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YU (FLORA) KUANG

Incentive Effects of Performance-Vested Stock Options

**INCENTIVE EFFECTS OF PERFORMANCE-VESTED
STOCK OPTIONS**

INCENTIVE EFFECTS OF PERFORMANCE-VESTED STOCK OPTIONS

Proefschrift

ter verkrijging van de graad van doctor aan de Universiteit van Tilburg, op
gezag van de rector magnificus, prof.dr. F.A. van der Duyn Schouten, in het
openbaar te verdedigen ten overstaan van een door het college voor
promoties aangewezen commissie in de aula van de Universiteit op dinsdag
30 oktober 2007 om 16.15 uur door

Yu Kuang

geboren op 5 september 1977 te Jiangxi, China

PROMOTOR: Prof. Dr. L.A.G.M. van Lent

COPROMOTOR: Dr. J.P.M. Suijs

to my family

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Almere

September 2007

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Chapter 1: Introduction

1.1 BACKGROUND

The Emergence of Principal-agent Problems

Principal-agent problems arise due to the separation of ownership and management and the presence of information asymmetry between managers and shareholders (Holmstrom, 1979, 1982; Fama, 1980; Fama and Jensen, 1983). Agency theory predicts that the interest of managers conflicts with that of shareholders and that managers choose actions to maximize their own utility, which does not necessarily improve shareholder value. Ample evidence has shown that by using private information about the firm's business, managers might extract rents from the organization at the cost of shareholders (Jensen and Meckling, 1976; Baiman, 1982; Jensen, 2003).

Compensation contracts are designed to provide managers with incentives to select and implement actions that improve shareholder wealth (Jensen and Murphy, 1990). Incentive mechanisms include performance-based bonuses and equity compensation, such as stock and stock options. More specifically, by granting equity compensation, stockholders share any value increase of the firm with managers and managers obtain a claim to the firm's residual value. Since with equity compensation it is in the interest of both shareholders and managers to increase the firm's net profit and long-run market value, stock and stock options have been argued to be efficient in providing managers with value-increasing incentives (Warfield et al., 1995). This also partially explains the intensive grants of equity compensation since the 90s; as a consequence top managers' remuneration has grown dramatically (Murphy, 1999; Jensen, 2003).

Institutional Background of PVSO awards

In the wake of some eye-catching corporate scandals from the beginning of this decade, increasing concerns have been raised regarding managerial compensation (Jensen, 2003; DeFond et al., 2005). One of the major concerns pertains to the incentive effects of traditional stock options (hereafter TSOs). The vesting of TSOs is, in general, contingent only upon the passage of time. Opponents argue that managerial compensation might merely reflect price increases in a rising market. Managers will in such cases receive windfall gains, even if they underperform relative to the market average or to their peers. As a reform on traditional stock option plans, performance hurdles have been introduced as a condition for option vesting. Without clearing these hurdles, managers cannot exercise the options, no matter how long they have held them. Performance-vested stock options (hereafter PVSOs) can be considered as a compensation instrument with ingredients that stem from contingent pay, such as performance-based bonuses, and traditional stock options, respectively.

In the UK, managerial pay level and its association with firm performance are subjects that generate much heated debate among regulators, capital markets, and academics (Conyon et al., 2000; Conyon and Murphy, 2000). Since the 1980s, the rapidly increasing managerial compensation in leading companies (largely due to the growing popularity of stock options) has drawn intensive scrutiny from many commentators (Conyon and Murphy, 2000). It has become a topical policy issue to consider how executive compensation should be crafted so as to provide efficient incentives for higher managerial effort. Concerns about TSOs providing unearned gains to managers were voiced in influential corporate governance codes, issued by Cadbury- (1992), Greenbury- (1995) and the Hamble- (1998) committees, which describe the general framework of management compensation. Substantial changes were witnessed afterwards. For example, all listed firms must now include an audited report on executive remuneration in their annual reports, stating clearly their compensation policy for top managers and describing fully the remuneration packages of executive and non-executive directors. A remuneration committee chaired by an

independent director is responsible for setting the remuneration packages for the CEO and the other directors. At annual general meetings (AGMs), shareholders vote on executive compensation packages. Although it is not mandatory to do so, companies often adhere to the outcomes of these votes (Conyon et al., 2006). Many reforms also took place in managerial compensation, the most prominent of which was to introduce performance hurdles into executive equity compensation, such as stock options. In the post-reform period, the majority of stock option exercises are conditional on the achievement of predetermined performance targets.

Performance targets attached with option vesting are designed to reward managers for performance delivered. The most widely adopted target is the growth rate of earnings per share (EPS) and option vesting requires a firm's growth in EPS exceeds the growth in inflation by prespecified amount. The second most frequently used performance condition is total shareholder return (TSR). When this measure is applied, option vesting usually depends on the market return of a firm relative to a peer group.¹

In the UK, some investors and top managers have voiced doubts about the proposed changes in the compensation system as they believe that firms will suffer a brain drain of top talent when performance targets are attached to option vesting, especially in view of the lack of U.S.-sized pay packages². In spite of this opposition, the recommendations in the corporate governance codes have met with widespread approval and implementation. In 1997, among the largest 200 UK firms, almost 60% of the operating stock option compensation plans for

¹ The choice of performance targets might be due to the distinction in accounting treatment between market-based performance targets (e.g., achieving a specified share price or a specified target based on a comparison of the entity's share price with an index of share prices of other entities) and non-market performance targets (e.g., revenues or profits). IFRS 2 states that the accounting for share-based payments depends on whether the performance condition is market-based, non-market based, or both. More specially, non-market based performance measures should not be included in the determination of the fair value of the share-based payments at the grant date. True-up adjustments are made at interim reporting dates and only the options that vest are ultimately expensed. However, market-based performance conditions should be taken into account when estimating the fair value of the equity instrument granted and thus there is no opportunity for true-up adjusting after option grants. When both performance features are applied to option grants, Paragraph 21 states that the grant date fair value of the share-based payment with market-based performance conditions that has met all its other vesting conditions should be recognized, irrespective of whether that market condition is achieved. But if all vesting conditions are met except the non-market based performance condition, nil expense will be charged (Deloitte, 2004).

² "How U.K. checks CEO pay", *Wall Street Journal*, February 8, 2006.

CEOs were based on performance criteria (Conyon et al., 2000). In the sample of this dissertation, 54% of the firms that adopted stock option plans in their top manager compensation contracts attached performance targets to these stock options in 1999, and this proportion increases to 94% in 2004.

In the US, pension funds and other activist shareholders have been calling for a reform of TSO plans (Gerakos et al., 2005). Since the beginning of this decade, several high profile companies, from ConAgra Foods Inc. to Peoples Energy Corp., have started to put performance hurdles in stock and stock option compensation. In 2005, 30 out of 100 major U.S. corporations based a portion of the equity granted to their CEOs on performance targets, up from 23 in 2004 and 17 in 2003 and it has been predicted that half of them will use such awards by the end of 2006.³ A variety of performance goals are employed as option vesting constraints in US firms, some of which are based on financial performance (i.e. earnings or revenue growth rate), while others link option exercise price to a market index or a certain price target. Under US regulations, however, firms are not required to divulge numerical goals, which is justified as to avoid “a competitive disadvantage” (William Nuti, CEO of NCR Corp.).

1.2 OVERVIEW AND OUTLINE

In spite of the fact that PVSOs have been advocated as in line with “best corporate governance practice” (PWC, 2006) and have been implemented increasingly, especially in high-profile companies, little is known about their implications for managerial behavior. Nevertheless, their purported interest alignment warrants empirical testing and further theoretical exploration. The aim of this dissertation is to investigate the effects of PVSOs in motivating managers to promote shareholder value. I also examine undesired consequences associated with PVSOs.

³ “U.S. boards tie CEO pay to results”, *Wall Street Journal*, February 22, 2006.

Chapter 2 of this dissertation, *Performance-vested Stock Options and Interest Alignment*, answers two research questions: 1) Is PVSO associated with greater interest alignment between managers and shareholders? 2) What is the role of vesting target difficulty in this association? I find that the presence of PVSO schemes in executive-compensation contracts is associated with a higher degree of interest alignment, as measured by the “pay-performance sensitivity” that measures how managerial compensation changes with firm performance. Moreover, the results testify to the role of vesting-target difficulty of PVSOs in aligning managerial interest with shareholder value. Specifically, more difficult targets negatively affect managers’ choice of effort and the interests of managers will diverge from those of shareholders.

The presence of performance targets may also create some problems. Prior evidence shows that making managers’ payments or promotion opportunities conditional on the achievement of performance targets reduces the incentive effects of compensation and may even incentivize managers to game the system at the cost of shareholder wealth (Healy, 1985; Gaver et al., 1995; Buck et al., 2003; Jensen, 2003). If the vesting of stock options is conditional upon the achievement of predetermined targets, managers might face similar incentives. Chapter 3, *Performance-vested Stock Options and Earnings Management*, investigates the effects of PVSOs on the propensity of managers to engage in earnings management. Using abnormal accruals, book-tax income difference, and deferred tax income as proxies for earnings management, as well as the return-earnings association, I show that managers engage more in earnings management when they hold a larger proportion of their compensation in PVSOs. Performance evaluation takes place at the end of the performance period (i.e., at the end of the third year after the grant dates) and vesting decisions are made at that time. Results show that the association between PVSO compensation and earnings

management depends on how far removed different PVSO grants are from the end of the performance period.

In Chapter 4, *Incentive Effects of Performance-vested Stock Options*, I provide an analytical model to assess PVSOs' ability to induce managerial effort. I show that PVSO induces higher managerial effort relative to TSOs when performance targets are set not too difficult (i.e., with high attainability). When performance targets are at the optimal level, the analysis indicates a higher than 70% vesting probability, consistent with the consensus in the goal-setting literature that states that "tight, but achievable" targets are associated with firm performance benefits.

1.3 MULTIPLE PERSPECTIVES ON COMPENSATION

A wide array of explanations from economics, sociology and organizational theories have been proposed for understanding the phenomenon that firms devote considerable resources to constructing managerial compensation. In what follows, I briefly review some of these theories and show how they relate to PVSO compensation. My purpose is to provide a boarder view over compensation studies in alternative theoretical paradigms and explain my choice of principal-agent theory as the theoretical framework in the current dissertation.

Theories on Managerial Compensation

Tournament theory models compensation schemes as sequential elimination tournaments in which managers compete against one another in a related series of tournaments (Calvo and Sellisz, 1979; Rosen, 1986, 1982; Larcker et al., 1993). The option value of self-development within firms and the potential to earn higher levels of compensation with promotions provide managers with incentives to compete and exert effort.

Moreover, the further a manager advances, the lower expected value of career-advancement internally. At the final tournament, CEOs are competing at the top of the organizational pyramid and thus have zero expected value regarding promotions within the firms. One mechanism to motivate top managers is to make the difference between winning and losing at the final level substantially larger than for previous tournaments. Compared with TSOs, the likelihood of benefiting is smaller for PVSOs because the vesting targets increase the difficulty and cost of realizing option value. Studies show that firms might reward managers more options to compensate the additional risk in the case of PVSOs (Bettis et al., 2007), which further enlarges the difference in top managerial pay between meeting and missing the performance targets.

From both the psychology and sociology perspectives, fairness is a fundamental objective of pay systems, which includes both procedural fairness and distributive fairness (Brockner et al., 2000; Miceli, 1993). A pay structure is more likely to be judged fair if it is based on the work and the skills required to perform the work and if people have an opportunity to be involved in some way in determining the pay structure (Miceli and Mulvey, 1998; Hundley and Kim, 2000; Konovsky, 2000). In contrast, receiving windfalls by merely taking the advantage of the general market price improvements (which might happen with TSOs) contradicts the distributive fairness principle in managerial pay. With PVSO compensation, managers can benefit from their options only after the realization of vesting targets, which suggests that effort-irrelevant factors that used to influence managerial pay are filtered out and managerial pay becomes more fair. Employees' perception of fairness in pay structure increases their morale and thus productivity (Scarpello and Jones, 1996). Therefore, compared to traditional stock options, PVSO compensation is conjectured to motivate managers better.

Institutional theory argues that some organizations ignore the question of

firm-specific strategy; instead, they simply copy what others are doing since it is called “best-practice”. Studies show that benchmark practices of the best companies facilitate others’ copying those practices regardless of to what extent they are applicable (Zucker, 1987; Barringer and Milkovich, 1998). With little regard to whether the practices make sense (fit) for the particular organization, such epigenous behavior often has negative implications on firm performance (Levinson, 1994). From an institutional theory perspective, firms might adopt PVSO plans to placate shareholders’ calling for compensation reforms even if the practices are not consistent with the firms’ optimal strategies. Under these circumstances, improvements on firm performance are not expected.

Psychology Theories on Performance Targets

Recall that PVSO and TSO differ with respect to the performance hurdles attached to option vesting. In psychology, it is a general belief that setting specific performance targets consistently leads to higher performance than simply urging people to do their best (Locke and Latham, 1990, 2002). The reason is that defining specific performance targets (i.e. vesting targets) reduces the ambiguity about what is to be achieved and thus is expected to be associated with higher performance. Following this line of argument, stock options with vesting targets provide better incentives compared to traditional ones.

Theories on the mechanisms through which goals affect performance predict that goals serve a directive function; they direct attention and effort toward goal-relevant activities and away from goal-irrelevant activities. People who are given multiple tasks will improve their performance on the dimension for which they have goals but not on other dimensions (Bryan and Locke, 1969; Locke and Latham, 2002). Guided by the pre-specified vesting targets, managers are expected to work on improving performance on these dimensions (but not others). However, due to the lack of a perfect association between the pre-defined vesting

targets and firm economic performance (Buck et al., 2003), achieving vesting targets does not necessarily improve firm economic performance.

Choice of Principal-agent Theory

Much of the economics-based research on organizational incentives uses principal-agent models. Agency theory has largely addressed the design of optimal compensation contracts in highly stylized settings (Lambert et al., 1993), although recent developments in economics are to incorporate conceptually important elements from other theoretical paradigms (e.g., sociology, psychology, and organization theories).

I employ principal-agent theory as an overall framework in tackling the incentive effects of vesting performance hurdles attached to stock option compensation. Since these competing theories (as briefly mentioned above) seem to predict very much the same effects on managerial behaviour of performance-vested stock options as principal-agent theory, concerns about the appropriateness of relying exclusively on economics in the development of this dissertation might be somewhat alleviated. This choice should not be read as an adverse judgement on the power of theories from other fields but only reflect my preference for the elegant framework and powerful predictions provided by agency theory.

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Chapter 2: Performance-vested Stock Options and Interest Alignment*

2.1 INTRODUCTION

In the wake of the corporate scandals that plagued the beginning of this decade, concerns have increasingly been raised regarding various aspects of corporate governance (DeFond, Hann, and Hu, 2005). As an important component of corporate governance reforms, managerial compensation, especially equity compensation (stock and stock options), has come under scrutiny. This study empirically analyses the effectiveness of attaching performance targets to option vesting in aligning managerial interest and shareholder value.

The vesting of traditional stock options (hereafter, TSOs) is contingent simply upon the passage of time. Opponents of TSOs argue that the link between managers' pay and firm performance is inadequate (Gerakos et al., 2005), as managers are generously rewarded when the market as a whole rises even if they underperform the market average or their peers. Accordingly, activist shareholders have proposed that firms attach company-specific performance targets to equity compensation and condition option vesting on the achievement of performance targets. These proposals have been rapidly implemented.⁴

Although the claim is that compared with traditional stock option plans vesting performance targets provide better incentives, the implications of such an awards mechanism on managerial behavior are the subject of debate (Bruce and Buck, 2005). Under vesting targets, managers are expected to be paid on the basis of real improvements in firm

* Based on a paper co-authored with Bo Qin (University of Groningen).

⁴ In the US, 30 out of 100 major US corporations based a portion of the equity granted to their executives on performance targets in 2005, up from 17 in 2003 and 23 in 2004 (Mercer Human Resource Consulting, 2006). In the UK, nearly 60% the largest 200 UK firms with stock option compensation plans for CEOs were based on performance criteria (Conyon et al., 2000a). In our sample, 94% of the firms that adopted stock options plans in their CEO compensation contracts attached performance targets to CEOs' stock options in 2004, and 54% in 1999.

performance and in turn shareholder wealth. Some theoretical studies show that performance-vested stock options (hereafter, PVSOs) provide managers greater incentives than their traditional counterparts to behave in line with the owners' best interest (Johnson and Tian, 2000; Kuang and Suijs, 2006). However, theoretical evidence also suggests that this compensation design may have undesirable consequences: because risk-averse managers with undiversified portfolios have an incentive to influence their own compensation in order to maximize their private interests (Bertrand and Mullainathan, 2001; Hall and Murphy, 2002), basing managers' remuneration or their promotion opportunities on performance targets induces managerial game-playing at the expense of shareholders (Healy, 1985; Gaver et al., 1995; Jensen, 2003; Camara and Henerson, 2005). The consensus in the goal-setting literature is that "challenging" targets, i.e., targets that are achievable by exerting high effort, are associated with improvements in firm performance (Merchant and Manzoni, 1989; Locke and Latham, 2002; Hansen et al., 2003; Jensen et al., 2004). But the high achievability of performance targets calls into question whether they are vulnerable to managerial manipulation (Conyon and Murphy, 2000).

The debate on the incentive effects of PVSOs is also conducted among practitioners. In its Global Best Practice 2006 for "Corporate Performance Management", PWC advocates that firms attach performance targets to stock option compensation. In contrast, some high profile corporations urge shareholders to reject the PVSOs, as they believe that attaching performance targets to stock options puts the company at a competitive disadvantage in the sense that the performance hurdles constrain the company's ability to recruit and retain top talent.⁵ Moreover, some executive compensation critics challenge the incentive effects of PVSOs. They allege that firms merely grant PVSOs in order to placate investors calling for compensation reform, and that the symbolically adopted PVSOs with easily achievable

⁵ "Activists sink claws into executives' pay", *Wall Street Journal*, February 27, 2006.

performance targets provide no additional incentives (Gerakos et al., 2005).

