefer the R strategy over the S strategy. The question we are interested in is whether the manager’s preference for the R strategy diminishes monotonically with backdating and stock price manipulation. As we will show, under plausible general assumptions the answer is yes, implying that stock price manipulation and backdating generally increase the relative value of safer strategies vis a vis riskier strategies. Therefore, loosely speaking, manipulation induces less risk taking. However, as we shall demonstrate, there are certain circumstances under which the opposite may be true.

Since $c^S < c^R$ is consistent with shareholders preferring either the S strategy or the R strategy, we shall accordingly distinguish in our analysis between an excessively risky strategy and a beneficially risky strategy. In addition, since options are typically granted at the money, we shall start by assuming that $k < e^{rf} s^i$, that is, the strike price is lower than the forward price of the stock with either the R or S strategy. Later we shall explore the consequence of relaxing this assumption, which may become relevant these days.

3.1. Standard Case: $k < e^{rf} s$

3.1.1. Excessively Risky Strategies

Proposition 3 (Backdating)

If the S strategy is more valuable to shareholders but less valuable to managers than the R strategy and $k < e^{rf} s^i$, then backdating increases the relative value of the S strategy over the R strategy.

To prove proposition 3 one needs to show that $N(d_2^S) > N(d_2^R)$. Analytically, $N(\cdot)$ is a monotonically increasing function of its argument, so $N(d_2^S) > N(d_2^R)$ is equivalent to $d_2^S > d_2^R$, or explicitly, to

$$\frac{\ln(s^S/k) + r_f - \sigma_s^2/2}{\sigma_s} > \frac{\ln(s^R/k) + r_f - \sigma_r^2/2}{\sigma_r} \quad (3)$$

Now d_2 is an increasing function of the price and a decreasing function of the volatility of the underlying asset. Formally, $\frac{\partial d_2}{\partial s} = \frac{1}{s\sigma} > 0$ and $\frac{\partial d_2}{\partial \sigma} = -\frac{d_1}{\sigma} < 0$, assuming $k < e^{rf} s^i$ which implies that $\ln(s^i/k) + r_f > 0$. Since $s^S \geq s^R$ and $\sigma_s < \sigma_r$ it follows that $d_2^S > d_2^R$ and $N(d_2^S) > N(d_2^R)$, which completes the proof.

Proposition 3 states that backdating monotonically reduces the relative value of the R strategy vis-à-vis the S strategy from the manager's perspective, and therefore induces less risk taking. Intuitively, proposition 3 means that the manager gains more from any 1 dollar reduction in the strike price of her option when she takes a safer strategy that is more valuable to shareholders, than a riskier strategy that is less valuable to shareholders.

A nice way to see this is through the interpretation of $N(d_2)$. As pointed out above, $N(d_2)$ can be interpreted as the risk-adjusted or risk neutral probability that an option ends up in the money (see, for example, Nielsen, 1993). It follows that the effects of backdating on the relative value of the strategies, from the manager's perspective, depends completely on the question whether the risk adjusted probability that the option ends up in the money is greater with the S strategy or with the R strategy. With this interpretation, Proposition 3 implies that, under its conditions, the risk adjusted probability that the option finishes in the money is always greater for a more valuable safer strategy than a less valuable riskier strategy. This reflects the "out of the money" or "rocking the boat" effect we coined in the Introduction.

The reader should note, however, that the risk adjusted probability that an option ends up in the money is different from the actual probability that the option will end up in the money. The former uses the probability that would apply if investors were risk neutral and would therefore require a risk free rate of return on the stock (without changing the stock price), the latter uses real probabilities. Proposition 3 uses the risk-adjusted probability rather than the actual probability. It is possible that the actual probability that an option ends up in the money is greater for the R strategy than for the S strategy, but still backdating will increase the relative price of the S strategy rather than the R strategy!¹¹ The reason why the actual probabilities are not a good measure to apply is

¹¹ To illustrate consider the following two stocks: Stock R (from footnote 13) has the following characteristics $s=100$, $\sigma=40\%$, and $r=20\%$. Assuming the stock can take two values in one period, we calculated that the actual probability of increase is $p^*=67\%$ and the risk adjusted probability is $p=46\%$ (the stock price can either increase by roughly 50% or decrease by 33%, and p^* solves $100=e^{-0.2}(150p^* + (1-p^*)67)$), while p solves $100=e^{-0.05}(150p + (1-p)67)$. Consider now Stock S with the following characteristics $s=100$, $\sigma=30\%$, and $r=10\%$. This stock can either increase by 35% or decrease by 26%. The actual probability of an increase q^* solves $100=e^{-0.1}(135q^* + (1-q^*)74)$, that is, $q^*=60\%$. The risk adjusted probability q is 51% (solves $100=e^{-0.05}(135q + (1-q)74)$). As one can see, even though stock S is safer than stock R, the actual probability that a call option with strike price of 100 will finish in the money is *greater* for stock R than for stock S ($67\% > 60\%$)! However, the risk adjusted probability that the call option will finish in the money is indeed greater for stock S than for stock R ($51\% > 46\%$).

that we don't really know what discount factor to apply to different future payments. In contrast to backdating, the effect of stock price manipulation on the relative values of the strategies is more subtle, as stated in the following proposition.

Proposition 4 (Stock Price Manipulation)

Suppose that the S strategy is more valuable to shareholders but less valuable to managers than the R strategy and that $k < e^{r_f} s^l$. Then stock price manipulation increases the relative value of the S strategy over the R strategy, if the volatility of the S strategy does not exceed a threshold value $\bar{\sigma}_s$ or the value of the S strategy exceeds a threshold value \bar{s}^s both implicitly defined by $s^s N(d_1^s) = s^r N(d_1^r)$.

To prove proposition 4 one needs to show that for a “sufficiently” safe or valuable S strategy, that is, low σ_s , or high s^s , $s^s N(d_1^s) > s^r N(d_1^r)$. Since $s^s \geq s^r$, a sufficient condition for stock price manipulation to increase the relative value of the S strategy over the R strategy is that $N(d_1^s) > N(d_1^r)$. Recall that $N(d_1)$ is the delta of a call option, that is, the rate at which the value of a call option changes with the value of the underlying asset; It is the cumulative standard normal distribution evaluated at d_1 . Since $\frac{\partial N(d_1)}{\partial s} = \frac{1}{s\sigma} N'(d_1) > 0$ it follows that $N(d_1)$ increases with the value of the underlying asset.

Figure 3 depicts $N(d_1)$ as a function of the volatility of the underlying asset for the values $s = 100$, $k = 100$ and $r_f = 5\%$.

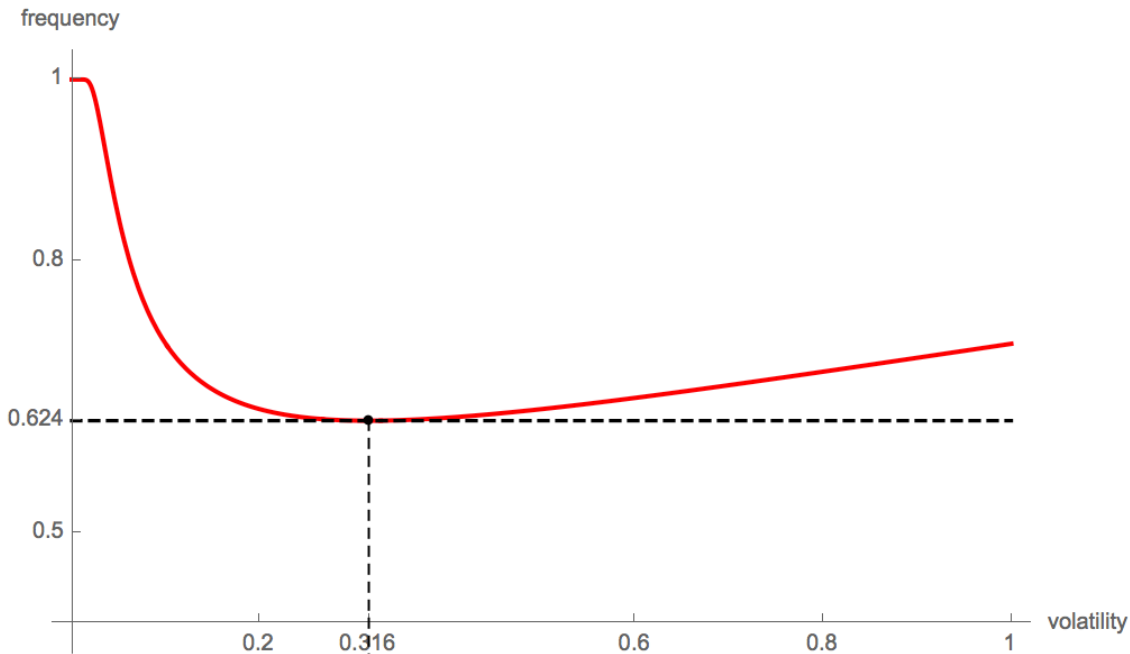


Figure 3. $N(d_1)$ and volatility ($k < e^{r_f} s$)