This study empirically examines the incentive effects of attaching performance targets to option vesting by testing the relation between PVSO compensation and interest alignment between owners and managers, where the level of interest alignment is measured by pay-performance sensitivity (PPS) (Jensen and Murphy, 1990; Garen, 1994; Aggarwal and Samwick, 1999; Conyon et al., 2000b). We attempt to answer two research questions. First, is PVSO compensation associated with greater interest alignment between managers and shareholders? Second, what is the role of difficult-to-achieve vesting targets (“vesting-target difficulty”, hereafter) in this relationship? The study focuses on the UK because listed firms in the UK disclose more detailed information on managerial compensation compared to firms in the US, an advantage that facilitates our investigation.⁶ Based on a dataset of 4,238 observations from 1,383 executive directors in the largest 244 UK non-financial firms from 1999 to 2004, we find that the presence of PVSO schemes in managerial compensation contracts is associated with a higher level of pay-performance sensitivity, which suggests improved alignment of owner and manager interests through the use of PVSOs. In addition, we find that increased target difficulty influences pay-performance sensitivity by decreasing interest alignment.

The contribution of this paper to the compensation literature is threefold. First, we are among the first to investigate empirically the incentive effects of PVSOs. Despite the popularity of PVSOs in contemporary compensation packages, the extent to which this incentive instrument is effective remains an open question. Second, our findings have implications for investor and regulator proposals that advocate firms condition managerial equity compensation upon the achievement of real improvements in firm performance. Finally,

⁶ The information on executive remuneration disclosed in UK annual reports is currently more detailed than the information provided under US disclosure regulations (“How the UK checks CEO pay”, *Wall Street Journal*, February 8, 2006). All listed firms in the UK are required to include an audited remuneration report in their annual report that discloses executive compensation in detail, while firms in the US are not subject to such a requirement

we make a methodological contribution in that we address the fact that some executives (firms) are more alike than others (i.e., within one firm (within one industry) in our sample), and thus observations are not completely independent in the full sample.

The remainder of the paper is organized as follows. We develop the hypotheses in Section 2.2, followed by a description of our methods and sample selection procedure in Section 2.3. Data sources are presented in Section 2.4. We discuss the empirical findings in Section 2.5. Section 2.6 presents the results of sensitivity tests. The paper concludes with a summary and discussion in Section 2.7.

2.2 HYPOTHESIS DEVELOPMENT

This section develops our hypotheses regarding the functioning of performance-vested stock options (PVSOs) in aligning shareholder and management interests. We test two hypotheses. The first hypothesis compares the functioning of PVSOs and TSOs with respect to interest alignment. The second hypothesis explores the role of target difficulty.

2.2.1 Compensating managers with PVSOs

Since the interests of managers and owners are not inherently aligned, firms design compensation contracts to induce managers to operate in the owners' interest. However, errors in measuring managerial effort constrain the provision of such incentives (Holmstrom, 1979). Consider the case of TSOs. The payoff of managers depends solely on the difference between market prices at the exercise date and exercise prices as determined on the grant date. Market prices are thus implicitly used as a performance measure. Yet market prices do not

over the sample period that we consider.

necessarily reflect managerial effort. For example, during a bull market managers receive windfall gains from exercising stock options even if they underperform the market (Gerakos et al., 2005), and managers may realize option-related value simply from staying with the firm long enough. Faced with the opportunity to reap effort-irrelevant gains, effort-averse managers are more likely to shirk than work on improving long-run shareholder wealth.

PVSOs, in contrast, add signals that are informative about managerial effort. The performance targets attached to PVSOs are usually based on market or peer group performance, rewarding managers if, for example, they meet or beat an inflation-adjusted earnings per share (EPS) growth target and/or if they achieve above-median performance compared to industry peers.⁷ Rewarding managers on the basis of how well they do relative to macroeconomic circumstances and/or industry peers reduces the noise in observed performance, thereby increasing the precision in inferring unobservable managerial effort (Baker, 2000). Compensation contracts based on performance measures with direct effort implications motivate managers to exert higher effort and increase firm performance, consistent with shareholders' interest.⁸

Taken together, the aforementioned suggests performance-vested stock options generate better interest alignment relative to traditional stock options. Our first hypothesis is thus as follows:

H1: *Ceteris paribus*, interest alignment is higher for performance-vested stock options than for traditional stock options.

2.2.2 Target difficulty in PVSOs

In an agency setting, Kuang and Suijs (2006) find that PVSOs induce higher

⁷ This is consistent with the recommendation of the Greenbury code (1995) that managers should not be rewarded for increases in market prices or other indicators that reflect general price inflation, general movements in share prices, or movements in the share prices of an entire market or industry.

⁸ Managerial ownership may result in entrenchment problems (Claessens et al., 2002; Lennox, 2005). In such

managerial effort when performance targets are below a certain threshold, indicating that difficult performance targets negatively impact managerial choice of effort. ‘Difficult targets’ are generally interpreted as those beyond managers’ ability (Latham and Locke, 2002), that is, those such that high effort is associated with a sufficiently low probability of reaching the target that the expected benefits from exerting such effort are below the manager’s personal cost of doing so. In such a case, expected utility maximization implies that a manager will not choose a high level of effort.⁹

Prior studies are consistent with the negative impact of difficult targets on managerial effort.¹⁰ A consensus in the goal-setting literature is that performance benefits are associated with challenging but attainable performance targets, while firm performance decreases when the targets are set beyond managers’ ability (Locke et al., 1988; Merchant and Manzoni, 1989; Hirst and Lowy, 1990; Covaleski et al., 2003; Hansen et al., 2003; Jensen et al., 2004). Empirical evidence on performance bonuses also shows that confronted with unattainable bonus targets, managers are less than well motivated. Lower firm performance is correlated with difficult targets, suggesting that managers stop exerting higher effort and even “save” potential performance for future benefits by “taking a bath”, i.e. using accruals to shift expenses and revenues over time (Healy, 1985; Gaver et al., 1995; Holthausen et al., 1995; Jensen, 2003).

Based on this discussion, our second hypothesis focuses on the effects of difficult vesting targets on interest alignment. Confronted with difficult targets, managers are likely to exert lower effort. Firm performance is thus more likely to decrease. We therefore predict that

cases, managers have incentives to pursue their own interest without increasing firm value.

⁹ Our economic reasoning is consistent with theories of motivation in the psychology literature. Expectancy theory (Vroom, 1964) states that human behavior is motivated by valence (anticipated satisfaction), instrumentality (the belief that performance is rewarded), and expectancy (the belief that effort will lead to the rewarded performance). Since difficult goals reduce people’s expectancy of goal success, lower performance is predicted.

¹⁰ An inverted U-shaped relationship between performance and target difficulty has been documented in the goal-setting literature (see Latham and Locke, 2002, for a review). We test for the existence of such a relation between pay-performance sensitivity and target difficulty in the robustness check section.

difficult targets result in a lower level of interest congruence between managers and shareholders. Our third hypothesis is thus:

H2: *Ceteris paribus*, more difficult performance targets are associated with lower interest alignment between managers and shareholders.

2.3 METHODOLOGY

This section quantifies the extent to which management pay is sensitive to corporate performance, and the effect of the presence of PVSOs on PPS. In an attempt to address some of the concerns with prior PPS modelling methodologies, we introduce a multilevel modelling method.

2.3.1 Measuring compensation and firm performance

We use pay-for-performance sensitivity (PPS) to measure the extent of interest alignment between shareholders and managers. Empirically, the relation between executive pay and shareholder value (PPS) measures how managerial compensation changes with firm performance and shareholder wealth, with a high sensitivity indicating a large degree of interest alignment between managers and shareholders (Jensen and Murphy, 1990; Garen, 1994; Hall and Liebman, 1998; Aggarwal and Samwick, 1999).¹¹

Prior PPS studies on executive compensation in the UK mainly focus on salary and bonuses (Conyon et al., 2000b; Conyon and Sadler, 2001). By excluding equity-based components of executives' overall remuneration, the estimated relationship between

¹¹ PPS is commonly interpreted in the literature as a measure of incentive alignment but this might be problematic because (1) it is unclear that higher PPS is always better (although the empirical evidence to date suggests that current levels of PPS are very low which makes it likely that we are still in the upward sloping region of the function) and (2) the PPS measure is potentially affected by the option grant size (we try to control for this later on

compensation and performance may be biased, as the incentive effect of any one component of the compensation package depends on how the other components are concurrently adjusted (Lambert et al., 1991; Kole, 1997). Moreover, with the increasing popularity of incentive-based executive pay, non-cash elements of pay are now often larger than their cash counterpart (Conyon and Murphy, 2000). We therefore employ two measures of executive pay:

1. Total Compensation (TotComp): salary, bonus, pension, other cash compensation (e.g., relocation and fringe benefits), and changes in the unrealized value of stocks of executive wealth. (Buck et al., 2003)¹²
2. Change of Total Wealth (ChgTotWealth): TotComp plus the estimated present value of the change in cash compensation over the remaining life-span of the executive.

Both accounting-based (e.g., earnings per share or return on equity) and market-based (shareholder return or shareholder wealth) measures have been employed in prior empirical models to measure firm performance (Jensen and Murphy, 1990; Garen, 1994; Aggarwal and Samwick, 1999; Conyon et al., 2000b). However, since the principal-agent model emphasizes the convergence of owner and management interests, a market-based measure reflecting share price appreciation and dividend yield (i.e., total shareholder return) seems more intuitive (Conyon and Salder, 2001). In this vein, we measure corporate performance using total shareholder return (TSR), which is also a commonly used proxy in the literature (see Jensen and Murphy, 1990; Garen, 1994; Aggarwal and Samwick, 1999, among others).¹³

in the robustness section).

¹² We use the sum of changes in the Black-Scholes value of stock options, changes in the value of executives' equity, and changes in the estimated value of restricted stocks, as in Buck et al., 2003. In the Black-Scholes fair value model, volatility is measured using daily stock return volatility over the last three months. We take the dividend yield of the current year. The risk-free rate is the yield on a treasury security with approximately the same maturity as the years remaining to maturity for the stock options. Black-Scholes valuation model may overestimate value of stock option compensation. In robustness tests, we discount PVSO value at various rates and the results are qualitatively unchanged.

2.3.2 Measuring the presence of PVSO and TSO, and vesting target difficulty

We capture the presence PVSOs or TSOs in a manager's compensation contract by the use of indicators. The indicator DummyPVSO is equal to one if PVSOs are present in a manager's compensation contract, and zero otherwise.¹⁴ The indicator DummyTSO is similarly constructed to indicate the presence of TSOs. With respect to the performance targets attached to option vesting, we employ three measures to capture target difficulty: absolute target difficulty (ABSDIF), relative target difficulty (RELDIF), and *ex-post* difficulty (DIFF). ABSDIF is the stated EPS target itself. RELDIF measures the distance of the EPS target in excess of the industry median, allowing us to compare sample firms from different industries. DIFF is an *ex-post* measure, which is coded one for missing pre-determined targets, and zero for achieving the targets. Each manager has a different perception of target difficulty, and it is not feasible for a large-sample study to investigate perceived target difficulty at the executive level. To the extent that *ex-post* performance results can reflect a manager's *ex-ante* perception of target difficulty, this proxy is valid.¹⁵ Following firms' vesting requirements (Camera and Herderson, 2005), the target difficulty proxies are constructed on a three-year rolling average basis¹⁶. As mentioned in Section 2, performance targets attached to PVSOs generally take two forms, namely, the rate of earnings per share (EPS) growth over inflation (where the deflator of interest is the retail price index) and total shareholder returns (TSR)

¹³ We nevertheless conduct robustness tests with accounting-based performance measures.

¹⁴ No distinctions are made between accounting-based and market-based vesting targets.

¹⁵ The target difficulty measures are suggestive since only threshold vesting targets are investigated and partial vesting is ignored. However, our inferences are based on consistent results across the three target difficulty measures, which to some extent may mitigate the possibility of bias in the results. Meanwhile, our findings are most likely to hold when managers' actual perception of target difficulty is above our estimation due to the demotivation effects of overambitious performance targets (e.g., Locke and Latham, 2002). The possibility of retesting PVSO performance targets is not considered, consistent with 'the Best Practice' in the Combined Code in Corporate Governance (2003).

¹⁶ Consider the following scenario: in 2000, Firm A grants PVSOs with an EPS performance target of 2% annual growth above the retail price index growth rate, in 2001, the EPS target for newly granted PVSOs increases to 3% over the inflation rate, and in 2002, the performance target for new PVSO grants remains the same. The annual EPS growth rate calculated on a three-year rolling basis is 2.67% [i.e., $(2\%+3\%+3\%)/3$] above the retail price index growth rate.

Table 1
Variable definitions

Variable Name	Description
<i>Dependent variables:</i>	
TotComp	Salary, bonus, pension, other cash compensation (e.g., relocation and fringe benefits), plus changes in the unrealized value of executives' stock (i.e., the sum of changes in the Black-Scholes value of stock options, changes in the value of executives' stock, and changes in the estimated value of restricted stock)
ChgTotWealth	Salary, bonus, pension, other cash compensation, changes in the unrealized value of executives' stock, plus the estimated present value of the change in cash compensation over the remaining life-span of the executive (3% annual interest rate; supposing executive directors work till the age of 70)
<i>Independent variables:</i>	
TSR	Total shareholder return (including dividends) in the current year
DummyPVSO	A dummy variable indicating the presence of PVSOs in executive compensation (1=yes; 0=no)
DummyTSO	A dummy variable indicating the presence of TSOs in executive compensation (1=yes; 0=no)
RELDIF	Difference between a firm's EPS vesting condition and the average EPS vesting condition for the industry to which the firm belongs
ABSDIF	Absolute value of a firm's EPS vesting condition
DIFF	A dummy variable, equal to zero if the EPS target is achieved in year t ; one otherwise
<i>Control variables (firm level):</i>	
Ln(MV)	Natural logarithm of market value
Dummy_Loss	A dummy variable indicating the presence of a loss in total shareholder return (1=yes; 0=no)
Leverage	Measured by total debt ratio, which is the ratio of total liabilities to total assets
Board_Size	The number of board members

Variable Name	Description
%Outside_Director	The proportion of outside directors among all board members; outside director refers to any member of a company's board who has never been employed by the company and sits on that company's board
<i>Control variables (executive level):</i>	
Year-to-retirement	The length of time, stated in years to retirement, based on the company's retirement age; where the executive's age is not disclosed, the time to retirement is assumed to be 65
Dummy_Male	A dummy variable indicating a male executive (1=yes; 0=no)
#Committee_Roles	The total number of positions the individual executive holds on a particular company's committee
Networks	The total number of the executive's associations, which shows all the links an executive has to another executive via the quoted and private boards they have served on, the charities they have worked for, their schooling, or any other recreational activities they have shared over a given time period
Year-on-board	The length of time, stated in years, that the executive has been on the Board ¹⁷
Education	The total number of academic and professional accreditations an individual executive received
#Quoted_Boards	The total number of boards of quoted companies on which the individual executive is serving at the report date selected
<i>Others:</i>	
DirectComp	Salary, bonus, pension, and other cash compensation (e.g., relocation and fringe benefits);
TotEquity	Estimated value of stock options (Black-Scholes value) and stock
ValuePVSOs	Black-Scholes value of PVSOs
ValueTSOs	Black-Scholes value of TSOs

¹⁷ If the date when the executive joined the board is not available, then the assumed date is the start of the financial year when the executive is first quoted in the annual report. If the date of board exit is not known then the assumed date is the end of the financial year.

Variable Name	Description
#PVSO	Volume of PVSO holdings scaled by total shares outstanding
#TSO	Volume of TSO holdings scaled by total shares outstanding
#SO	Volume of stock option holdings scaled by total shares outstanding
#LTIPs	Volume of long-term incentive plan (performance-vested stocks) holdings scaled by total shares outstanding
%Share	Volume of share holdings scaled by total shares outstanding
Ln(Total Assets)	Natural logarithm of book value of total assets
MtB	Ratio of market value of equity to book value of equity
EPS	Earnings per share
ROA	Return on total assets

relative to firm-specific peer groups. Only the former vesting targets are comparable across sample firms, since the benchmark (the retail price index) is common to all firms. In contrast, when peer groups are used, each firm might select a distinct benchmark group against which to compare TSR performance. Thus, all three measures are based on EPS figures. Table 1 summarizes the variable definitions.¹⁸

2.3.3 Control variables

Following prior literature, we include a number of firm- and executive-level control variables in our analysis. First, we control for firm size effects, as measured by the natural logarithm of market value, on executive compensation (Jensen and Murphy, 1990). Next,

¹⁸ Accurately capturing managers' perception of target difficulty is a controversial topic (Locke and Latham, 2002). We seek to provide a better understanding of target difficulty perception and thus measure target difficulty from multiple angles (e.g., ex ante incentives vs. ex post realization; absolute difficulty measure vs. relative difficulty measure). Results on correlation matrix show that ABSDIFF and RELDIFF are highly correlated (corr=0.975, p-value<0.01), which suggests the validity of our target difficulty measures although we fail to identify a significant correlation between ex-ante target difficulty perception measures and ex-post difficulty measure (i.e. DIFF). Nevertheless, we acknowledge the possible deficiency of our target difficulty measures.

because prior literature documents that loss firms and firms in financial distress may have different executive compensation structures (Gilson and Vetsuypens, 1993; Matejka et al., 2005; Leone et al., 2006), we include a dummy variable to indicate the years in which the firm realized a negative cumulative total shareholder return (dividend-adjusted) at the end of the year and a variable for the leverage ratio. Corporate governance also influences the design of executive compensation and actual pay and hence board size and the proportion of outside directors on the board are included to control for the efficiency of the board in monitoring the design of executive compensation packages. Executive characteristics such as age, gender, tenure, and education are also controlled for (Finkelstein and Hambrick, 1989; Core and Guay, 1999; He and Conyon, 2004). Managerial power in influencing boardroom decisions is taken into account by incorporating variables indicating the number of committee roles the executive serves, the number of networks he/she has to related other executives (Collins and Clark, 2003), and the number of other boards the executive serves (i.e., managerial activity).