As is evident from Figure 3 this relationship is non-monotonic. Analytically, $N(d_1)$ is a monotonically increasing function of d_1 , so $N(d_1^s) > N(d_1^r)$ is equivalent to $d_1^s > d_1^r$, or explicitly, to:

$$\frac{\ln(s^s/k)+r_f+\sigma_s^2/2}{\sigma_s} > \frac{\ln(s^r/k)+r_f+\sigma_r^2/2}{\sigma_r} \quad (4)$$

The shape of $N(d_1)$ as a function of σ is determined by $\frac{\partial N(d_1)}{\partial \sigma} = \left(\frac{\sigma-d_1}{\sigma}\right) N'(d_1) \cdot N(d_1)$, therefore, obtains its (interior) minimum value at $\sigma = d_1$, that is, at $\sigma = \sqrt{2(\ln(\frac{s}{k}) + r_f)}$ (in Figure 3 $\sigma_{min} = 31.6\%$). It decreases sharply from one for $\sigma < \sqrt{2(\ln(\frac{s}{k}) + r_f)}$, and increases slowly to one for $\sigma > \sqrt{2(\ln(\frac{s}{k}) + r_f)}$.¹² It follows then that for sufficiently low σ , d_1 becomes sufficiently large and so $N(d_1)$ approaches 1 ($\lim_{\sigma \rightarrow 0} N(d_1) = 1$). Indeed, for sufficiently low σ , the LHS in (4) is larger than the RHS of (4). Moreover, there exists a value of σ_s for which $s^S N(d_1^S) \geq s^R N(d_1^R)$ and for which for all values not exceeding it, stock price manipulation increases the relative value of the S strategy over the R strategy.¹³

The second part follows straightforwardly because even if $N(d_1^S) < N(d_1^R)$, a sufficiently valuable safer strategy that satisfies $s^S \geq s^R N(d_1^R)/N(d_1^S)$ would increase the relative value of the safer strategy vis a vis the riskier strategy.

Proposition 4 implies that there might be strategies that are more valuable to shareholders but less valuable to managers holding call options for which stock price manipulation increases the relative value of the riskier strategy over the safer strategy. According to proposition 4 these safer strategies cannot be sufficiently safer or valuable than the riskier strategies. If the S strategy is completely safe ($\sigma_s = 0$), then proposition 4 means that manipulation increases the relative value of the safe strategy vis a vis the riskier strategy. The explanation for this would be that with a completely safe strategy the option always ends up in the money (since $k < e^{rf} s^l$) and therefore the manager captures the entire benefits of her manipulation. The same thing cannot be said if the S strategy is also risky, since then there will be instances where the option will end up out of the money, and so the manager will not reap the entire benefits of her manipulation.

To understand why proposition 4 is restricted to “sufficiently” safe or valuable strategies one needs to understand how volatility affects future stock prices. The key point is that volatility increases future stock prices in some states of the world, while reducing them in other states of the world. More precisely, volatility affects future stock prices in asymmetrical way which is skewed to the right, that is, towards higher prices. One way to see why future stock prices must be skewed to the right is to recall that stocks prices are bounded below since stock prices cannot be negative, but are not bound above. This implies that stock prices can increase by more than 100% but cannot decrease by more than 100%. In terms of stochastic processes, stock prices are assumed to follow a lognormal distribution which is skewed to the right.

Therefore, an increase in the volatility of a strategy has two effects regarding the value of stock price manipulation. On the one hand, as demonstrated above, higher volatility decreases the risk adjusted probability that the option will end up in the money. This tends to reduce the relative value of stock price manipulation, since in the bad states of the world the manager will not benefit, at least

¹² The second order sufficient condition for a minimum $\frac{\partial^2 N^2(d_1)}{\partial \sigma^2} = \frac{2(\ln(\frac{s}{k})+r_f)}{\sigma^3} > 0$ is satisfied.

¹³ To illustrate suppose that $k=100$, $s^s=100$, $s^r=98$, $r_f=5\%$ and $\sigma_r=60\%$, then the cut off value is 20%, which means that for all strategies with NPV 100 (indeed, 98 or more) and volatility less than or equal to 20%, stock price manipulation increases the relative value of these strategies over the riskier strategy. Note if the volatility of the R strategy is 40%, then stock price manipulation will increase the relative value of the S strategy for all relevant volatilities. The same is true if the value of the R is 95.

not entirely, from her actions. On the other hand, higher volatility increases the upside value of the stock proportionally more than it reduces the downside. This tends to increase the relative value of stock price manipulation on riskier strategies as long as manipulation inflates stock prices proportionally, since option payoffs are convex.¹⁴ As is evident in Figure 3, starting from a riskless strategy, an increase in the volatility of a strategy reduces the relative value manipulation, since it increases the probability that the option will end up out of the money. However, with ever increasing volatility, the second force comes to dominate and the more than proportional increase in the value of the stock in the good states of the world more than offsets the decrease in the probability that the option will end up out of the money.

3.1.2. Beneficially Risky Strategies

In the previous part we showed that if shareholders prefer the R strategy over the S strategy, managers will also prefer the R strategy over the S strategy and backdating or stock price manipulation will not alter this preference. However, backdating or stock price manipulation may affect the relative value of the strategies. In particular, they may decrease or increase the relative value of the S strategy over the R strategy.

Even though backdating and stock price manipulation tend to increase the relative value of safer strategies over riskier strategies, for sufficiently valuable riskier strategies the reverse may be true.

To see this recall that the effects of stock price manipulation on the relative values of the strategies depend on the comparison between $s^S N(d_1^S)$ and $s^R N(d_1^R)$. Now even if the S strategy is completely safe, $\sigma_S = 0$, such that $N(d_1^S) = 1$, while the R strategy is risky and therefore $N(d_1^R) < 1$, it still might be the case that s^R is sufficiently greater than s^S so that $s^R N(d_1^R) > s^S N(d_1^S)$. Indeed, with a completely safe strategy, s^R should satisfy $s^R > s^S / N(d_1^R)$ for stock price manipulation to increase the relative value of the R strategy over the S strategy.¹⁵

As to backdating, recall that the effects of backdating on the relative value of the strategies depend on the risk adjusted probability that the option finishes at the money. Now, as shown above, the risk adjusted probability increases with the value of the underlying asset, but decreases with its volatility. Thus, if the R strategy is more valuable than the S strategy, the effect of backdating on the relative value of the strategies is ambiguous.¹⁶

In contrast to stock price manipulation, with backdating a sufficiently more valuable riskier strategy does not guarantee an increase in the relative value of the R strategy. This is so for the case where the safe strategy is completely safe (i.e., $\sigma_S = 0$). In this case, the manager reaps the entire benefits of backdating if he takes the S strategy, and therefore taking the R strategy cannot offer more.

3.2. Rare Case: $k > e^{rf}s$

The analysis thus far assumed that options are granted at the money. Therefore, $k < e^{rf}s$. In this part we will discuss the implications of relaxing this assumption. In particular, we shall assume that $k > e^{rf}s$. For simplicity, we shall carry our analysis under the assumption that the R strategy is

¹⁴ Another way to see this point is to recognize that the expected net present value of receiving the option can be written as $N(d_1)e^{-rf}E[S_T | S_T > k]$. But higher volatility decreases $N(d_1)$ but increases $E[S_T | S_T > k]$.

¹⁵ To illustrate, suppose that $s^S = 100$, $\sigma_S = 0\%$, $\sigma_R = 40\%$, $k = 100$ and $r_f = 5\%$. Then $s^S N(d_1^S) = 100$. Then $s^R \geq 124$ increases the relative value of the R strategy over the S strategy.

¹⁶ To illustrate the possibility that backdating may increase the relative value of the R strategy over the S strategy suppose that $s^S = 100$, $\sigma_S = 20\%$, $s^R = 120$, $\sigma_R = 40\%$, $k = 100$ and $r_f = 5\%$. Then $N(d_1^S) = 0.55$ and $N(d_1^R) = 0.65$.

more valuable to shareholders than the S strategy, i.e., for a beneficially risky strategy. The consequences concerning an excessively risky strategy are straightforward.

One immediate implication of $k > e^{rf} s^S$ is that the call option is worthless for a completely safe strategy (i.e., $\sigma_s = 0$). Since option prices are continuous with k and σ , it is also immediate that small scale backdating and stock price manipulation will not change the fact that the option is worthless with a completely safe strategy. More generally, however, one can prove the following result.

Proposition 5 (Stock Price Manipulation)

Suppose that the R strategy is more valuable to shareholders and to managers than the S strategy and that $k > e^{rf} s^S$. Then stock price manipulation increases the relative value of the R strategy over the S strategy.

To prove proposition 5 one needs to show that $s^r N(d_1^r) > s^s N(d_1^s)$. Since $s^r \geq s^s$ a sufficient condition for this to be true is that $N(d_1^r) > N(d_1^s)$. But $N(d_1)$ is an increasing function of both the value of the underlying asset and its volatility, for $k > e^{rf} s^S$. Formally, $\frac{\partial N(d_1)}{\partial s} = \frac{1}{s\sigma} N'(d_1) > 0$ and $\frac{\partial N(d_1)}{\partial \sigma} = \left(\frac{\sigma - d_1}{\sigma}\right) N'(d_1) = -\frac{d_2}{\sigma} N'(d_1) > 0$. This completes the proof.