2.3.4 Empirical models

Prior studies show that PPS is jointly determined by both firm-level factors (e.g., firm size, beta, uncertainty about firm value) and CEO-specific factors (including age, risk aversion, and private cost associated with exerting effort) (Garen, 1994). Thus, PPS studies need to control for factors at both levels. Notwithstanding, however, empirical models are usually estimated at the individual executive level (Hall and Liebman, 1998; Aggarwal and Samwick, 1999; Buck et al., 2003). One concern about his approach relates to the interdependency among managers. Contagion Theory (Hopwood, 1974) predicts inter-correlated executive compensation within a firm and prior literature documents that compensation granted to managers in the same firm is similarly constructed across managers

(Fee and Hadlock, 2004). In other words, executives are clustered according to firms (the same applies to firms within one industry). The intra-class correlation violates the independence assumption of OLS. A consequence of ignoring dependence within a cluster is that the standard error of the regression coefficient will be too low (Hox, 2001).

We employ multilevel modelling to allow for firm- and executive-level fixed effects within the nested data structure. Fixed effects allow for simultaneous analysis of each level. Fixed effects also address the problem that the firm- or executive-specific factors (such as corporate governance quality, managerial risk aversion, etc.) influence the results, as the statistics show that severe fixed effects exist in our sample at both the firm and the executive level. More specifically, 30.51% (30.72%) of the total variance in $\ln(\text{ChgTotWealth})$ ($\ln(\text{TotComp})$) can be explained by the variance among executives, and the firm-level variance explains 20.52% (20.38%) of the total variance in $\ln(\text{ChgTotWealth})$ ($\ln(\text{TotComp})$).

Despite of the importance of equity compensation in executive pay, cash compensation accounts for a significant portion of total pay (Zhang et al., 2005). Accordingly, we define pay-for-performance sensitivity as the sensitivity of total compensation to firm performance.

To test our first hypothesis, we construct the following three-level model:¹⁹

$$\begin{aligned} \ln(\text{Compensation_PROXY})_{ijk} &= \beta_{0ijk} + \beta_1 \text{TSR}_{ik} + \beta_2 \text{DummyPVSO}_{ijk} \\ &+ \beta_3 \text{TSR}_{ik} * \text{DummyPVSO}_{ijk} + \beta_4 \text{DummyTSO}_{ijk} + \beta_5 \text{TSR}_{ik} * \text{DummyTSO}_{ijk}, \quad (1) \\ &+ \beta \text{CONTROLS} \\ \beta_{0ijk} &= \gamma_{000} + v_{0k} + u_{0jk} + e_{0ijk}, \\ [v_{0k}] &\sim N(0, \Omega_v), \\ [u_{0jk}] &\sim N(0, \Omega_u), \\ [e_{0ijk}] &\sim N(0, \Omega_e) \end{aligned}$$

where i, j, k denote year, executive, and company, respectively;

Compensation_PROXY = TotComp and ChgTotWealth as defined in Section 2.3.1;

TSR = dividend-adjusted total shareholder return, as defined in Section 2.3.1;

PVSO = a dummy variable indicating the presence of PVSO compensation, as defined in Section 2.3.2;

¹⁹ A detailed description of the construction of three-level hierarchical linear models appears in Appendix A. We use Maximum Likelihood (ML) estimators in our multilevel regression analysis.

TSO = a dummy variable indicating the presence of TSO compensation, as defined in Section 2.3.2.²⁰

The first hypothesis concerns the relative effects of PVSOs and traditional stock options (TSOs) on PPS. In particular, H1 predicts that compared with TSOs, PVSOs align owner- and management interests more closely. Thus, we expect β_3 to be greater than β_5 in equation (1). Further, we expect β_3 to be significantly positive.

To test the impact of target difficulty on the association between managerial compensation and firm performance, we test the following model on the subset of firms that adopted EPS-based PVSOs:

$$\begin{aligned} \ln(\text{Compensation_PROXY})_{ijk} &= \beta_{0ijk} + \beta_1 \text{TSR}_{ik} + \beta_2 \text{DIF_PROXY}_{ik} \\ &+ \beta_3 \text{TSR}_{ik} * \text{DIF_PROXY}_{ik} + \beta \text{CONTROLS} \end{aligned} \quad (2)$$

$$\begin{aligned} \beta_{0ijk} &= \gamma_{000} + \nu_{0k} + u_{0jk} + e_{0ijk} \\ [\nu_{0k}] &\sim N(0, \Omega_\nu) \\ [u_{0jk}] &\sim N(0, \Omega_u), \\ [e_{0ijk}] &\sim N(0, \Omega_e) \end{aligned}$$

where i, j, k denote year, executive, and company, respectively;
 DIF_PROXY = RELDIF, ABSDIF, and DIFF, indicating the difficulty level of performance targets attached to PVSO compensation, as defined in Section 2.3.2.

Our second hypothesis, which predicts that difficult targets are associated with lower pay-performance sensitivity, implies a negative coefficient on the interaction term $\text{TSR} * \text{DIF_PROXY}$.

2.4 SAMPLE SELECTION AND DATA SOURCES

Our initial sample consists of the 350 largest non-financial²¹ firms in the UK, based on

²⁰ Results are robust to a more parsimonious specification of (1):

$$\begin{aligned} \ln(\text{Compensation_PROXY})_{ijk} &= \beta_{0ijk} + \beta_1 \text{TSR}_{ik} + \beta_2 \text{DummyPVSO}_{ijk} \\ &+ \beta_3 \text{TSR}_{ik} * \text{DummyPVSO}_{ijk} + \beta \text{CONTROLS} \end{aligned}$$

market capitalization in 2004. The reason for focusing on large firms is three-fold. First, large firms are of greatest concern to investors. Second, large firms are more likely to reward managers with PVSOs (Conyon et al., 2000a), and usually disclose sufficient information for us to carry out our empirical tests, especially the tests of target difficulty. Third, the vast majority of prior studies employ a sample of large firms (see Buck et al., 2003, among others). By concentrating on large firms, we are able to produce results that are comparable with prior studies. Firms without sufficient information on PVSO compensation or the required financial data are eliminated. We also remove executives who served as a board member only for two years, since the compensation associated with temporary employment may reflect factors other than firm performance improvement. Our final sample includes 1,383 executive directors from 244 firms over 1999 to 2004.

Information on company board characteristics, managerial compensation, and executive demography comes from the BoardEx database.²² Data on performance targets are obtained directly from the proxy statement of the firm's annual report.²³ Firm-level financial information is taken from Compustat Global industrial and commercial files, and capital market information is provided by Datastream.

where $\beta_{0ijk} = \gamma_{000} + v_{0k} + u_{0jk} + e_{0ijk}$.

²¹ The financial sector is excluded from our sample, as prior studies indicate that compensation contracts in these firms exhibit idiosyncratic features.

²² For more details, see www.boardex.com. We randomly select 50 firms and compare their records in BoardEx with the firms' annual reports. We find no substantial difference between the two data sources.

²³ Extracts on the descriptions of vesting targets are provided in Appendix B.

Table 2
Summary of sample selection process

Top 350 (by market capitalization) non-financial firms in 2004	350
<i>Less:</i> Firms that delisted after 2004	43
Firms without sufficient information to make a distinction between PVSOs and TSOs	9
Firms with incomplete financial information	54
<i>Total:</i> Firms included	244
# of executives	1,569
<i>Less:</i> Executives functioning for less than two years	186
<i>Total:</i> Executives included	<u>1,383</u>
# of observations as executive-years	<u>4,328</u>

2.5 EMPIRICAL ANALYSIS

2.5.1 Descriptive statistics

Top managers in the UK receive two separate forms of compensation: a direct component and deferred rewards. The direct component consists of salary, annual bonus, pension, and other cash compensation. The deferred rewards generally comprise stock and stock options (e.g., PVSOs and TSOs).

Figure 1 depicts the time series of the composition of total executive pay in our sample. The cash-based component accounts for less than 35% of the average total compensation received by executive directors, with this percentage declining precipitously since 2002. Meanwhile, equity-based components of executive total wealth have increased. In particular, PVSOs have become one of the most important elements in executive pay, whereas TSOs have observed a declining weight: in 1999, PVSOs (measured at their Black-Scholes (1973) value) accounted for 24.45% of executives' total equity holdings, which is approximately twice as large as the proportion of TSOs' equity compensation in the same year, whereas in

Figure 1
Composition of executive wealth 1999~2004

Panel A: Direct payment/Total pay vs. Equity compensation/Total pay

Panel B: PVSOs/Equity compensation vs. TSOs/Equity compensation

Notes:

Direct payment: Salary, bonus, pension, and other cash compensation (e.g., relocation and fringe benefits);

Equity compensation: Estimated value of stock options (Black-Scholes value) and stock;

Total pay: Cash compensation plus estimated value of stock options and shareholdings.

2004, PVSOs accounted for 36.68% of total equity compensation, while the value of TSOs declined to 3.99% of equity compensation, approximately one-tenth of the PVSOs' value.

Table 3 reports summary statistics for 4,328 executive director-years, which comprises 1,234 CEO-years and 3,004 non-CEO executive-years. Panel B and C indicate that for both CEOs and non-CEOs, each compensation component is skewed positively (i.e., salary, bonus, total cash payment, stock options), as is total executive pay. Panels B and C report that, on average, CEOs are paid more than non-CEOs, and equity-based compensation is the main driver behind the difference. Panels D and E of Table 3 indicate that in the presence of PVSOs managers generally receive more cash (e.g., salary, bonus) but their equity compensation is lower than that for executives without PVSOs.²⁴ Firms that grant PVSOs are larger in size and have lower earnings per share relative to those not granting PVSOs. Panel F summarizes the major components of compensation packages for firms with TSOs. Compared to the PVSO (DummyPVSO=1) group, the TSO (DummyTSO=1) group does not differ significantly in terms of cash or equity compensation, but firms using TSOs are relatively larger in size and have lower leverage.²⁵ Nonparametric tests also show that firms granting TSOs have significantly lower EPS growth compared to those granting PVSOs to their executives. Finally, Panel H shows that consistent with the prior literature (Conyon et al. 2000), the overwhelming majority of firms in our sample attach EPS targets to option vesting (84.45%), while the use of TSR performance targets is low (11.17%).

²⁴ Both parametric (ANOVA) and nonparametric (Kruskal-Wallis) tests show a significant difference (with $p < 0.01$) in cash compensation and executive total equity compensation between the two groups (PVSO=0/1).

²⁵ We are aware of the right-hand side skewness of executive compensation data. In robustness checks, we truncate the sample at the 90th and 95th percentiles, respectively. The results of the main subsamples (i.e., the 90- and 95-percentiles) are consistent with the findings based on the full sample. We further winsorize the dependent variables (i.e., $\ln(\text{TotComp})$ and $\ln(\text{ChgTotWealth})$) and independent variable (i.e., TSR) at the 1% and 99% levels. In multilevel models, this manipulation serves only to improve the significance level of reported results.

Table 3
Summary of executive compensation and firm characteristics
(4,238 executive-years)

This table presents summary of executive compensation and firm characteristics of the full sample and sub-samples; compensation measures are in '000 GBP (£).

	Mean	Std. Dev.	1%	25%	Median	75%	99%
<i>Panel A: Total executive directors (N=4,238)</i>							
Salary	271	165	30	165	237	332	816
Bonus	125	204	0	12	71	150	959
DirectComp	451	368	48	239	360	546	1,954
ValuePVSOs	540	1,632	0	0	172	583	5,023
ValueTSOs	217	3,273	0	0	0	6	3,257
TotEquity	7,131	39,661	0	377	987	2,622	131,727
Ln(MV)	6.709	1.471	4.297	5.535	6.499	7.672	10.266
Ln(Total Assets)	6.878	1.581	3.791	5.625	6.807	8.000	10.332
TSR	0.160	0.831	-0.705	-0.152	0.090	0.352	1.667
EPS (penny per share)	26.202	59.084	-92.227	6.345	18.397	36.175	263.425
ROA	0.037	0.152	-0.571	0.026	0.050	0.085	0.203
Leverage	0.571	0.175	0.096	0.458	0.579	0.689	0.958
<i>Panel B: CEOs (N=1,234)</i>							
Salary	371	191	61	247	325	454	968
Bonus	184	292	0	1	108	225	1,534
DirectComp	634	501	72	341	508	757	2,771
ValuePVSOs	903	2,749	0	0	287	883	9,355
ValueTSOs	525	6,017	0	0	0	8	9,982
TotEquity	18,233	69,791	0	824	2,365	6,757	402,814
Ln(MV)	6.650	1.481	4.260	5.487	6.413	7.519	11.224
Ln(Total Assets)	6.786	1.592	3.715	5.569	6.682	7.832	10.517
TSR	0.179	0.815	-0.719	-0.137	0.102	0.378	1.674
EPS (penny per share)	25.639	60.053	-89.940	6.177	18.091	35.549	298.382
ROA	0.041	0.133	-0.434	0.026	0.050	0.086	0.234
Leverage	0.566	0.176	0.085	0.456	0.575	0.689	0.949
<i>Panel C: Non-CEO executive directors (N=3,004)</i>							
Salary	230	132	28	150	209	288	600
Bonus	100	148	0	12	62	121	761
DirectComp	376	262	40	215	312	461	1,287
ValuePVSOs	391	761	0	0	145	479	3,355

	Mean	Std. Dev.	1%	25%	Median	75%	99%
ValueTSOs	90	450	0	0	0	6	1,655
TotEquity	2,571	12,164	0	300	737	1,687	34,428
Ln(MV)	6.733	1.466	4.299	5.562	6.545	7.734	10.192
Ln(Total Assets)	6.915	1.574	3.855	5.643	6.935	8.081	10.253
TSR	0.153	0.838	-0.707	-0.161	0.085	0.348	1.668
EPS (penny per share)	26.434	58.690	-92.751	6.468	18.785	36.327	263.425
ROA	0.035	0.159	-0.598	0.026	0.050	0.084	0.195
Leverage	0.573	0.175	0.112	0.460	0.580	0.690	0.966

Panel D: Executive directors with PVSO plans, DummyPVSO=1 (N=2,810)

Salary	286	172	68	177	250	350	823
Bonus	129	202	0	18	78	159	849
DirectComp	474	368	100	254	384	573	1,963
ValuePVSOs	815	1,948	13	176	409	845	6,460
ValueTSOs	109	747	0	0	0	0	2,316
TotEquity	4,507	32,234	51	461	1,024	2,423	62,107
Ln(MV)	6.734	1.386	4.371	5.626	6.551	7.642	9.892
Ln(Total Assets)	6.936	1.474	4.018	5.850	6.932	7.970	10.089
TSR	0.152	0.881	-0.684	-0.161	0.092	0.352	1.574
EPS (penny per share)	23.716	53.079	-77.704	5.509	15.577	33.907	303.731
ROA	0.035	0.131	-0.442	0.025	0.047	0.076	0.188
Leverage	0.572	0.181	0.095	0.457	0.580	0.694	0.959

Panel E: Executive directors without PVSO plans, DummyPVSO=0 (N=1,428)

Salary	242	145	0	150	210	299	759
Bonus	116	208	0	0	59	127	1,182
DirectComp	406	364	4	208	313	484	1,920
ValuePVSOs	0	0	0	0	0	0	0
ValueTSOs	428	5,535	0	0	0	26	4,712
TotEquity	12,295	50,842	0	234	859	3,316	272,278
Ln(MV)	6.660	1.624	4.272	5.337	6.357	7.809	11.602
Ln(Total Assets)	6.762	1.767	3.685	5.227	6.665	8.153	11.877
TSR	0.176	0.723	-0.771	-0.130	0.087	0.365	1.718
EPS (penny per share)	31.122	69.211	-184.348	8.430	24.078	42.318	186.118
ROA	0.041	0.187	-1.538	0.029	0.057	0.093	0.245
Leverage	0.569	0.165	0.193	0.461	0.577	0.672	0.960

	Mean	Std. Dev.	1%	25%	Median	75%	99%
<i>Panel F: Executive directors with TSO plans, DummyTSO=1 (N=1,207)</i>							
Salary	299	211	52	171	257	365	952
Bonus	132	232	0	5	70	150	1,161
DirectComp	483	419	75	242	390	566	2,227
ValuePVSOs	441	1,047	0	0	105	491	4,179
ValueTSOs	761	6,105	1	15	74	399	10,649
TotEquity	5,428	32,053	50	511	1,180	2,966	93,338
Ln(MV)	7.084	1.643	4.299	5.654	7.023	8.317	11.602
Ln(Total Assets)	7.201	1.736	3.574	5.877	7.262	8.459	11.976
TSR	0.136	0.774	-0.771	-0.180	0.037	0.365	1.817
EPS (penny per share)	22.682	55.543	-198.841	6.624	17.803	36.319	303.731
ROA	0.025	0.203	-1.631	0.027	0.053	0.083	0.195
Leverage	0.553	0.175	0.085	0.443	0.574	0.676	0.906
<i>Panel G: Executive directors without TSO plans, DummyTSO=0 (N=3,031)</i>							
Salary	260	140	28	163	230	321	759
Bonus	122	192	0	15	71	150	901
DirectComp	438	345	33	238	348	534	1,763
ValuePVSOs	580	1,812	0	0	197	607	5,116
ValueTSOs	0	0	0	0	0	0	0
TotEquity	7,810	42,297	0	339	900	2,452	142,954
Ln(MV)	6.559	1.368	4.276	5.509	6.349	7.368	9.709
Ln(Total Assets)	6.749	1.495	3.857	5.545	6.664	7.770	10.155
TSR	0.170	0.853	-0.682	-0.144	0.103	0.352	1.617
EPS (penny per share)	27.605	60.388	-66.445	6.148	18.787	36.130	263.425
ROA	0.042	0.126	-0.441	0.026	0.050	0.086	0.215
Leverage	0.578	0.175	0.099	0.456	0.580	0.691	0.973
<i>Panel H: PVS0 plans with EPS target (N=2,373)</i>							
Salary	287	157	79	180	251	351	837
Bonus	127	193	0	16	77	158	821
DirectComp	474	353	104	254	386	576	1,932
ValuePVSOs	832	2,079	13	173	400	833	6,867
ValueTSOs	94	730	0	0	0	0	2,131
TotEquity	4,769	34,931	51	445	993	2,346	75,172
Ln(MV)	6.798	1.380	4.421	5.724	6.608	7.696	9.896
Ln(Total Assets)	6.989	1.426	4.069	5.955	6.975	7.987	9.851