As to backdating, the effects are more subtle. The following proposition can be proven.

Proposition 6 (Backdating)

Suppose that the R strategy is more valuable to shareholders and managers than the S strategy and that $k > e^{rf} s^i$. Then backdating decreases the relative value of the S strategy over the R strategy, if the volatility of the S strategy does not exceed a threshold value $\bar{\sigma}_s$ or the value of the R strategy exceeds a threshold value \bar{s}^r both implicitly defined by $N(d_2^r) \geq N(d_2^s)$.

To prove proposition 6 one needs to show that for a sufficiently safe strategy, that is, low σ_s , or valuable risky strategy, high s^r , $N(d_2^r) > N(d_2^s)$. Recall that $N(d_2)$ reflects the risk adjusted probability that an option finishes in the money. Recall further that $N(d_2)$ is increasing with the value of the underlying asset. Therefore, there necessarily exists a threshold value of the R strategy, implicitly defined by $N(d_2^r) \geq N(d_2^s)$, such that for all values exceeding it, the relative value of the S strategy decreases. Figure 4 depicts $N(d_2)$ as a function of the volatility of the underlying asset.

As is evident from Figure 4 the relationship between $N(d_2)$ and volatility is non-monotonic. Analytically, the shape of $N(d_2)$ is determined by the sign of $\frac{\partial N(d_2)}{\partial \sigma} = -\frac{d_1}{\sigma} N'(d_2)$. $N(d_2)$, accordingly, obtains its (interior) maximum value at $\sigma = \sqrt{-2(\ln(\frac{s}{k}) + r_f)}$ (in terms of Figure 4 at $\sigma_{min} = 31.6\%$). It increases sharply from zero for $\sigma < \sqrt{-2(\ln(\frac{s}{k}) + r_f)}$, and decreases slowly to zero for $\sigma > \sqrt{-2(\ln(\frac{s}{k}) + r_f)}$.¹⁷ It follows then that for sufficiently low σ , d_2 becomes sufficiently small and so $N(d_2)$ approaches zero ($\lim_{\sigma \rightarrow 0} N(d_2) = 0$). More importantly, for sufficiently low σ , the LHS in (3) is smaller than the RHS of (3). Moreover, there exists a value of

¹⁷ The second order sufficient condition for a maximum $\frac{\partial N^2(d_2)}{\partial \sigma^2} = \frac{2(\ln(\frac{s}{k}) + r_f)}{\sigma^3} < 0$ is satisfied.

σ_s denoted $\bar{\sigma}_s$ for which (3) holds with equality and for which for all values not exceeding it $N(d_2^r) > N(d_2^s)$, which implies that backdating decreases the relative value of the S strategy over the R strategy.¹⁸

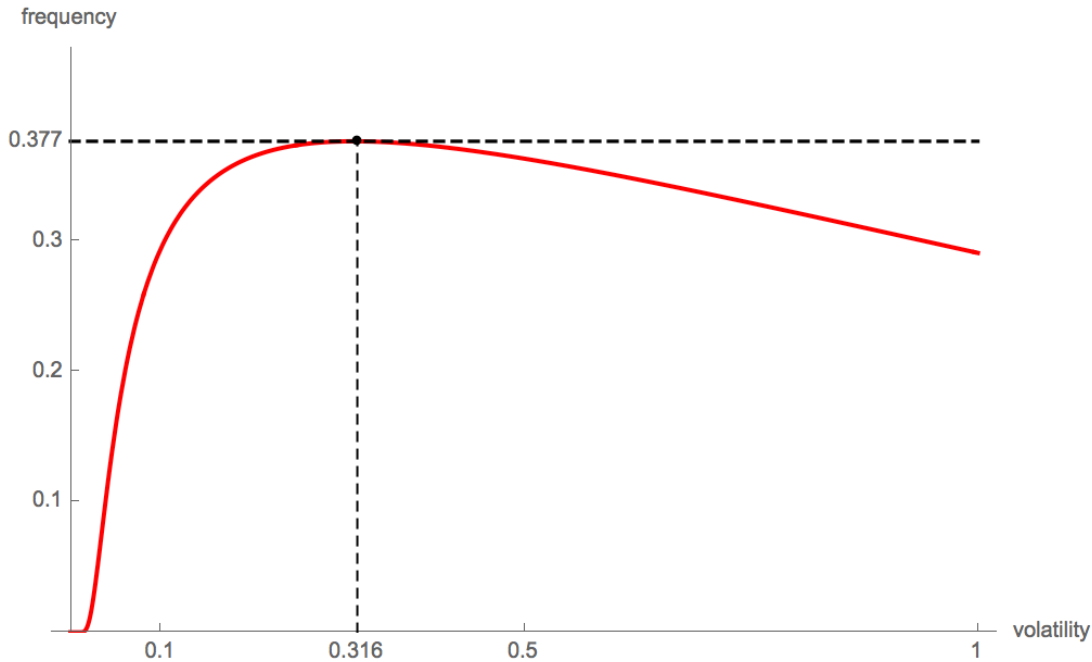


Figure 4. $N(d_2)$ and volatility ($k > e^{r_f} s$)