	Mean	Std. Dev.	1%	25%	Median	75%	99%
TSR	0.120	0.453	-0.697	-0.161	0.083	0.351	1.509
EPS (penny per share)	24.564	51.299	-59.746	6.020	15.795	33.968	310.269
ROA	0.037	0.130	-0.479	0.027	0.047	0.075	0.191
Leverage	0.576	0.175	0.096	0.462	0.580	0.691	0.965

Panel I: PVSO plans without EPS target (N=437)

Salary	279	239	50	170	250	340	775
Bonus	140	244	0	25	79	171	1,129
DirectComp	478	441	50	249	374	565	2,209
ValuePVSOs	722	954	7	187	449	891	5,901
ValueTSOs	187	831	0	0	0	26	4,991
TotEquity	3,083	7,308	56	540	1,133	2,854	28,000
Ln(MV)	6.375	1.367	4.221	5.195	6.130	7.306	9.683
Ln(Total Assets)	6.640	1.687	3.946	5.137	6.381	7.735	10.248
TSR	0.332	1.978	-0.666	-0.168	0.150	0.396	14.826
EPS (penny per share)	19.024	61.876	-224.396	2.433	13.949	31.930	224.957
ROA	0.023	0.136	-0.709	0.009	0.046	0.092	0.166
Leverage	0.552	0.210	0.055	0.413	0.577	0.702	0.948

Panel J: PVSO plans with TSR target (N=314)

Salary	328	269	76	208	293	381	881
Bonus	145	252	0	23	97	176	975
DirectComp	539	453	118	313	459	646	2,187
ValuePVSOs	810	1,377	20	184	421	769	7,075
ValueTSOs	232	965	0	0	0	26	5,257
TotEquity	14,089	89,473	49	444	1,040	2,754	667,443
Ln(MV)	6.603	1.156	4.777	5.724	6.649	7.310	9.635
Ln(Total Assets)	7.210	1.300	4.819	6.278	7.239	7.820	10.248
TSR	0.069	0.471	-0.684	-0.246	0.064	0.277	1.646
EPS (penny per share)	34.098	105.638	-218.415	-0.635	7.981	30.977	555.164
ROA	0.013	0.100	-0.373	-0.003	0.028	0.059	0.205
Leverage	0.572	0.240	0.052	0.441	0.587	0.770	0.926

Panel K: PVSO plans without TSR target (N=2,496)

Salary	281	155	65	174	248	348	822
Bonus	127	195	0	17	75	155	832
DirectComp	466	355	99	248	374	564	1,949

	Mean	Std. Dev.	1%	25%	Median	75%	99%
ValuePVSOs	816	2,009	12	174	409	871	6,339
ValueTSOs	93	714	0	0	0	0	1,800
TotEquity	3,302	12,348	51	465	1,023	2,371	54,105
Ln(MV)	6.750	1.412	4.266	5.614	6.528	7.678	9.892
Ln(Total Assets)	6.901	1.491	3.983	5.722	6.880	7.986	10.060
TSR	0.163	0.919	-0.697	-0.145	0.098	0.359	1.517
EPS (penny per share)	22.404	41.851	-76.454	6.342	16.667	34.068	179.957
ROA	0.038	0.134	-0.571	0.027	0.050	0.080	0.189
Leverage	0.572	0.172	0.107	0.459	0.579	0.690	0.965

Panel L: DummyPVSO=1 & DummyTSO=1 (N=705)

Salary	326	231	70	200	282	390	953
Bonus	129	218	0	8	77	156	1,069
DirectComp	510	420	99	282	421	591	2,210
ValuePVSOs	755	1,281	13	17	406	821	6,330
ValueTSOs	435	1,445	0	13	55	280	7,274
TotEquity	4,935	35,009	76	593	1,277	3,142	48,859
Ln(MV)	7.145	1.451	4.189	5.972	7.264	8.317	9.892
Ln(Total Assets)	7.349	1.507	2.698	6.285	7.317	8.745	9.829
TSR	0.155	0.932	-0.723	-0.194	0.048	0.374	1.817
EPS (penny per share)	22.579	61.354	-175.833	6.624	13.542	30.654	310.269
ROA	0.031	0.118	-0.378	0.025	0.046	0.070	0.187
Leverage	0.558	0.185	0.074	0.432	0.580	0.701	0.912

Panel M: DummyPVSO=0 & DummyTSO=0 (N=926)

Salary	232	127	0	150	207	281	682
Bonus	105	179	0	0	59	123	1,091
DirectComp	384	332	0	211	305	454	1,746
ValuePVSOs	0	0	0	0	0	0	0
ValueTSOs	0	0	0	0	0	0	0
TotEquity	15,643	59,578	0	129	716	4,018	316,122
Ln(MV)	6.476	1.436	4.257	5.307	6.136	7.438	9.666
Ln(Total Assets)	6.638	1.616	3.792	5.184	6.520	7.954	9.930
TSR	0.213	0.828	-0.684	-0.124	0.109	0.379	1.718
EPS (penny per share)	35.604	75.587	-55.709	8.557	24.487	42.172	309.026
ROA	0.053	0.102	-0.276	0.027	0.055	0.090	0.252
Leverage	0.582	0.166	0.193	0.469	0.582	0.688	0.977

Table 4 summarizes the statistics for the variables used in the empirical tests. Panel A presents descriptive statistics. Skewness in compensation is reduced by taking natural logarithms.²⁶ The mean of the DummyPVSO is 0.660, indicating that about two-thirds of the executive-year observations have PVSOs in compensation packages. Panel B reports Pearson correlations. The panel shows that compensation measures are positively correlated with firm performance (i.e., TSR), which suggests that high performance is correlated with improvements in executive pay. The panel also shows that DummyPVSO is negatively correlated with DummyTSO, which suggests that firms with PVSOs grant fewer TSOs. Note that the correlations between control variables are moderate (<0.50), suggesting that they measure different dimensions of firm- and executive-level characteristics and do not merely substitute for each other. Finally, Panels C and D illustrate the Pearson correlations between various compensation measures and firm performance (i.e., TSR) for sub-samples grouped by PVSO and TSO, respectively. The correlations are greater when DummyPVSO=1 than when DummyPVSO=0, indicating that in the presence of PVSOs the pay-performance correlation is stronger. The correlations for sub-samples grouped by DummyTSO do not appear to follow the same pattern, however.

2.5.2 Main results

The following subsections report the empirical results on the two hypotheses. Section 2.5.2.1 reports the results on the first hypothesis; the discussion focuses on the association between PPS and PVSO compensation. Section 2.5.2.2 evaluates the role of target difficulty in the association between PPS and PVSOs.

²⁶ Taking natural logarithm implicitly assumes a convexity association between managerial compensation and firm performance. When the effort choice of managers significantly influences firm risk, convexity will be added to the optimal compensation contracts (Hemmer et al., 1999; Feltham and Wu, 2001; Core et al., 2003; Lambert and

Table 4
Summary statistics

Panel A reports descriptive statistics for the variables used in the analysis. Panel B and C report Pearson correlation statistics computed for the variables used in analyses. See Section 2.3 for more details on variable definitions. p-values are reported in the brackets. *, **, and *** corresponds to 10%, 5% and 1% significance levels (two-tailed).

Panel A: Descriptive statistics for regression variables

Variables	Mean	Std. Dev.	1%	25%	Median	75%	99%
ln(TotComp)	13.363	1.267	10.210	12.608	13.295	14.040	17.130
ln(ChgTotWealth)	13.415	1.261	10.132	12.678	13.372	14.086	17.037
TSR	0.160	0.831	-0.705	-0.152	0.090	0.352	1.667
DummyPVSO	0.660	0.473	0.000	0.000	1.000	1.000	1.000
DummyTSO	0.280	0.451	0.000	0.000	0.000	1.000	1.000
ABSDIF	3.273	1.657	1.207	2.330	3.000	3.387	10.000
RELDIF	-0.032	1.590	-2.351	-0.793	-0.180	0.153	6.466
DIFF	0.480	0.500	0.000	0.000	0.000	1.000	1.000
LnMV	6.709	1.471	4.297	5.535	6.499	7.672	10.266
Dummy_Loss	0.400	0.490	0.000	0.000	0.000	1.000	1.000
Leverage	0.571	0.175	0.096	0.458	0.579	0.689	0.958
Board_Size	9.790	2.593	5.000	8.000	9.000	11.000	18.000
%Outside_Director	0.501	0.127	0.200	0.417	0.500	0.571	0.818
Year-to-retirement	14.490	6.923	0.000	9.000	14.000	20.000	30.000
Dummy_Male	0.980	0.151	0.000	1.000	1.000	1.000	1.000
#Committee_Roles	0.960	1.585	0.000	0.000	0.000	1.000	7.000
Networks	34.050	48.261	6.000	13.000	19.000	37.000	251.000
Year-on-board	7.180	6.256	1.000	2.800	5.100	9.500	29.120
Education	1.350	1.186	0.000	0.000	1.000	2.000	5.000
#Quoted_Boards	1.420	0.787	1.000	1.000	1.000	2.000	4.510

Panel B: Pearson correlation matrix

Variables	Ln(TotComp)	Ln(ChgTotWealth)	TSR	DummyPVSO	DummyTSO	ABSDIF	RELDIFF	DIFF	LnMV	Dummy_Loss	Leverage	Board_Size	%Outside_Director	Year-to-retirement	Dummy_Male	#Committee_Roles	Networks	Year-on-board	Education	#Quoted_Boards
Ln(TotComp)	1.000	0.981**	0.247**	-0.021	0.031	0.099**	0.110**	-0.064**	0.323**	-0.347**	0.030	0.137**	0.136**	-0.039*	0.039*	0.190**	0.164**	0.188**	0.049**	0.155**
Ln(ChgTotWealth)		1.000	0.245**	-0.014	0.032	0.082**	0.097**	-0.061*	0.337**	-0.346**	0.034*	0.149**	0.149**	-0.030	0.034*	0.192**	0.177**	0.162**	0.047**	0.158**
TSR			1.000	-0.014	-0.019	0.065**	0.068**	-0.162**	0.021	-0.399**	-0.087**	-0.084**	0.034**	0.038*	0.024	-0.031*	-0.043**	-0.009**	0.005	-0.028
DummyPVSO				1.000	-0.105**	N/A	N/A	N/A	0.024	-0.007	0.006	0.030	0.134**	0.094**	-0.054**	-0.004	-0.008	-0.142**	-0.039*	-0.011
DummyTSO					1.000	-0.038	-0.024	-0.096**	0.161**	0.043**	-0.065**	0.151**	0.063**	-0.010	0.055**	0.105**	0.124**	-0.022	0.063**	0.068**
ABSDIF						1.000	0.975**	-0.020	-0.101**	-0.026	-0.017	-0.159**	-0.046*	0.101**	0.001	-0.070**	-0.025	0.072**	-0.032	-0.053*
RELDIFF							1.000	-0.012	-0.046**	-0.032	-0.040	-0.122**	-0.017	0.083**	-0.003	-0.046*	-0.007	0.061**	-0.034	-0.023
DIFF								1.000	-0.013	0.149**	0.094**	0.023	0.011	-0.025	-0.041	-0.018	0.014	-0.012	0.037	0.026
LnMV									1.000	-0.031*	0.115**	0.480**	0.284**	-0.125	-0.009	0.278**	0.420**	-0.123**	0.166**	0.268**
Dummy_Loss										1.000	-0.003	0.095**	-0.040**	0.030	-0.027	0.007	0.044**	-0.010	0.028	0.042**
Leverage											1.000	0.128**	0.163**	-0.030	0.024	0.079**	0.054**	-0.161**	0.045**	0.029
Board_Size												1.000	0.087**	-0.123**	-0.022	0.179**	0.329**	-0.104**	0.058**	0.178**
%Outside_Director													1.000	0.012	0.041**	0.200**	0.232**	-0.221**	0.183**	0.179**
Year-to-retirement														1.000	-0.098**	-0.239**	-0.134**	-0.361**	0.017	-0.194**
Dummy_Male															1.000	0.001	-0.028	0.032*	0.042**	-0.011
#Committee_Roles																1.000	0.372**	0.113**	0.186**	0.425**
Networks																	1.000	0.018	0.206**	0.430**
Year-on-board																		1.000	-0.091**	0.103**
Education																			1.000	0.156**
#Quoted_Boards																				1.000

Panel C: Pearson correlation coefficients: by PVSO

	TSR (DummyPVSO=1)	TSR (DummyPVSO=0)
ln(TotComp)	0.278**	0.196**
ln(ChgTotWealth)	0.274**	0.197

Panel D: Pearson correlation coefficients: by TSO

	TSR (DummyTSO=1)	TSR (DummyTSO=0)
ln(TotComp)	0.275**	0.239**
ln(ChgTotWealth)	0.273**	0.236**

2.5.2.1 PPS and PVSO compensation

The findings for Model 1 are summarized in Table 5. Two regression equations are presented for each of the two measures of managerial compensation, $\ln(\text{TotComp})$ and $\ln(\text{ChgTotWealth})$. Chi-square statistics show that both models are significant at $p < 0.01$. Wald tests show that the variances of u_{0jk} and v_{0k} are significant at $p < 0.01$, indicating that after including more explanatory variables the firm- and executive-level fixed effects still explain the total variance of executive compensation to a significantly large degree. We measure the model fit by performing a chi-square test (χ^2) based on the differences in the -2 LogLikelihood between the unrestricted model and the intercept-only model relative to the extra degree of freedom that is equal to the number of explanatory variables. We find significant chi-squares, which suggest an improvement in model fit by adding extra explanatory variables to the intercept-only model.

For both compensation specifications, the results support our first hypothesis: the presence of PVSOs in senior manager compensation is associated with greater interest alignment relative to TSOs. Wald tests show that the coefficient on the test variable $\text{TSR} \times \text{DummyPVSO}$ is significantly greater than that on $\text{TSR} \times \text{DummyTSO}$, and the null hypothesis (i.e., $\beta_3 < \beta_5$) is rejected at a significance level of $p < 0.01$ ($p < 0.05$) in the $\ln(\text{TotComp})$ ($\ln(\text{ChgTotWealth})$) specification. Specifically, in the $\ln(\text{TotComp})$

Table 5
Multilevel models examining the efficiency of PVSOs vs. TSOs (full sample)

This table presents regression results on Model (1). Standard errors are reported in parentheses. Significance levels are based on one-tailed tests where there is a prediction of the sign of the coefficient and based on two-tailed tests otherwise. *, **, and *** correspond to 10%, 5%, and 1% significance levels, respectively. Model (1) is:

$$\ln(\text{Compensation_PROXY})_{ijk} = \beta_{0ijk} + \beta_1 \text{TSR}_{ik} + \beta_2 \text{DummyPVSO}_{ijk} + \beta_3 \text{TSR}_{ik} * \text{DummyPVSO}_{ijk} + \beta_4 \text{DummyTSO}_{ijk} + \beta_5 \text{TSR}_{ik} * \text{DummyTSO}_{ijk} + \beta \text{CONTROLS}$$

$$\beta_{0ijk} = \gamma_{000} + \nu_{0ik} + u_{0jk} + e_{0ijk}$$

	ln(TotComp)	ln(ChgTotWealth)
Intercept (β_0)	9.902*** (0.286)	10.149*** (0.283)
TSR (β_1)	-0.070* (0.038)	-0.050 (0.038)
DummyPVSO (β_2)	-0.056 (0.049)	-0.052 (0.049)
TSR*DummyPVSO (β_3)	0.262*** (0.043)	0.235*** (0.043)
DummyTSO (β_4)	-0.082 (0.051)	-0.058 (0.050)
TSR*DummyTSO (β_5)	0.077* (0.042)	0.076* (0.042)
Controls (firm level)		
LnMV (β_6)	0.379*** (0.027)	0.367*** (0.026)
Dummy_Loss (β_7)	-0.747*** (0.037)	-0.729*** (0.036)
Leverage (β_8)	0.048 (0.178)	0.075 (0.174)
Board_Size (β_9)	-0.015 (0.012)	-0.014 (0.012)
%Outside_Director (β_{10})	0.745*** (0.201)	0.620*** (0.200)
Controls (Executive level)		
Year-to-retirement (β_{11})	0.020*** (0.004)	0.020*** (0.004)
Dummy_Male (β_{12})	0.232 (0.157)	0.192 (0.158)
#Committee_Roles (β_{13})	0.055*** (0.017)	0.056*** (0.017)
Networks (β_{14})	0.000 (0.001)	0.000 (0.001)
Year-on-board (β_{15})	0.057*** (0.005)	0.050*** (0.005)

Education (β_{16})	0.007 (0.022)	0.001 (0.022)
#Quoted_Boards (β_{17})	0.006 (0.037)	0.002 (0.037)
Model fit²⁷		
-2*loglikelihood (-2LLH) /deviance	9,296	9,233
Chi-square (χ^2)	1,478***	1,448***
Wald tests for fixed effects (χ^2)		
Variance of v_{0k} (company-fixed)	46***	40***
Variance of u_{0jk} (executive-fixed)	176***	177***
Wald tests for H1 (χ^2)		
Null hypothesis: $\beta_3 \leq \beta_5$ (H1)	7.945***	5.888**
Number of observations	3,394	3,377

specification, for an average executive a 10% increase in TSR brings about a 0.07% [i.e., $10 \times (0.077 - 0.070)\%$] increase in TotComp when TSOs are included in the compensation package, which is much less than the 1.92% [i.e., $10 \times (0.262 - 0.070)\%$] increase due to PVSOs. The coefficient on the interaction between TSO and DummyPVSO is positive, and the null hypothesis $\beta_3 = 0$ is rejected at $p < 0.01$. The results confirm the implication of the first hypothesis.

Taken together, a higher pay-performance relation is associated with PVSO compensation, consistent with the conjecture that imposing performance conditions on option vesting induces higher managerial effort. Thus, by issuing PVSOs to executives, shareholders align managerial payments with their own interests to a larger extent; such convergence of interests promotes firm performance and shareholder value.