It is interesting to note the relationship between proposition 3 and proposition 5 and between proposition 4 and proposition 6. Proposition 3 shows that backdating increases the relative value of S strategy over R strategy for all excessively risky strategy provided that the strike price is not deeply out of the money. Proposition 5, on the other hand, demonstrates that stock price manipulation decreases the relative value of the S strategy over the R strategy for beneficially risky strategy, provided that the strike price is deeply out of the money. Similarly, proposition 4 shows that stock price manipulation increases the relative value of the S strategy over the R strategy for excessively risky strategy provided that the S strategy is sufficiently safe and the strike is not deeply out of the money. Proposition 6, in contrast, shows that backdating decreases the relative value of the S strategy over the R strategy for all beneficially risky strategy, provided that the S strategy is sufficiently safe and that the strike price is deeply out of the money.

To intuitively understand propositions 5 and 6 one needs to understand how the risk adjusted probability that an option finishes in the money is affected by the volatility of the underlying asset. This is closely related to how volatility affects the distribution of future stock prices. As noted above, when $k > e^{r_f} s^s$, a sufficiently safe strategy will be out of the money. Therefore, increasing the volatility, in these cases, will increase the likelihood that the option will end up in the money, which tends to increase the relative value of strategies. But as volatility increases further, future stock prices become skewed to the right, but this necessitates a decrease of the probability that

¹⁸ To illustrate, suppose that $k=100$, $s^s=100$, $s^r=102$, $r_f=5\%$ and $\sigma_r=60\%$, then $\bar{\sigma}_s = 14.5\%$ which means that for all strategies with NPV 100 (indeed, 102 or more) and volatility less than or equal to 14.5%, stock price manipulation decreases the relative value of these strategies over the riskier strategy.

future stock prices will be high and therefore that the option will end up in the money. It follows that the relationship between the risk adjusted probability that an option finishes in the money and volatility is non-monotonic, as indeed is evident in Figure 4 and suggested by Proposition 6.

As to stock price manipulation, recall that as volatility increases future stock prices are skewed to the right, and this tends to increase the relative value of riskier strategies since manipulation inflates stock prices proportionally. Proposition 5 implies that this effect always dominates the ambiguous effect volatility has on the probability that the option finishes in the money.

4. Concluding Remarks

In this paper we analyzed the effects of stock price manipulation and backdating on the risk-taking incentives of managers holding stock options. We showed that manipulation has complex and subtle effects on managers' incentives, but, in general, it tends to restrain risk taking. Indeed, we demonstrated that manipulation exceeding a certain threshold reverses managers' preference for risk that is not favored by shareholders. The explanation of our results is that a manipulative manager will not want to jeopardize the fruits of her wrongdoing by taking on too much risk that may drive her stock options out of the money. In a fundamental way, then, manipulation aligns the interests of managers and shareholders, because it increases the chances that the manager's stock options will be worth exercising. Indeed, there is a possible contradicting force, because manipulation may inflate the upside of the riskier strategy more than it inflates the upside of a safer strategy, but this effect is eventually dominated by the growing similarity between shareholders and managers that manipulation brings about.

Our theoretical results has an empirical content. They suggest a link between the financial crisis of 2001-2002, the regulation adopted in response, and the financial crisis of 2007-2010. Indeed, our analysis predicts the turn of events that led from the former to the latter crisis. Before the 2001-2002 crisis managers could relatively easily and safely engage in all sorts of manipulative practices which, in accordance with our argument, would restrain their risk-taking behavior. The regulation adopted in the United States and elsewhere in the wake of the Enron 2001-2002 crisis imposed severe anti-manipulation measures, which has effectively constrained managers from engaging in manipulative practices. This has led, in accordance with our prediction, to greater risk taking on the part of managers, which eventually resulted in the 2007-2010 mega-crisis. We call on empiricists to test our theoretical prediction. Policy-wise we recommend that regulators always couple anti-fraud measures with risk-restraining measures. In a sense, this has already happened in 2010 in the United States with the Dodd-Frank Act, but the risk- curbing legislation took place only after the mega crises.

Our analysis and results in this paper are subject to several important limitations, on some of which we briefly touch below.