Turning to the control variables, our inferences are consistent across both specifications

²⁷ The Maximum Likelihood procedure also produces a statistic called the deviance, which indicates how well the model fits the data. In general, models with a lower deviance fit better than models with a higher deviance (Hox, 2001). The intercept-only model is useful as a null model that serves as a benchmark against which other models are compared. The deviances of the two models can be used to compare their fit statistically. For nested models, the difference in deviance has a chi-square distribution with degrees of freedom equal to the difference in the number of parameters that are estimated in the two models.

and in general are in line with prior literature. Specifically, the coefficient on LnMV is positive and significant at $p < 0.01$, which suggests that larger firms pay their managers more (Jensen and Murphy, 1990). Further, when shareholders are realizing a loss, managers are compensated less, as indicated by the negative and significant coefficient on Dummy_Loss (Leone et al., 2006). The proportion of outside directors on board has a positive association with managerial payments, which suggests that efficiency of monitoring executive directors decreases with the number of independent directors, mainly due to time and effort in reconciling diversified opinions in management (Westphal and Zajac, 1998). The coefficients on Year_to_retirement, #Committee_Roles, and Year_on_board are significantly positive with $p < 0.01$, implying that executives who have more years to retirement, take on more roles in committees, and have longer tenure on the board receive more wealth from their firm.

2.5.2.2 Pay-performance sensitivity and PVSO target difficulty

The analysis on PVSO target difficulty focuses on the sub-sample of firms that have EPS growth targets attached to option vesting. Three proxies measure the difficulty level: absolute difficulty level (ABSDIF), difficulty level relative to the industry median (RELDIF), and *ex-post* difficulty (DIFF). Table 6 summarizes the empirical results. Chi-square statistics show that all models are significant at $p\text{-value} < 0.01$. The variances of u_{0jk} and v_{0k} , which respectively capture executive- and firm-level fixed effects, are significant at $p < 0.01$, which suggests the necessity of employing multilevel modelling procedure to handle executive- and firm-level intra-correlations.

The results are consistent across model specifications. Specifically, in the $\ln(\text{TotComp})$ specifications, the coefficients on the test variable $\text{TSR} * \text{DIF_PROXY}$ are negative and significant at $p < 0.05$ for the three target difficulty proxies, consistent with the idea that PPS is reduced by difficult targets. For instance, the coefficient on $\text{TSR} * \text{DIFF}$ is -0.378 at $p < 0.01$

Table 6
Multilevel models examining the role of vesting target difficulty

This table presents regression results on Model (2). Standard errors are reported in parentheses. Significance levels are based on one-tailed tests where there is a prediction of the sign of the coefficient and based on two-tailed tests otherwise. *, **, and *** correspond to 10%, 5%, and 1% significance levels, respectively. Model (2) is:

$$\ln(\text{Compensation_PROXY})_{ijk} = \beta_{0ijk} + \beta_1 \text{TSR}_{ik} + \beta_2 \text{DIF_PROXY}_{ik} + \beta_3 \text{TSR}_{ik} * \text{DIF_PROXY}_{ik}$$

+ β CONTROLS

$$\beta_{0ijk} = \gamma_{000} + v_{0ik} + u_{0ijk} + e_{0ijk}$$

	ln(TotComp)			ln(ChgTotWealth)		
Intercept (β_0)	9.889*** (0.305)	10.109*** (0.297)	9.893*** (0.319)	10.126*** (0.307)	10.283*** (0.299)	10.046*** (0.319)
TSR (β_1)	0.887*** (0.122)	0.686*** (0.061)	0.981*** (0.091)	0.793*** (0.118)	0.634*** (0.059)	0.892*** (0.088)
ABSDIF (β_2)	0.064*** (0.019)			0.046** (0.019)		
TSR* ABSDIF (β_3)	-0.059** (0.026)			-0.047** (0.025)		
RELDIF (β_2)		0.061*** (0.020)			0.045** (0.020)	
TSR* RELDIF (β_3)		-0.057** (0.027)			-0.049** (0.026)	
DIFF (β_2)			0.115** (0.046)			0.116** (0.046)
TSR* DIFF (β_3)			-0.378*** (0.100)			-0.401*** (0.095)
Controls (firm level)						
LnMV (β_4)	0.402*** (0.030)	0.399*** (0.030)	0.399*** (0.032)	0.401*** (0.030)	0.399*** (0.030)	0.403*** (0.032)
Dummy_Loss (β_5)	-0.468*** (0.054)	-0.472*** (0.053)	-0.459*** (0.059)	-0.480*** (0.052)	-0.483*** (0.052)	-0.452*** (0.057)
Leverage (β_6)	0.038 (0.197)	0.051 (0.197)	0.186 (0.211)	0.035 (0.196)	0.044 (0.196)	0.195 (0.208)
Board_Size (β_7)	-0.040*** (0.014)	-0.040*** (0.015)	-0.044*** (0.015)	-0.039*** (0.014)	-0.039*** (0.014)	-0.044*** (0.015)
%Outside_Director (β_8)	0.917*** (0.234)	0.917*** (0.234)	0.983*** (0.247)	0.846*** (0.231)	0.845*** (0.231)	0.872*** (0.247)
Controls (Executive level)						
Year-to-retirement (β_9)	0.001 (0.004)	0.001 (0.004)	0.001 (0.005)	0.001 (0.004)	0.001 (0.004)	0.000 (0.005)
Dummy_Male (β_{10})	0.123 (0.141)	0.126 (0.141)	0.197 (0.152)	0.083 (0.143)	0.086 (0.143)	0.146 (0.153)
#Committee_Roles (β_{11})	0.050** (0.020)	0.051** (0.020)	0.050** (0.021)	0.049** (0.020)	0.050** (0.020)	0.049** (0.021)
Networks (β_{12})	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.001 (0.001)

Year-on-board (β_{13})	0.031*** (0.005)	0.031*** (0.005)	0.034*** (0.006)	0.026*** (0.005)	0.026*** (0.005)	0.029*** (0.006)
Education (β_{14})	0.039* (0.024)	0.040* (0.024)	0.027 (0.025)	0.041* (0.024)	0.041* (0.024)	0.031 (0.025)
#Quoted_Boards (β_{15})	-0.017 (0.044)	-0.019 (0.044)	-0.026 (0.046)	-0.024 (0.043)	-0.025 (0.043)	-0.027 (0.046)
Model fit						
-2*loglikelihood (-2LLH) /deviance	4,543	4,545	4,070	4,457	4,458	3,981
Chi-square (χ^2)	6,231***	6,229***	6,704***	6,224***	6,223***	6,700***
Wald tests for fixed effects (χ^2)						
Variance of v_{0k} (company-fixed)	24***	24***	25***	24***	24***	24***
Variance of u_{0jk} (executive-fixed)	58***	58***	49***	72***	72***	64***
Number of observations	1,853	1,853	1,656	1,853	1,853	1,658

and the coefficient on TSR is 0.981 at $p < 0.01$. This result suggests that, *ceteris paribus*, for those managers who miss EPS targets, the pay-performance sensitivity is 38.53% (i.e., $0.378/0.981$) lower than the PPS level for managers achieving vesting targets.

In summary, the results show that difficult targets negatively affect the PPS level. We expect a significant decrease of the pay-performance relation when vesting targets are missed.

The sign of coefficients on the control variables are generally consistent with prior results. That said, after considering the effect of target difficulty, executive age is no longer significant, while board size has statistically significant power in explaining the variance in executive compensation: the negative coefficient on Board_Size suggests that managerial power in influencing their own compensation is diluted in a large board.

2.6 ROBUSTNESS TESTS

This section performs several tests to examine the robustness of the prior findings. We conduct two types of additional tests. First, we examine a plausible alternative explanation, namely, size effects. Second, we perform some validity tests.

2.6.1 Alternative explanation

With vesting targets, managers are eligible to exercise PVSOs only when they have achieved the pre-specified performance hurdles. This performance requirement imposes additional risk on managers, and hence managers will ask for increased compensation. One way to compensate managers for the additional risk is to increase the volume of stock option grants, which suggests that firms that use PVSOs to compensate their executives grant more options relative to firms that use TSOs. This possibility may result in firms granting PVSOs to compensate their executives more intensively in equity (and in turn in total), which could then explain the higher pay-performance relationship associated with the use of PVSOs.

To test the validity of this alternative explanation, we first perform nonparametric tests by comparing means and medians among different groups. The results (untabulated) show that an average/median manager who has PVSO in his portfolio does not hold more company equity or receive more total pay relative to an average/median manager who has TSO. In fact, we observe the opposite pattern: firms that compensate executives with TSOs grant more equity/total payment to their executives compared with firms that compensate their executives with PVSOs, which goes against the alternative explanation.

Next, we control for the plausible grant size effects by interacting TSR with volume of equity holdings in the regressions. Table 7 presents the empirical results. Wald tests show that after controlling for the grant size effects, the prior findings still stand: the coefficient on the test variable $TSR * DummyPVSO$ is significantly ²⁸ larger than the coefficient on $TSR * DummyTSO$, suggesting that greater incentive alignment is associated with the use of PVSO compensation after taking into account the possibility that firms grant more PVSOs to compensate managers for additional risk.

Table 7
Models testing a plausible alternative explanation

This table presents regression results on a plausible alternative explanation. Variables are defined in Table 1. Standard errors are reported in parentheses. Significance levels are based on one-tailed tests where there is a prediction of the sign of the coefficient and based on two-tailed tests otherwise. *, **, and *** correspond to 10%, 5%, and 1% significance levels, respectively.

	ln(TotComp)		ln(ChgTotWealth)	
Intercept	9.907*** (0.235)	9.902*** (0.236)	10.132*** (0.233)	10.125*** (0.234)
TSR	-0.120*** (0.037)	-0.122*** (0.037)	-0.102*** (0.037)	-0.104*** (0.037)
DummyPVSO	-0.142*** (0.048)	-0.104** (0.047)	-0.117** (0.047)	-0.084* (0.046)
TSR*DummyPVSO	0.450*** (0.058)	0.344*** (0.052)	0.417*** (0.057)	0.308*** (0.051)
DummyTSO	-0.076 (0.047)	-0.121*** (0.046)	-0.054 (0.047)	-0.095** (0.046)
TSR*DummyTSO	0.002 (0.045)	0.108*** (0.039)	-0.004 (0.045)	0.104*** (0.039)
#PVSO	1.085*** (0.113)		1.013*** (0.110)	
TSR*#PVSO	0.404*** (0.100)		0.381*** (0.100)	
#TSO	0.357** (0.168)		0.355** (0.167)	
TSR*#TSO	0.531*** (0.162)		0.555*** (0.162)	
#SO		0.905*** (0.088)		0.864*** (0.086)
TSR*#SO		0.163** (0.083)		0.136** (0.083)
#LTIPs	1.533*** (0.210)	1.441*** (0.210)	1.548*** (0.208)	1.456*** (0.209)
TSR*#LTIPs	-0.186 (0.224)	-0.043 (0.223)	-0.225 (0.224)	-0.080 (0.223)
%Share	7.100*** (0.527)	7.053*** (0.528)	7.251*** (0.530)	7.212*** (0.531)
TSR*%Share	6.232*** (0.663)	6.236*** (0.664)	6.154*** (0.664)	6.148*** (0.665)
<i>Controls (firm level)</i>				
LnMV	0.454*** (0.024)	0.459*** (0.024)	0.447*** (0.023)	0.452*** (0.023)
Dummy_Loss	-0.694*** (0.036)	-0.715*** (0.036)	-0.697*** (0.036)	-0.700*** (0.036)
Leverage	0.159 (0.152)	0.172 (0.153)	0.179 (0.149)	0.191 (0.150)

²⁸ The significance level is even enhanced compared to that in the model without the controls for equity holdings

Board_Size	-0.024** (0.011)	-0.026** (0.011)	-0.026** (0.011)	-0.028** (0.011)
%Outside_Director	0.435*** (0.180)	0.412** (0.181)	0.314* (0.180)	0.292 (0.181)
<i>Controls (Executive level)</i>				
Year-to-retirement	0.007** (0.003)	0.007** (0.003)	0.006** (0.003)	0.007** (0.003)
Dummy_Male	0.094 (0.124)	0.102 (0.124)	0.058 (0.125)	0.064 (0.125)
#Committee_Roles	0.049*** (0.015)	0.052*** (0.015)	0.049*** (0.015)	0.052*** (0.015)
Networks	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Year-on-board	0.021*** (0.004)	0.021*** (0.004)	0.015*** (0.004)	0.015*** (0.004)
Education	0.011 (0.017)	0.011 (0.017)	0.008 (0.017)	0.007 (0.017)
#Quoted_Boards	-0.007 (0.033)	-0.013 (0.032)	-0.010 (0.032)	-0.016 (0.032)
<i>Model fit</i>				
-2*loglikelihood (-2LLH) /deviance	8,187	8,212	8,151	8,175
Chi-square (χ^2)	2,587***	2,562***	2,530***	2,506***
<i>Wald tests for fixed effects (χ^2)</i>				
Variance of v_{0k} (company-fixed)	44***	45***	40***	41***
Variance of u_{0jk} (executive-fixed)	74***	73***	72***	72***
<i>Wald tests for H1 (χ^2)</i>				
Null hypothesis: $\beta_3 \leq \beta_5$ (H1)	29.162***	12.245***	25.726***	9.190***
Number of observations	3,263	3,263	3,251	3,251

2.6.2 Validity tests

2.6.2.1 Alternative model specifications and performance measures

We first replicate the analysis using first-differencing models that are not uncommon in pay-performance association studies. Untabulated results are generally consistent with our prior findings. Specifically, the results fully support H1, while for H2 the signs are consistent with our predictions but not statistically significant.

Second, although market-based performance provides a direct measure of shareholder wealth, accounting-based performance measures (i.e., return on assets (ROA) and earnings per share (EPS)) have also been employed in prior studies (Conyon et al., 2000b; Zhang et al., 2005). In both model specifications, the results support our prior findings that PVSOs provide managers with greater incentives to perform in line with shareholder interests. The results on the role of target difficulty are mixed, however, depending on the specification of the target-difficulty measurement. Next, we substitute raw TSR with TSR adjusted by the market index and replicate the analyses. The results are consistent with prior findings. We also exclude fix payments, i.e., salaries, from total compensation since that part is deemed to be invariant with firm performance. The results confirm our prior predictions.

Executives may be paid on the basis of previous performance and in this case PVSOs may (partially) be granted more to compensate past effort rather than provide incentives for future performance. We therefore add lagged performance to our models to control for this possibility. The results show that lagged performance is positively associated with contemporary payments, but this does not affect our prior findings in a meaningful way.

2.6.2.2 CEO vs. non-CEO subsamples

The descriptive statistics show a large difference between CEO pay and non-CEO pay. Prior literature documents that the pay-performance sensitivity of a CEO may be different from that of a non-CEO executive director (Conyon and Sadler, 2001). CEOs possess greater financial incentives than other executives because CEOs are already at the top of the organizational hierarchy and have fewer possibilities for further promotion, which to some extent can be seen as an alternative form of financial compensation. To test for between-group differences in PPS, we split our sample into a CEO group²⁹ and a non-CEO group and apply the same regression models as in the previous sections within each group.

²⁹ For the CEO sample, our models reduce into two levels: firm-level and executive year-level.

The results (in Tables 8 and 9) support our prior findings, especially for the non-CEO sub-sample. For the CEO sub-sample, however, the null hypothesis for H1 (i.e., $\beta_3 < \beta_5$) cannot be rejected at conventional significance levels in both specifications.

Regarding the tests on target difficulty, the coefficients on TSR*DIFF-PROXY are in general significantly negative for both model specifications. Specifically, in $\ln(\text{TotComp})$ model, for the managers missing the vesting targets, the pay-performance sensitivity is 53.40% (i.e., $0.495/0.927$) lower than the PPS level with achievable targets.

In the non-CEO sample, both signs and significance levels of the interaction coefficients are consistent with the prior results in the full sample. Specifically, for a non-CEO executive director, the coefficients on the interaction term TSR* DIFF-PROXY are significantly negative at $p < 0.05$ for both compensation specifications, suggesting that the difficult vesting targets are associated with a lower PPS level. Specifically, with difficult targets, the pay-performance sensitivity of non-CEO directors' TotComp (ChgTotWealth) to firm market performance is 36.07% (38.97%) lower than the PPS level with achievable performance targets.

The difference in the findings between CEO and non-CEO samples might contribute to their different sensitivity to PVSO compensation. For an average CEO in our sample, the proportion of PVSO value to total equity compensation is 4.95% (median: 12.14%) while this number for an average non-CEO is 15.21% (median: 19.67%). The difference in the importance of PVSO in total pay might (partially) explains that the results are less strong in the CEO sample.

Table 8
Multilevel models with CEO sample

This table presents regression results by using CEO sample. Variables are defined in Table 1. Standard errors are reported in parentheses. Significance levels are based on one-tailed tests where there is a prediction of the sign of the coefficient and based on two-tailed tests otherwise. *, **, and *** correspond to 10%, 5%, and 1% significance levels, respectively.

Panel A: Multilevel models examining the efficiency of PVSOs vs. TSOs

	ln(TotComp)	ln(ChgTotWealth)
Intercept (β_0)	11.828*** (0.579)	12.576*** (0.612)
TSR (β_1)	0.012 (0.082)	0.033 (0.080)
DummyPVSO (β_2)	-0.195* (0.100)	-0.218*** (0.099)
TSR*DummyPVSO (β_3)	0.180** (0.093)	0.160* (0.091)
DummyTSO (β_4)	-0.349*** (0.104)	-0.330*** (0.102)
TSR*DummyTSO (β_5)	0.392*** (0.139)	0.403*** (0.136)
<i>Controls (firm level)</i>		
LnMV (β_6)	0.282*** (0.045)	0.267*** (0.045)
Dummy_Loss (β_7)	-0.910*** (0.089)	-0.838*** (0.087)
Leverage (β_8)	-0.101 (0.304)	-0.016 (0.304)
Board_Size (β_9)	0.058** (0.023)	0.063*** (0.023)
%Outside_Director (β_{10})	0.739** (0.373)	0.723* (0.375)
<i>Controls (Executive level)</i>		
Year-to-retirement (β_{11})	0.016** (0.007)	0.014** (0.007)
Dummy_Male (β_{12})	-0.640 (0.435)	-1.267*** (0.462)
#Committee_Roles (β_{13})	-0.033 (0.029)	-0.036 (0.028)
Networks (β_{14})	0.000 (0.001)	0.000 (0.001)
Year-on-board (β_{15})	0.044*** (0.007)	0.041*** (0.007)
Education (β_{16})	-0.081** (0.038)	-0.074* (0.038)

#Quoted_Boards (β_{17})	0.053 (0.055)	0.040 (0.054)
Model fit		
-2*loglikelihood (-2LLH) /deviance	2,946	2,903
Chi-square (χ^2)	388***	373***
Wald tests for fixed effects (χ^2)		
Variance of v_{0k} (company-fixed)	40***	44***
Wald tests for H1 (χ^2)		
Null hypothesis: $\beta_3 \leq \beta_5$ (H1)	1.561	2.144
Number of observations	956	954

Panel B: Multilevel models examining the role of vesting target difficulty

	ln(TotComp)			ln(ChgTotWealth)		
Intercept (β_0)	10.694*** (0.549)	10.857*** (0.536)	10.744*** (0.571)	10.964*** (0.596)	11.087*** (0.588)	10.936*** (0.629)
TSR (β_1)	0.964*** (0.242)	0.667*** (0.110)	0.927*** (0.174)	0.874*** (0.239)	0.637*** (0.109)	0.966*** (0.171)
ABSDIF (β_2)	0.046 (0.032)			0.034 (0.032)		
TSR* ABSDIF (β_3)	-0.087** (0.052)			-0.070* (0.051)		
RELDIF (β_2)		0.047 (0.033)			0.038 (0.033)	
TSR* RELDIF (β_3)		-0.089* (0.055)			-0.071* (0.054)	
DIFF (β_2)			0.273*** (0.096)			0.293*** (0.094)
TSR* DIFF (β_3)			-0.495*** (0.189)			-0.539*** (0.185)
Controls (firm level)						
LnMV (β_4)	0.436*** (0.047)	0.434*** (0.047)	0.430*** (0.049)	0.434*** (0.048)	0.432*** (0.048)	0.434*** (0.049)
Dummy_Loss (β_5)	-0.639*** (0.109)	-0.645*** (0.108)	-0.671*** (0.116)	-0.625*** (0.107)	-0.630*** (0.106)	-0.622*** (0.115)
Leverage (β_6)	-0.141 (0.312)	-0.126 (0.312)	0.011 (0.321)	0.024 (0.317)	0.036 (0.317)	0.139 (0.325)
Board_Size (β_7)	-0.010 (0.026)	-0.010 (0.026)	-0.020 (0.027)	-0.006 (0.026)	-0.006 (0.026)	-0.014 (0.027)
%Outside_Director (β_8)	0.784* (0.402)	0.774* (0.403)	0.749* (0.413)	0.758* (0.410)	0.751* (0.411)	0.735* (0.423)
Controls (Executive level)						

Year-to-retirement (β_9)	-0.005 (0.008)	-0.005 (0.008)	-0.012 (0.009)	-0.006 (0.008)	-0.006 (0.008)	-0.015* (0.009)
Dummy_Male (β_{10})	-0.165 (0.376)	-0.165 (0.376)	-0.060 (0.397)	-0.448 (0.412)	-0.450 (0.412)	-0.371 (0.438)
#Committee_Roles (β_{11})	-0.062* (0.032)	-0.062* (0.032)	-0.070** (0.033)	-0.078** (0.031)	-0.078* (0.031)	-0.086*** (0.032)
Networks (β_{12})	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)
Year-on-board (β_{13})	0.028*** (0.008)	0.028*** (0.008)	0.029*** (0.008)	0.031*** (0.008)	0.031*** (0.008)	0.032*** (0.008)
Education (β_{14})	-0.030 (0.044)	-0.030 (0.044)	-0.029 (0.046)	-0.021 (0.044)	-0.021 (0.044)	-0.019 (0.046)
#Quoted_Boards (β_{15})	0.038 (0.061)	0.037 (0.061)	0.042 (0.063)	0.036 (0.061)	0.034 (0.061)	0.037 (0.063)
Model fit						
-2*loglikelihood (-2LLH) /deviance	1,289	1,289	1,172	1,286	1,286	1,167
Chi-square (χ^2)	2,045***	2,045***	2,162***	1,990***	1,990***	2,109***
Wald tests for fixed effects (χ^2)						
Variance of v_{ok} (company-fixed)	16	16	13	19	19	16
Number of observations	501	501	454	503	503	456

2.6.2.3 Valuation of PVSOs

The Black-Scholes stock option fair-value model might overestimate PVS0 values because the option vesting probability is strictly smaller than 1. Overvalued option compensation would bias our results upward due to the systematic link between equity compensation and firm market prices. To test this restriction in our analyses, we re-perform the tests using three different discount rates,³⁰ as implied in prior studies (Conyon et al., 2005; Kuang and Suijs, 2006). The results show that our prior findings do not depend on the valuation assumption. We also assign different discount rates to PVS0s with different types of vesting targets and re-perform the analyses.³¹ The results are qualitatively the same.

³⁰ Conyon et al. (2005) use a discount rate of 80% to capture the vesting probability of performance-based equity compensation; Kuang and Suijs (2006) show that the optimal vesting probability for PVS0s is above 72%. Furthermore, the sample in the current study indicates a realization probability of 52% for PVS0s.

³¹ We discount the value of PVS0s with market-based targets at 50% (Camara, 2001); of PVS0s with accounting-based targets at 80% (Conyon et al., 2005); and the value of performance-based stocks at 50% since vesting is generally subject to TSR performance relative to the median of a peer group.

Table 9
Multilevel models with non-CEO sample

This table presents regression results by using non-CEO sample. Variables are defined in Table 1. Standard errors are reported in parentheses. Significance levels are based on one-tailed tests where there is a prediction of the sign of the coefficient and based on two-tailed tests otherwise. *, **, and *** correspond to 10%, 5%, and 1% significance levels, respectively.

Panel A: Multilevel models examining the efficiency of PVSOs vs. TSOs

	ln(TotComp)	ln(ChgTotWealth)
Intercept (β_0)	9.861*** (0.260)	10.148*** (0.256)
TSR (β_1)	-0.026 (0.042)	-0.019 (0.041)
DummyPVSO (β_2)	-0.032 (0.050)	-0.014 (0.049)
TSR*DummyPVSO (β_3)	0.211*** (0.047)	0.194*** (0.047)
DummyTSO (β_4)	-0.048 (0.052)	-0.026 (0.051)
TSR*DummyTSO (β_5)	0.054 (0.042)	0.050 (0.041)
<i>Controls (firm level)</i>		
LnMV (β_6)	0.392*** (0.027)	0.391*** (0.026)
Dummy_Loss (β_7)	-0.716*** (0.040)	-0.713*** (0.039)
Leverage (β_8)	0.351** (0.177)	0.332* (0.172)
Board_Size (β_9)	-0.022* (0.013)	-0.025** (0.012)
%Outside_Director (β_{10})	0.461** (0.213)	0.297 (0.210)
<i>Controls (Executive level)</i>		
Year-to-retirement (β_{11})	0.023*** (0.003)	0.023*** (0.004)
Dummy_Male (β_{12})	0.118 (0.125)	0.078 (0.128)
#Committee_Roles (β_{13})	0.027 (0.020)	0.033* (0.020)
Networks (β_{14})	-0.002** (0.001)	-0.001** (0.001)
Year-on-board (β_{15})	0.041*** (0.005)	0.031*** (0.005)
Education (β_{16})	0.018 (0.020)	0.000 (0.020)

#Quoted_Boards (β_{17})	-0.063 (0.041)	-0.070* (0.041)
Model fit		
-2*loglikelihood (-2LLH) /deviance	6,090	6,030
Chi-square (χ^2)	1,112***	1,126***
Wald tests for fixed effects (χ^2)		
Variance of v_{0k} (company-fixed)	51***	44***
Variance of u_{0jk} (executive-fixed)	27***	36***
Wald tests for H1 (χ^2)		
Null hypothesis: $\beta_3 \leq \beta_5$ (H1)	5.118**	4.422**
Number of observations	2,438	2,423

Panel B: Multilevel models examining the role of vesting target difficulty

	ln(TotComp)			ln(ChgTotWealth)		
Intercept (β_0)	9.565*** (0.296)	9.817*** (0.287)	9.665*** (0.311)	9.864*** (0.288)	10.071*** (0.280)	9.953*** (0.299)
TSR (β_1)	0.911*** (0.137)	0.704*** (0.070)	0.901*** (0.100)	0.835*** (0.133)	0.654*** (0.068)	0.852*** (0.096)
ABSDIF (β_2)	0.073*** (0.020)			0.060*** (0.019)		
TSR* ABSDIF (β_3)	-0.061** (0.029)			-0.054** (0.028)		
RELDIF (β_2)		0.071*** (0.021)			0.059*** (0.020)	
TSR* RELDIF (β_3)		-0.061** (0.029)			-0.057** (0.029)	
DIFF (β_2)			0.054 (0.051)			0.050 (0.049)
TSR* DIFF (β_3)			-0.325*** (0.115)			-0.332*** (0.110)
Controls (firm level)						
LnMV (β_4)	0.420*** (0.031)	0.416*** (0.031)	0.409*** (0.033)	0.415*** (0.030)	0.412*** (0.030)	0.404*** (0.032)
Dummy_Loss (β_5)	-0.441*** (0.060)	-0.445*** (0.060)	-0.415*** (0.066)	-0.463*** (0.058)	-0.456*** (0.058)	-0.437*** (0.063)
Leverage (β_6)	0.272 (0.198)	0.286 (0.198)	0.419** (0.215)	0.248 (0.192)	0.259 (0.192)	0.415** (0.206)
Board_Size (β_7)	-0.035** (0.015)	-0.035** (0.015)	-0.034** (0.016)	-0.035** (0.015)	-0.035** (0.015)	-0.034** (0.016)

%Outside_Director (β_8)	0.653*** (0.248)	0.654*** (0.248)	0.735*** (0.263)	0.582** (0.241)	0.581** (0.241)	0.610** (0.253)
Controls (Executive level)						
Year-to-retirement (β_9)	0.008** (0.004)	0.008** (0.004)	0.008** (0.004)	0.008** (0.004)	0.008** (0.004)	0.007* (0.004)
Dummy_Male (β_{10})	0.101 (0.120)	0.105 (0.120)	0.158 (0.132)	0.063 (0.119)	0.066 (0.118)	0.104 (0.128)
#Committee_Roles (β_{11})	0.025 (0.024)	0.024 (0.024)	0.028 (0.025)	0.038 (0.024)	0.038* (0.023)	0.043 (0.024)
Networks (β_{12})	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.001 (0.001)	-0.000 (0.001)
Year-on-board (β_{13})	0.015*** (0.006)	0.015*** (0.006)	0.017*** (0.006)	0.006 (0.005)	0.006 (0.005)	0.006 (0.006)
Education (β_{14})	0.030 (0.022)	0.030 (0.022)	0.022 (0.023)	0.022 (0.022)	0.022 (0.021)	0.016 (0.023)
#Quoted_Boards (β_{15})	-0.019 (0.050)	-0.019 (0.050)	-0.057 (0.054)	-0.026 (0.049)	-0.026 (0.049)	-0.058 (0.053)
Model fit						
-2*loglikelihood (-2LLH) /deviance	3,080	3,081	2,737	2,998	2,999	2,648
Chi-square (χ^2)	4,112***	4,121***	4,465***	4,158***	4,157***	4,508***
Wald tests for fixed effects (χ^2)						
Variance of v_{0k} (company-fixed)	28***	28***	28***	27***	27***	27***
Variance of u_{0jk} (executive-fixed)	2	2	2	3	3	3
Number of observations	1,352	1,352	1,202	1,350	1,350	1,202

2.6.2.4 Extension of target difficulty

The goal-setting literature has consistently documented that increased target difficulty initially has positive economic effects, but that targets that are too difficult demotivate managers and result in lower exerted effort (Hirst and Lowy, 1990; Covalleski et al., 2003; Kuang and Suijs, 2006). Untabulated results show that our main results do not change when allowing for an inverted U-shaped relation between PPS and target difficulty. We also examine the association between *ex-ante* target difficulty perception (i.e., ABSDIF and RELDIF) and *ex-post* success rate (i.e. (1-DIFF)). Extremely easy targets do not result in the highest success rate and an inverted U-shape is present.

2.7 CONCLUSIONS

This paper investigates the incentive effects of performance-vested stock options in aligning shareholder and management interests. Option vesting conditions are expected to prevent managers from benefiting from effort-irrelevant factors, and our results are supportive of this conjecture. Specifically in our full sample and non-CEO sub-sample, we find that the presence of a PVSO plan in an executive compensation contract is associated with higher pay-for-performance sensitivity, suggesting the convergence of owner and management interests. Further, in a sample of firms that have adopted PVSOs, we find that target difficulty has a negative effect on PPS.

This study is subject to several limitations. First, we focus on how PVSO functions with respect to aligning manager and shareholder interests. However, PVSO may also be used for other purposes that are beyond the scope of this paper. Further, an endogeneity problem may exist in our models. For example, firms that choose PVSO compensation differ substantially from those without PVSO compensation in aspects such as corporate governance, the structure of managerial compensation, and market performance. In our multilevel modelling setup, we control for these firm- and executive-level fixed effects simultaneously, thereby mitigating the endogeneity problem to a certain extent.³² In addition, this study might suffer from measurement error problems. First, although we measure target difficulty from different angles, they may not fully reflect managerial perceptions of the difficulty they face in meeting their targets. For instance, because we limit attention to the threshold target level, we may underestimate managerial perception of target difficulty. However, the literature on goal-setting suggests an inverted-U shaped association between performance and target difficulty. According to our results, it is most likely the case that the majority of our observations lie on the right-hand side of the peak. Thus, our findings may still hold for more

³² Prior studies also show that using fixed effect estimation reduces the endogeneity bias and produces consistent

difficult targets. Second, the Black-Scholes stock option fair-value model might result in overestimated PVSO value. Due to the mechanical relationship between equity compensation and firm performance, the overestimation may bias our results. However, we believe that the consistent results we obtain from tests using discounted PVSO mitigate the overestimation problem to some extent. Third, the valuation of PVSO may vary with performance targets (i.e., accounting performance measures vs. market-based ones). We address this problem by discounting PVSO (and also performance-based stocks) at different rates according to target types.

Finally, the sample consists of the 244 largest UK firms, which limits the generalizability of the results. Future research could focus more on small- and medium-sized firms to explore the features regarding incentive compensation in a broader sample. However, to the extent large firms are of greatest concern to stakeholders, and the current study sheds light on the way in which PVSO can help align the interests of managers and shareholders.

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2.A CONSTRUCTION OF THREE-LEVEL HIERARCHICAL LINEAR MODEL

In an attempt to justify the appropriate number of levels within the hierarchical structure of our sample data, we first construct an intercept-only model with four levels:

$$\begin{aligned}\ln(\text{ChgTotWealth})_{0ijkl} &= \beta_{0ijkl} \\ \beta_{0ijkl} &= 13.421(0.046) + f_{0l} + v_{0kl} + u_{0jkl} + e_{0ijkl} \\ [f_{0l}] &\sim N(0, \Omega_f) : \Omega_f = [0.000(0.000)] \\ [v_{0kl}] &\sim N(0, \Omega_v) : \Omega_v = [0.357(0.048)] \\ [u_{0jkl}] &\sim N(0, \Omega_u) : \Omega_u = [0.499(0.038)] \\ [e_{0ijkl}] &\sim N(0, \Omega_e) : \Omega_e = [0.801(0.024)]\end{aligned}$$

where l stands for industry, k for firms, j for executives, and i for executive years.

The average values on the dependent variable (e.g., change of executive total wealth) vary with groups at each level within the hierarchical structure. Instead of incorporating a number of indicators for these groups (i.e., industry, firm, or executive dummies) into the model, a multilevel model captures group fixed effects by assigning a random intercept that consists of several components, one for each level. Specifically, in our models, f_{0l} , v_{0kl} , and u_{0jkl} control for the group fixed effects at the level of industry, firm, and individual executive, respectively. As a consequence, the residual term is now partitioned into four components corresponding to each level in the hierarchy. e_{0ijkl} stands for the residual at the lowest level (i); u_{0jkl} , v_{0kl} , and f_{0l} control for executive-, firm-, and industry fixed effects, respectively. The residual variance also comprises four components: Ω_f , Ω_v , Ω_u , and Ω_e for variance among industries, firms, executive, and executive-years, respectively. The similarity among observations in the same level is measured by the intra-class correlation, which measures the extent to which the value of the dependent variable (e.g., change of CEO total wealth) of observations within the same group compares with the value of observations

from other groups. Put differently, intra-class correlation refers to the proportion of the total residual variation that is due to the difference between groups at a specific level. We calculate the intra-class correlation at the executive level as follows:

$$\rho_u = \frac{\sigma_u}{\sigma_f + \sigma_v + \sigma_u + \sigma_e} = \frac{0.499}{0.000 + 0.357 + 0.499 + 0.801} = 0.3011.$$

Likewise, we calculate ρ_v and ρ_f . Approximately 30.11% (21.55% and 0.00%) of the total variance in $\ln(\text{ChgTotWealth})$ can be attributed to differences among executives (firms and industries). Industry groups do not explain any proportion of the total variance. Meanwhile, Ω_f , i.e., σ_f^2 , is not significant.³³ We therefore compare the full model with a restricted model that excludes f_{0i} . The value of the likelihood ratio statistic also cannot reject $H_0: \Omega_f = 0$. For a robustness check, we employ executive total compensation $\ln(\text{TotComp})$ as the dependent variable in the intercept-only model. The results confirm the use of three levels: firm, executive, and executive-year. Thus, we finally construct three-level models specified as follows:

$$\begin{aligned} \ln(\text{Compensation_PROXY})_{ijk} &= \beta_{0ijk} + \beta_1 \text{TSR}_{ik} + \beta_2 \text{DummyPVSO}_{ijk} \\ &+ \beta_3 \text{TSR}_{ik} * \text{DummyPVSO}_{ijk} + \beta_4 \text{DummyTSO}_{ijk} + \beta_5 \text{TSR}_{ik} * \text{DummyTSO}_{ijk}, \\ &+ \beta \text{CONTROLS} \\ \beta_{0ijk} &= \gamma_{000} + v_{0k} + u_{0jk} + e_{0ijk}, \\ [v_{0k}] &\sim N(0, \Omega_v) \\ [u_{0jk}] &\sim N(0, \Omega_u). \\ [e_{0ijk}] &\sim N(0, \Omega_e) \end{aligned}$$

Again, we calculate ρ_u and ρ_v in the intercept-only model with three levels.