4.1. Manipulation Technology. We assumed that backdating reduces the strike price and stock price manipulation inflates stock prices in all future states of the world proportionally, regardless of the strategy chosen by the manager. Effectively, in our framework, riskier or safer strategies were not more or less prone to manipulation, although the artificial inflation is larger the higher the upside of the relevant strategy. This assumption is defensible if a priori manipulation is not easier or more lucrative when a safer or a riskier strategy is taken. Obviously, in reality, in certain cases, more opportunities to manipulate the financial statements and indirectly inflate stock prices are present when one type of strategy is pursued. Many may believe, for example, that riskier projects offer more room for manipulation, because they are more complex to understand. Indeed, prior to

the last financial crisis, many firms engaged in risky, complex business that no one could understand. This, of course, would suggest that manipulation may induce more rather than less risk taking. On the other hand, safer business strategies are sometimes the result of business diversification, which creates complex and non-transparent business entities under which manipulation can prosper. All in all, if the possibility of manipulating stock prices and its extent are tied to the risky nature of the strategies, then our results could well be affected, but there would still be an interaction between risk-taking and manipulation incentives that is unidentified in the literature.

4.2. Option valuation. We assumed throughout the analysis that the manager values her stock options in accordance with Black and Scholes' option pricing model. As we have argued, this model is widespread in both theoretical and empirical papers as well as in practice. Under this model, and as manifests in our analysis, stock options are more valuable the greater the risk, that is, volatility, of the business strategy. However, in recent years, there is a growing literature questioning the applicability of the Black-Scholes option-pricing model to valuing managers' stock options, because managers are not diversified and cannot trade freely and hedge the position in their option (for example, Carpenter, 2000). This literature shows that, at least in theory, stock options do not always increase the managerial appetite for risk.¹⁹ This literature requires, however, specific assumptions regarding the wealth of managers, the portfolio they hold (their ability to diversify unique and systematic risks), and their degree of risk aversion. We therefore chose not to follow this literature in our paper, which is the first to tackle the interaction between manipulation and risk-taking incentives. We speculate that our general result that manipulation induces less risk taking holds under alternative stock option valuation models as well, but we leave it to future research to examine this rigorously.

4.3. Systematic and unique risks. We assumed in our analysis that the riskier strategy is riskier than the safer strategy in terms of both systematic and unique risk. In practice, however, there may not necessarily be any correspondence between both types of risks. A strategy can feature high systematic risk with low unique risk, and vice versa. These mismatch possibilities between systematic and unique risk create a further misalignment between shareholders and managers holding stock options. The fundamental reason for this misalignment is that the value of a stock does not (and should not) reflect unique risks but only systematic risk, while the value of an option on that stock reflects both unique and systematic risks. Indeed, recently, Armstrong and Vashishtha (2012), relying on a non-Black and Scholes option-pricing model, argued that stock options provide managers with an incentive to increase systematic risk rather than unique risks, because managers can hedge systematic risks by trading the market portfolio. We again leave it to future research to investigate how manipulation affects this sort of misalignment between shareholders and managers.

Finally, it is important to recognize that our analysis was positive; we took the typical structure of managerial compensation packages and examined how it affects managers' incentives to engage in risk taking when they can manipulate share prices or engage in backdating. In this respect, our analysis can guide shareholders how to improve compensation packages for managers. As we have argued, there were various tax and accounting regulations that favored granting managers with at-the-money stock options, instead of other, more risk-compatible instruments such as in-the-money stock options or restricted stocks. Future research can endogenize the optimal compensation

¹⁹ Although, as we saw, the vast majority of empirical papers do find a positive relationship between stock options and various measures of firm risk.

package into our framework, and account explicitly for the tradeoff between risk incentives and tax and accounting incentives in the presence of manipulation.

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APPENDIX

Part 1: We shall show that $\frac{\partial c}{\partial \gamma} = sN(d_1)$ and $\frac{\partial c}{\partial k} = -e^{-rf}N(d_2)$, while suppressing subscripts and superscripts. We first note that $\frac{\partial d_1}{\partial \gamma} = \frac{\partial d_2}{\partial \gamma} = \frac{1}{\gamma\sigma}$ and $\frac{\partial d_1}{\partial k} = \frac{\partial d_2}{\partial k} = -\frac{1}{k\sigma}$.

Now

$$\begin{aligned}\frac{\partial c}{\partial \gamma} &= sN(d_1) + \frac{1}{\gamma\sigma} (\gamma sN'(d_1) - ke^{-rf}N'(d_2)), \\ \frac{\partial c}{\partial k} &= -e^{-rf}N(d_2) - \frac{1}{k\sigma} (\gamma sN'(d_1) - ke^{-rf}N'(d_2))\end{aligned}$$

But

$$\gamma sN'(d_1) - ke^{-rf}N'(d_2) = 0$$

Therefore,

$$\frac{\partial c}{\partial \gamma} = sN(d_1) \quad \text{and} \quad \frac{\partial c}{\partial k} = -e^{-rf}N(d_2),$$

As required.