Approximately 30.51% and 20.52% of the total variance in $\ln(\text{ChgTotWealth})$ can be

³³ In the current study, the estimators in both first-order differencing and multilevel regression analyses are Maximum Likelihood (ML) estimators. Maximum Likelihood estimation includes procedures to generate standard errors for most of the parameter estimates. These can be used in significance testing by computing the test statistic Z: Z-parameter/st. error.

explained by the variance among executives and firms, respectively.³⁴

2.B DESCRIPTIONS ON VESTING TARGETS

Performance targets attached to option vesting are designed to reward managers for performance delivered. The most widely adopted target is the growth rate of earnings per share (EPS) (Conyon et al., 2000a). In its remuneration report of 2004, Allied Domecq describes its executives' Share Option Scheme as follows:

"...Options are normally exercisable after the third anniversary of the date of the grant and lapse ten years after the date of their original grant, subject to a performance condition based on earnings per share growth. Options become exercisable if company's growth in normalized earnings per share exceeds the growth in the UK retail prices index by 9% over three years following the grant of options."

The second-most frequently used performance condition is total shareholder return (TSR). When this measure is applied, option vesting usually depends on the market return of a firm relative to the performance of a peer group. The 2004 annual report of Cable & Wireless states the following:

"...The vesting of share options awarded to the Executive Directors is subject to relative TSR performance conditions. Full vesting occurs only if the TSR performance of the Company meets or exceeds the upper quartile (of FTSE 100) on the third anniversary of the date of grant. Where TSR performance meets the median, 50 percent of the initial award vests. A sliding scale operates between median and upper quartile, and nothing vests for TSR performance below the median."

³⁴ Note that 30.72% and 20.38% of the total variance in $\ln(TotComp)$ can be attributed to differences among executives and firms, respectively.

Chapter 3: Performance-vested Stock Options and Earnings Management

3.1 INTRODUCTION

Amid rising complaints about a weak link between improvements in the economic performance of a firm and the compensation of managers (Gerakos et al., 2005), considerable reforms have been witnessed regarding top managers' compensation schemes. In an effort to tighten managerial compensation and shareholder wealth, performance targets are introduced into managerial equity compensation, such as stock options³⁵. With such targets, not only on the passage of time but also on the achievement of predetermined targets determine whether options can be exercised or not. This reform of stock option compensation was advocated by activist shareholders³⁶ in a broad effort to improve corporate governance and has been rapidly implemented. As reported by Mercer Human Resource Consulting, 30 out of 100 major U.S. corporations based a portion of the equity granted to their executives on performance targets, up from 23 in 2004 and 17 in 2003. Mercer predicts that half of the big companies in the U.S. will be using such awards by the end of 2006.

In the UK, attaching performance targets to stock option compensation was proposed in the Corporate Governance Code in the early 90s' (Greenbury, 1995)³⁷ and has become a widespread practice for U.K. firms ever since. In 1997, almost 60% of the 200 largest U.K. firms operating stock option compensation schemes had performance criteria attached

³⁵ "US boards tie CEO pay to results", *Wall Street Journal*, February 22, 2006.

³⁶ For example, American Federation of State, County and Municipal Employees' Pension fund, United Brotherhood of Carpenters and Joiners of America, "Activists sink claws into executives' pay", *Wall Street Journal*, February 27, 2006.

³⁷ In the code, firms are strongly suggested to improve managerial stock option schemes by making exercise of the options conditional on "challenging performance criteria".

(Conyon et al., 2000). In 2003, this number had grown to 90% of FTSE top 250 non-financials (Kuang and Suijs, 2006).

The stated aim of conditioning stock option vesting on performance targets is to limit the possibility that managers receive windfall gains while their performance is modest or below average. However, performance targets may also create some problems. Evidence shows that basing managers' payments or promotion opportunities on the achievement of performance targets will reduce the incentive effects of compensation and may even incentivize managers to game the system at the cost of shareholder wealth (Healy, 1985; Gaver et al., 1995; Buck et al., 2003; Jensen, 2003). If the vesting of stock options is conditional upon the achievement of predetermined targets, managers might face similar incentives. Usually, targets are accounting-based (e.g., EPS growth) (Conyon et al., 2006). Managers may use their discretion over reported earnings to meet the targets and ensure that stock options vest. Even when the targets are market-based (e.g., TSR), the incentive for earnings manipulation will not disappear. Given the market reaction to accounting earnings (Easton and Zmijewski, 1989; Collins and Kothari, 1989; Teets and Wasley, 1996; Sloan, 1996; Collins and Hribar, 2000; Xie, 2001), managers have an incentive to manage earnings to obtain a desirable market response.

This paper attempts to answer two questions: first, are performance-vested stock option (PVSO³⁸) compensation and earnings management correlated? Second, how does the composition of a PVSO compensation package relate to earnings management behavior? I focus on UK firms because disclosure regulations are such that more information about managerial compensation, especially PVSO compensation, is available compared to the US. The sample consists of 1,191 firm-year observations from the 244 largest non-financial firms

³⁸ PVSO is the abbreviation for performance-vested stock option, where the option vesting is conditional upon the achievement of predetermined performance targets. Correspondingly, the abbreviation for traditional stock option is TSO, where the option vesting is simply contingent upon time lapse.

in the UK between 1997 and 2004. Earnings management is measured by book-tax differences, the deferred portion of income tax, and abnormal accruals (Dechow and Dichev, 2002; Phillips et al., 2003; Lev and Nissim, 2004; Hanlon, 2005). I also investigate the return-earnings association (see e.g., Chan et al., 2006). The empirical results support a positive association between earnings management and PVSO compensation, which is consistent with the hypothesis that managers use their discretion over accounting procedures when they hold a large proportion of their compensation in PVSOs. Second, the results from the return-earnings association show that the presence of PVSOs in managerial compensation schemes is associated with less informative reported earnings, which is consistent with the market recognizing the effects of PVSOs on the incentives of managers to manipulate earnings and discounting the informativeness of reported earnings. When grouping PVSOs on the basis of their maturing stages (i.e. vesting in the current year, vesting after the current year, new grant and vested before the current year), the results indicate that not all PVSO tranches have the same association with earnings management. This is in line with the conjecture that the relation between PVSO compensation and earnings management varies across PVSO tranches. I expect earnings management to be the strongest when a manager hold large proportion of his wealth in PVSOs with the performance period ended in the current year or afterwards. The results are in general consistent with my conjecture.

Increasing attention has been paid to the consequences of equity compensation granted to managers (Burns and Kedia, 2003; Cheng and Warfield, 2005; Bergstresser and Philippon, 2006). This study contributes to the literature by shedding some light on the effects of non-traditional stock options, i.e., PVSOs, on earnings management. Notwithstanding the extensive applications of PVSO compensation, especially in the U.K., there is limited knowledge on the implications of this incentive instrument on managerial behavior. Some analytical studies show that PVSO compensation may provide managers with incentives to

use their discretion over accounting procedures and manage earnings (Camara and Henderson, 2005; Kuang and Suijs, 2006). This paper adds to the literature as being among the first to provide some empirical evidence on this issue. Meanwhile, I compare PVSOs with TSOs in providing managers with incentives to engage in earnings management and the level of earnings management is measured using three different proxies.³⁹ The inferences are consistent across each specification.

The remaining of the paper is organized as follows: Section 3.2 previews the related literature on the incentive effects of stock options and develops the hypotheses. Research design and method are presented in Section 3.3. Section 3.4 describes the sample selection procedure. Section 3.5 reports the empirical results. Additional tests are performed in Section 3.6. In Section 3.7, conclusions are drawn.

3.2 RELEVANT LITERATURE AND HYPOTHESIS DEVELOPMENT

The economic consequences of traditional stock option (TSO) compensation have been widely discussed in the incentive literature. Studies have shown that stock options compensation may mitigate the agency problem between managers and investors and stock option grants can improve firm performance (Hanlon et al., 2003; Nagar et al., 2003; Ittner et al., 2003). Increasing attention has been paid to the unintended economic consequences of stock option compensation ever since the widely reported accounting scandals. A positive association between accounting accruals and the use of options has been documented, suggesting that when managers' potential total compensation is more closely tied to option holdings, problems from earnings management are more pronounced (Bergstresser and Philippon, 2005; Cheng and Warfield, 2005). Corporate frauds may be more likely in cases of

³⁹ Apart from conventional earnings management measures, e.g. abnormal accruals, I identify tax fundamentals

particularly severe earnings management. Although the empirical evidence on the link between equity compensation and corporate frauds is mixed (Erickson et al., 2006), studies have documented that managers' stock option compensation is positively associated with misreporting, accounting fraud, and shareholder litigation (Burns and Kedia, 2003; Johnson et al., 2003; Peng and Roell, 2004).

Compared to the large body of literature on the incentive effects of TSO compensation, the economic consequences of PVSOs are a less-explored field and the current knowledge is mainly based on theoretical evidence or relies on intuitive notions (Camara and Henderson, 2005). In what follows, I develop hypotheses on the association between PVSO compensation and earnings management behavior. PVSOs can be considered as a compensation instrument with ingredients (i.e., equity incentives and the use of targets) that stem from stock options and contingent pay, such as cash bonuses. The first hypothesis focuses on the equity incentive feature of PVSOs and predicts how it relates to earnings management behavior. The second hypothesis investigates how vesting targets provide managers with incentives to engage in earnings management. The third hypothesis is more explorative, in which I conjecture that managers perceive different incentives to manage earnings depending on the composition of their PVSO holdings.

3.2.1 Performance Targets and Earnings Management

The gain from stock option compensation increases with the intrinsic value, calculated as the difference between the market price of the stock on the exercise date and the exercise price that is determined on the grant date. This helps to motivate managers to exert higher effort and increase firm economic performance. However, given the market's reaction to

such as book-tax income difference and deferred tax income as another context in which earnings management can

accounting numbers (e.g. Easton and Zmijewski, 1989; Collins and Kothari, 1989; Teets and Wasley, 1996), managers may temporarily change the market's valuation of the firm by managing earnings and as such increase the value of their stock option holdings. Prior literature has documented that managers can use their discretions on accounting reporting to affect reported earnings and stock prices (O'Brien, 1988; Brown and Kim, 1991; Cheng and Warfield, 2005; Bergstresser and Philippon, 2006).

With PVSO compensation, the compensation mechanism of payoff is unchanged and managers still benefit from the increase on the intrinsic value of the stock options. An effort-averse manager may manage earnings in an attempt to obtain a desirable market price and I predict that such incentive increases with the importance of PVSOs in managerial compensation. The first hypothesis states that:

H1: *Ceteris paribus*, earnings management is positively associated with the importance of PVSOs in managers' compensation packages.

Compared to TSOs, the vesting of PVSOs is subject to the achievement of a predetermined performance target; managers therefore have an incentive to meet the targets. The purpose of attaching performance targets to option vesting is to filter out the impact of effort-irrelevant factors on managerial pay⁴⁰ and managerial effort is more closely tightened to their pay. To get a higher pay, managers will increase their effort. But neither managerial effort nor the economic performance of a firm is observable to shareholders. Accordingly, some profit indexes, such as earnings per share (EPS) growth and/or total shareholder return (TSR) are usually employed as performance measures for evaluation purpose. These performance measures are not free from problems, however.

be expected (Phillips et al., 2003; Lev and Nissim, 2004; Hanlon, 2005).

⁴⁰ Examples of the economy-wide factors include inflation, interest rate changes, exchange rate movements and trade agreements (Greenbury Code, 1995).

Prior studies demonstrate that performance targets are associated with earnings management. Managers will influence the target-setting process and attempt to set targets that are easy to attain, e.g. which can be easily manipulated (Jensen, 2003)⁴¹. When accounting targets, such as EPS growth, are used, managers may exploit their discretion over accounting to achieve targets by managing the reported earnings (Healy, 1985; Gaver et al., 1995; Holthausen et al., 1995; Murphy, 2000; Leone and Rock, 2002). Even when market-based performance criteria, such as TSR, are used, the incentive for earnings manipulation will not disappear. Indeed, the existing literature provides ample evidence that capital markets react to accounting (e.g. Easton and Zmijewski, 1989; Collins and Kothari, 1989; Teets and Wasley, 1996). The market appears to even overprice those components of accounting earnings that are susceptible to manipulation (Sloan, 1996; Collins and Hribar, 2000; Xie, 2001). Therefore, managers have an incentive to manage earnings to elicit a desirable market response (Beneish and Vargus, 2002; Balsam et al., 2003; Safdar, 2003; Bergstresser and Philippon, 2006).⁴² Moreover, to be able to continuously meet the targets, managers may decrease earnings when business is good and economic performance is higher than the predetermined targets. In contrast, managers can use “cookie jar reserves” to boost reported earnings in unfavorable circumstances (see e.g. Healy, 1985; Leone and Rock, 2002).⁴³

Taken together, performance targets attached to option vesting are positively associated with earnings management and a manager’s incentive to manage earnings increases with the importance of PVSOs in his/her compensation package. Formally stated:

⁴¹ Presumably managers’ personal costs of increasing effort to meet targets in general outweigh the costs to managing earnings for the same purpose (Kuang and Suijs, 2006).

⁴² In firms with market-based targets, managerial choice on earnings manipulation is influenced by the sensitivity of market reaction to reported earnings. For instance, with relatively low sensitivity, managers might engage in more intensive earnings management to elicit a desired market response. Therefore, I have no explicit prediction on the differentiation of earnings management among performance targets.

⁴³ Managers may also use the timing of information flows (Aboody and Kasznik, 2000) and/or the timing of stock option grants/exercises to increase their benefits from stock option compensation (Yermack, 1997; Heath et al., 1999).

H2: *Ceteris paribus*, compared with TSOs, the level of earnings management is higher if a manager's compensation package comprises PVSOs.

3.2.2 Composition of PVSOs and Earnings Management Strategy

At the end of a performance period, the company board will decide whether or not PVSOs granted to managers will vest on the basis of firm performance during the performance period. It is useful to decompose managers' PVSO portfolios into four tranches on the basis of how far removed PVSOs are from the end of the performance period: the first tranche is PVSOs awarded during the current year (i.e., new grants), the second tranche is PVSOs with a performance period that ends in the current year (i.e., options vesting in the current year), the third tranche is PVSOs with a performance period ending after the current year (i.e., options vesting in future years), and the last tranche consists of PVSOs with a performance period that ended before the beginning of the current year (i.e., options vested before the current year). The first three tranches are PVSOs with performance targets not yet fulfilled at the beginning of the current year. The last tranche consists of PVSOs that are already exercisable at the beginning of the current year.

The association between PVSOs newly granted and earnings management is not clear-cut. To obtain a lower exercise price, managers have the incentive to manage earnings downward before the option grant date (Balsam et al., 2003). On the other hand, income-decreasing earnings management may reduce the chances of attaining the PVSO targets. The incentive to decrease earnings may be expected to dominate if its negative effects on meeting targets can be compensated in later years.

PVSOs after vesting may motivate managers to manage earnings upward in an attempt to increase the probability of a higher market price at the exercise date. This, however,

depends on whether they plan to exercise the options soon. Managing earnings is not free. For example, subject to public scrutiny and accounting regulations, managers may not manage earnings upward if they do not plan to exercise the options soon.

In contrast, PVSOs granted in prior years but within performance valuation period provide managers with incentive to engage in earnings-increasing manipulation. In order to meet the pre-specified vesting targets, managers who are aware of the implications of earnings management are expected to boost firm performance via manipulation.

Most firms require vesting targets to be met on a three-year annual average basis (Camara and Henderson, 2005) and boards will usually decide whether stock options become vested or not at the end of the three-year performance period. Thus, managers may build a strategy to meet the vesting requirements and engage in earnings manipulation with good “timing”. The reason is that the effect of earnings management is mean-reversing, suggesting the average annual performance endogenously cleans up the effects of managers’ earnings manipulation that takes place in the early years of a performance period. Therefore, managers may benefit more from managing earnings in the later years of a performance period. Categorized on the basis of where the PVSOs are in the three-year performance period, different PVSO tranches may impose managers with different incentives to make earnings management decisions. My third hypothesis states that:

H3: *Ceteris paribus*, managers’ incentive to manage earnings varies across PVSO tranches defined on the basis of PVSO life.

As an implication from the third hypothesis, I conjecture that *ceteris paribus* PVSOs vesting during the current year or afterwards provide managers with greater incentive to manage earnings upward relative to other PVSO tranches (i.e. PVSOs newly granted and PVSOs after vesting). Moreover, PVSOs vesting during the current year are expected to obtain a larger association to earnings management compared with PVSOs vesting afterwards.

3.3 RESEARCH DESIGN

This section documents the construction of the main variables. The empirical models for testing the three hypotheses are also presented.