Part 2: From $c^s \geq c^r$, it follows that $s^s N(d_1^s) \geq s^r N(d_1^r) + ke^{-rf}(N(d_2^s) - N(d_2^r))$. Therefore, $N(d_2^s) > N(d_2^r)$ implies that $s^s N(d_1^s) > s^r N(d_1^r)$. Since $N(\cdot)$ monotonically increases with its argument, it follows that $d_2^s > d_2^r \leftrightarrow N(d_2^s) > N(d_2^r)$. To summarize,

$$d_2^s > d_2^r \leftrightarrow N(d_2^s) > N(d_2^r) \rightarrow s^s N(d_1^s) > s^r N(d_1^r) \quad .1$$

Now the requirement $c^S \geq c^r$ imposes a restriction on the relationship among the four parameters s^S, s^r, σ_s and σ_r . In particular, if $c^S = c^r$, then the values of any three parameters determine the value of the fourth parameter (while if $c^S > c^r$, the values of any three parameters determine an inequality regarding the value of the fourth parameter). Unfortunately, however, it is not possible to express explicitly any one parameter using the other parameters. Instead the relationship among the four parameters is implicitly determined by $c^S \geq c^r$.

To tackle this problem, we shall look at incremental changes in the value and the volatility of a risky strategy, leading from the risky strategy to the safer strategy while maintaining the inequality $c^S \geq c^r$. In other words, any S strategy with s^S and σ_s and which satisfy $c^S \geq c^r$ can be obtained by starting from the R strategy with s^r and σ_r and then increasing the value of the R strategy slightly and decreasing its volatility appropriately so as to hold constant or increase the value of a call option on the strategy, and then repeating the process. Let ds and $d\sigma$ be the differentials applied to the R strategy. Maintaining $c^S \geq c^r$ requires that the total differential, dc , will satisfy (suppressing sub and superscripts):

$$dc = \frac{\partial c}{\partial s} ds + \frac{\partial c}{\partial \sigma} d\sigma \geq 0 \quad .2$$

But (for $T=1$)

$$\frac{\partial c}{\partial s} = N(d_1) \text{ and } \frac{\partial c}{\partial \sigma} = sN'(d_1).$$

Plugging $\frac{\partial c}{\partial s}$ and $\frac{\partial c}{\partial \sigma}$ into (2) and rearranging, we have:

$$d\sigma \geq -\frac{N(d_1)}{sN'(d_1)} ds \quad .3$$

We shall now use this inequality to analyze how d_2 is affected by changes ds and $d\sigma$. This is given by the total differential:

$$dd_2 = \frac{\partial d_2}{\partial s} ds + \frac{\partial d_2}{\partial \sigma} d\sigma.$$

But

$$\frac{\partial d_2}{\partial s} = \frac{1}{s\sigma} \text{ and } \frac{\partial d_2}{\partial \sigma} = -\frac{1}{\sigma} d_1.$$

Therefore,

$$dd_2 = \frac{1}{s\sigma} ds - \frac{1}{\sigma} d_1 d\sigma \quad .4$$

Now since $d\sigma < 0$, then (4) is clearly positive for $d_1 > 0$. The difficult part is to show that (4) is positive even for $d_1 < 0$. Utilizing inequality (3) we have that

$$\frac{1}{s\sigma} ds - \frac{1}{\sigma} d_1 d\sigma \geq \frac{1}{s\sigma} ds \left(1 + \frac{d_1 N(d_1)}{N'(d_1)}\right).$$

But (for any finite $d_1 < 0$):

$$N(d_1) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{d_1} e^{-\frac{t^2}{2}} dt < \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{d_1} e^{-\frac{t^2}{2}} \left(\frac{t}{d_1}\right) dt = \frac{1}{d_1} \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{d_1} e^{-\frac{t^2}{2}} t dt = -\frac{N'(d_1)}{d_1}.$$

That is,

$$\frac{d_1 N(d_1)}{N'(d_1)} > -1.$$

Therefore,

$$\frac{1}{s\sigma} ds \left(1 + \frac{d_1 N(d_1)}{N'(d_1)}\right) > 0.$$

It follows then that starting from the R strategy, increasing s and decreasing σ while maintaining $c^s \geq c^r$ leads to an increase in d_2 . Thus, $d_2^s > d_2^r$, which according to (1) proves part 2.

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