3.3.1 Measures of Earnings Management

Four measures are used to proxy for the level of earnings management. The first is abnormal accruals. I use a modified version of the Dechow and Dichev (2002) abnormal accruals model as suggested by Francis et al. (2005). Specifically, the modified Dechow and Dichev model (Francis et al. 2005) is:

$$TCA_{j,t} = \alpha_0 + \alpha_1 CFO_{j,t-1} + \alpha_2 CFO_{j,t} + \alpha_3 CFO_{j,t+1} + \alpha_4 \Delta Rev_{j,t} + \alpha_5 PPE_{j,t} + v_{j,t} \quad (1)$$

where

$TCA_{j,t} = (\Delta CA_{j,t} - \Delta Cash_{j,t}) - (\Delta CL_{j,t} - \Delta STDEBT_{j,t})$ = firm j's total current accruals in year t;

$CFO_{j,t} = NIBE_{j,t} - TA_{j,t}$, firm j's cash flow from operations in year t;

$NIBE_{j,t}$ = firm j's net income before extraordinary items in year t (Compustat #32);

$TA_{j,t} = (\Delta CA_{j,t} - \Delta Cash_{j,t}) - (\Delta CL_{j,t} - \Delta STDEBT_{j,t}) - DEPN_{j,t}$, firm j's total accruals in year t;

$\Delta CA_{j,t}$ = firm j's change in current assets between year t-1 and year t (Compustat #75);

$\Delta Cash_{j,t}$ = firm j's change in cash between year t-1 and year t (Compustat #60);

$\Delta CL_{j,t}$ = firm j's change in current liabilities between year t-1 and year t (Compustat #104);

$\Delta STDEBT_{j,t}$ = firm j's change in debt in current liabilities between year t-1 and year t (Compustat #94);

$DEPN_{j,t}$ = firm j's depreciation and amortization expense in year t (Compustat #11);

$\Delta Rev_{j,t}$ = firm j's change in revenues between year t-1 and year t (Compustat #1);

$PPE_{j,t}$ = firm j's gross value of property, plant and equipment in year t (Compustat #77); and

All variables are scaled with respect to firm j's average total assets (Compustat #89) in year t.

A cross-sectional version of the modified Dechow and Dichev model (i.e. Equation (1)) is employed to estimate abnormal portion of total accruals (ACC), where all firms that are available from Compustat Global database are matched on year and two-digit SIC code.

Consistent with prior literature, industries with less than 6 firms are omitted. The estimated residual term from Equation (1), i.e. $\hat{u}_{j,t}$, measures ACC.⁴⁴

The second measure is the difference between taxable income and reported income (BTD). Since taxable income is subject to less discretion than earnings in annual reports, the difference between these two numbers can be informative about management discretion in the accrual process. Prior studies show that book-tax income difference is incrementally useful beyond conventional accounting accruals in measuring the level of earnings management and a large book-tax difference is an indicator of a higher level of earnings management (Lev and Nissim, 2004; Hanlon, 2005). I also use the deferred tax expense as a measure of earnings management (ITD), since it reflects temporary book-tax differences associated with the income statement. Prior evidence shows that the deferred tax expense also provides incrementally useful information beyond accruals measures in detecting earnings management (Phillips et al., 2003). To control for the scale effect, both book-tax income and deferred tax expense are scaled by average total assets.

The last proxy of earnings management relies on the association between firm earnings and contemporaneous market returns over a 12-month window (Francis et al., 2005; Wang, 2006). The return-earnings association represents the extent that reported earnings reflect the underlying economics of business transactions of a firm (Dechow, 1994). Managed earnings are putatively less informative about the performance of a firm (Dechow and Dichev, 2002)⁴⁵, which will reduce the association between earnings and market returns. Therefore the return-earnings association can also be considered as a measure of earnings management.

⁴⁴ The explanatory power of the accrual model as measured by adjusted R-square improves significantly after adding economic factors from Jones' model.

⁴⁵ Managers may convey private information to the market via accruals and thus accruals may improve earnings' ability to reflect firm's underlying economic performance (Dechow, 1994).

3.3.2 Test Variables

An indicator variable (D_PVSO) is coded one if a manager's compensation package includes PVSO and zero otherwise. The importance of PVSOs in managerial compensation is measured as the proportion of PVSOs' Black-Scholes value⁴⁶ to total managerial compensation (PVSO%), where total managerial compensation includes cash-related awards (salary and bonus) and equity-based compensation (such as stocks and stock options). A higher proportion of PVSO value to total compensation indicates a higher importance perceived by managers about PVSO compensation. Similarly, I construct a variable (D_TSO) indicating the existence of TSO compensation and a continuous variable (TSO%) capturing the importance of TSOs in total managerial compensation.

Appendix 3.A explains how I divide aggregate PVSO compensation into four tranches (i.e. new grant, before vesting, vesting during the current year and already vested). The categorization is based on PVSO maturing.

3.3.3 Empirical Models

3.3.3.1 Empirical models for H1&H2

To test the first two hypotheses, the absolute values of abnormal accruals (ABS_ACC), book-tax difference (ABS_BTD) and deferred tax expense (ABS_ITD) are employed as the proxies for earnings management. The absolute value is used because earnings management involves both income-increasing and income-decreasing management. The absolute value captures the aggregate amount of earnings management (Wang, 2006; Bergstresser and

⁴⁶ Volatility is measured using daily stock return volatility of last three months. I take the dividend yield of the current year. Risk free rate is the yield on a treasury security with approximately the same maturity as the years remaining till maturity for the stock options. Vesting probability is taken into account for PVSO valuation in robust tests. IFRS 2 requires the valuation of performance-based equity compensation, such as PVSOs, to be based on the fair value of the compensation instruments. Evidence shows that the most popular option models used in practice

Philippon, 2006). A higher value corresponds to a greater level of earnings management. The earnings management proxies (ABS_ACC; ABS_BTD; ABS_ITD) are employed as the dependent variable in the following equation:

$$EM_PROXY_{j,t} = \gamma_0 + \gamma_1 PVSO\%_{j,t} + \gamma_2 TSO\%_{j,t} + \beta CONTROL_{j,t} + year + industry + \varepsilon_{j,t} \quad (2)$$

where

$EM_PROXY_{j,t}$ = the proxies of earnings management for firm j in year t , including ABS_ACC, ABS_BTD, ABS_ITD;

$PVSO\%_{j,t}$ = the proportion of Black-Scholes value of PVSOs to total compensation for firm j in year t (as defined in Section 3.2);

$TSO\%_{j,t}$ = the comparable proxy for TSO compensation for firm j in year t (as defined in Section 3.2); and

$CONTROL_{j,t}$ = the control variables for firm j in the end of year t .

Following prior literature, model-specific factors are controlled for when investigating earnings management. In particular, I control for firm size (LNMV), debt (LEV), market-to-book ratio (MTB) and sales growth (GROW) in the abnormal accruals regression (Cheng and Warfield, 2005; Wang, 2006). In the tax income related models (i.e. ABS_BTD or ABS_ITD as the dependent variable), firm profitability (ROA), debt (LEV), market-to-book ratio (MTB) and firm size (LNMV) are included as controls (Mills and Newberry 2001). The coefficient on PVSO% (γ_1) tests the association between PVSO compensation variable and the (aggregate) level of earnings management. As predicted in the first hypothesis, the coefficient on PVSO% (γ_1) is expected to be positive. Moreover, comparing the coefficient on PVSO% (γ_1) with that on TSO% (γ_2) shows to what extent these two types of stock options provide managers with different incentives to manage earnings. The coefficient on PVSO% (γ_1) is predicted to be significantly greater than that on TSO% (γ_2) because PVSOs are predicted to provide managers with relatively more incentives to manage earnings.

are fair value models such as the Black-Scholes model (Towers Perrin, 2005/2006).

I use the following model to investigate the impact of PVSO on the return-earnings association:

$$RET_t = \lambda_0 + \lambda_1 \Delta NI_t + \lambda_2 D_PVSO_t + \lambda_3 D_TSO_t + \lambda_4 \Delta NI_t * D_PVSO_t + \lambda_5 \Delta NI_t * D_TSO_t + \psi CONTROL_t + year + industry + \varepsilon_t \quad (3)$$

where

RET_t = 12-month dividend-adjusted cumulative raw return per share ending 3 months after the fiscal year end t ;

ΔNI_t = Change of earnings per share for year t , scaled by price per share at the end of $t-1$;

D_PVSO_t = the dummy variable for the presence of PVSO compensation for year t (as defined in Section 3.2);

D_TSO_t = the dummy variable for the presence of TSO compensation for year t (as defined in Section 3.2); and

$CONTROL_{j,t}$ = the control variables, including market value (LNMV) and market-to-book ratio (MTB).

Consistent with the first hypothesis, the coefficient on the interaction between ΔNI and D_PVSO , λ_4 , is expected to be significantly negative. If λ_4 is significantly lower than λ_5 , then this suggests that PVSO compensation is associated with less informative earnings than TSO compensation, as predicted in the second hypothesis.

3.3.3.2 Empirical model for H3

The development of H3 involves predictions on the direction of earnings management. Thus, the dependent variable is each of the earnings management proxies (without the absolute values). A positive value of each earnings management proxy corresponds to earnings-increasing management and a negative value indicates earnings-decreasing management.⁴⁷ The empirical model is:

$$EM_PROXY_{j,t} = \gamma_0 + \gamma_1 Grant_{j,t} + \gamma_2 Bef_Vest_{j,t} + \gamma_3 Curr_Vest_{j,t} + \gamma_4 Af_Vest_{j,t} + \gamma_5 TSO\% + \beta CONTROL_{j,t} + year + industry \quad (4)$$

where

$EM_PROXY_{j,t}$ = proxies for earnings management for firm j in year t ;

$Grant_{j,t}$ = the proportion of Black-Scholes value of PVSOs newly granted to total compensation during year t for

⁴⁷ The relation between the left hand side variables and discretionary accruals may be different in case the accruals are positive and negative and if so, the regression might be mis-specified.

firm j ;

$Bef_Vest_{j,t}$ = the proportion of Black-Scholes value of PVSOs with a performance period ended after year t to total compensation for firm j ;

$Curr_Vest_{j,t}$ = the proportion of Black-Scholes value of PVSOs with a performance ended during year t to total compensation for firm j ;

$Af_Vest_{j,t}$ = the proportion of Black-Scholes value of PVSOs with a performance period ended before year t to total compensation for firm j ; and

$CONTROL_{j,t}$ = natural logarithm of market capitalization (LNMV), market-to-book ratio (MTB), leverage ratio (LEV), turnover (TURN) and sales growth (GROW) for firm j in the end of year t .

The coefficients of each PVSO tranche, i.e. $Grant_{j,t}$, $Bef_Vest_{j,t}$, $Curr_Vest_{j,t}$, $Af_Vest_{j,t}$, capture how managers manage earnings (i.e., downward vs. upward) on the basis of different phases of PVSO maturity phrases. As predicted in the third hypothesis, the coefficients, i.e. γ_1 , γ_2 , γ_3 , γ_4 , are expected not to be equal. Meanwhile, I expect the coefficients on $Curr_Vest_{j,t}$ (γ_3) and $Bef_Vest_{j,t}$ (γ_2) to be significantly larger than the coefficients on $Grant_{j,t}$ (γ_1) and $Af_Vest_{j,t}$ (γ_4); and γ_3 to be significantly greater than γ_2 .

3.4 SAMPLE SELECTION AND DATA SOURCES

The sample initially starts with the 350 largest non-financial companies in the UK, based on market capitalization in 2004. The reason for focusing on large firms is two-fold: first, large firms are more likely to reward managers with PVSOs (Conyon et al. 2000); second, large firms are more likely to disclose the information needed to perform the empirical tests. Firms without sufficient information on PVSO compensation or with missing financial data are eliminated. The final sample includes 244 firms with 1,191 firm-year observations from 1997 to 2004.⁴⁸ Table 1 describes the sample selection procedure. Information on managerial compensation is collected from the BoardEx database⁴⁹.

⁴⁸ 1997 is selected as the starting year because the first-round of intensive PVSO adoption took place in 1997 (Conyon et al., 2000). Delisted firms are not included. So generalization of the findings might be subject to survivor bias.

⁴⁹ The credibility of BoardEx dataset has been verified by randomly selecting 20 firms and comparing their

Table 1
Summary of sample selection process

This table presents summary of sample selection process. The sample contains all firm-years of top 350 non-financial firms based on their market capitalization in 2004 from 1997 to 2004. To be included in the sample, a firm-year should contain sufficient information in Compustat Global to calculate variables employed in analyses.

	# of firms
Top 350 (by market capitalization) non-financial firms in 2004	350
<i>Less:</i> Delisted firms afterwards	43
Firms without sufficient information to make the distinction between PVSOs and TSOs	9
Firms with incomplete financial information	54
<i>Total:</i> Firms included	244
# of firm-year observations	1,191
<i>Including:</i>	
1997	20
1998	46
1999	96
2000	193
2001	223
2002	229
2003	234
2004	150

Accounting data are from the Compustat Global Industrial and Commercial files and capitalmarket information is from Datastream. Table 2 presents the descriptive statistics for the entire sample. All financial variables are winsorized at the 1st and 99th percentiles. For an average firm in my pooled sample, the value of PVSOs is about 19.6% of total compensation (i.e., direct compensation and holdings of the firm's stocks and stock options) while the comparable figure for TSOs is only 5.8%. Of the four tranches of PVSOs, PVSOs before

records in BoardEx with corresponding figures disclosed in firms' annual reports. No substantial difference has been found between the two data sources.

vesting comprise the greatest component of total managerial PVSO holdings (i.e. 7.9% on average of managerial total compensation).

Table 2
Summary of descriptive statistics

Table 2 presents summary statistics for variables used in the analyses. ABS_ACC is the absolute value of abnormal accruals as estimated by Equation (1); ABS_BT D is the absolute value of difference between pre-tax book income (Compustat #21) and taxable income, scaled by average total assets (Compustat #89), where taxable income is estimated as current portion of the income tax expense (i.e. Compustat #23 – Compustat #25) gross up by statutory corporate tax rate of that year; ABS_ITD is the absolute value of the deferred portion of income tax (Compustat #25), scaled by average total assets (Compustat #89); ACC is the value of abnormal accruals as estimated by Equation (1); BT D is the value of difference between pre-tax book income (Compustat #21) and taxable income, scaled by average total assets (Compustat #89), where taxable income is estimated as current portion of the income tax expense (i.e. Compustat #23 – Compustat #25) gross up by statutory corporate tax rate of that year; ITD is the value of the deferred portion of income tax (Compustat #25), scaled by average total assets (Compustat #89); RET is 12-month dividend-adjusted cumulative raw return per share ending 3 months after the fiscal year end; D_PVSO is a dummy variable that equals 1 for the existence of PVSOs in managerial compensation and 0 otherwise; PVSO% is the proportion of the Black-Scholes value of PVSOs in managerial total compensation; D_TSO is a dummy variable that equals 1 for the existence of TSOs in managerial compensation and 0 otherwise; TSO% is the proportion of the Black-Scholes value of TSOs in managerial total compensation; Grant is the Black-Scholes value of PVSOs newly granted in the current year in managerial total compensation; Bef_Vest is the Black-Scholes value of PVSOs with the performance period ending only after the current year in managerial total compensation; Curr_Vest is the Black-Scholes value of PVSOs with the performance period ending during the current year in managerial total compensation; Af_Vest is the Black-Scholes value of PVSOs with the performance period having ended before the beginning of the current year in managerial total compensation; Δ NI is change of earnings per share for the current year, scaled by share price at the end of the previous year. GROW is growth of sales (Compustat #1) in the current year; LNMV is the natural logarithm of market value of the firm at the end of the current year; MTB is the ratio of market value to book value of equity (Compustat #135) at the end of the current year; LEV is the leverage ratio of the firm at the end of the current year, equaling total debt (Compustat #118) divided by total assets (Compustat #89); ROA is net income (Compustat #32) plus interest expense before tax (Compustat #15), scaled by average total assets (Compustat #89) in the current year; TURN is sales (Compustat #1) scaled by average total assets (Compustat #89) in the current year; Year_dummy is the dummies indicating the year; Industry_dummy is the dummies indicating the industry, as defined by the 1-digit SIC code. The sample contains all firm-years of top 350 non-financial firms based on their market capitalization in 2004 from 1997 to 2004. To be included in the sample, a firm-year should contain sufficient information in Compustat Global to calculate variables employed in analyses.

Variable	Mean	Std. Deviation	1%	25%	Median	75%	99%
PVSO%	0.196	0.209	0.000	0.000	0.134	0.433	0.757
TSO%	0.058	0.152	0.000	0.000	0.000	0.020	0.793
D_PVSO	0.751	0.424	0.000	1.000	1.000	1.000	1.000
D_TSO	0.408	0.492	0.000	0.000	0.000	1.000	1.000
Grant	0.018	0.060	0.000	0.000	0.000	0.000	0.313
Bef_Vest	0.079	0.126	0.000	0.000	0.009	0.116	0.568
Curr_Vest	0.026	0.058	0.000	0.000	0.000	0.025	0.300
Af_Vest	0.049	0.091	0.000	0.000	0.000	0.067	0.426
ABS_BT D	0.047	0.074	0.000	0.009	0.023	0.049	0.326
ABS_ITD	0.003	0.005	0.000	0.000	0.002	0.004	0.020
ABS_ACC	0.060	0.071	0.000	0.018	0.038	0.072	0.326
BTD	-0.021	0.080	-0.326	-0.037	-0.006	0.014	0.151
ITD	0.001	0.005	-0.018	-0.001	0.000	0.003	0.020
ACC	0.009	0.088	-0.305	-0.026	0.007	0.046	0.326
RET	0.145	0.437	-0.724	-0.137	0.103	0.374	1.718
Δ NI	0.012	0.130	-0.471	-0.018	0.006	0.030	0.668
ROA	0.042	0.088	-0.500	0.023	0.049	0.085	0.218
LEV	0.573	0.177	0.095	0.460	0.581	0.691	0.973
GROW	0.230	2.542	-10.667	-0.112	0.140	0.482	13.307
TURN	1.117	0.729	0.056	0.593	0.974	1.443	3.537
LNMV	6.664	1.468	4.221	5.481	6.471	7.644	10.637
MTB	3.559	4.934	0.439	1.283	2.018	3.392	32.601

Table 3 presents univariate correlations for each model. The correlations among proxies for earnings management, i.e., ABS_BT D, ABS_ITD, and ABS_ACC; BTD, ITD and ACC; are low (<0.40), suggesting that the measures are not merely substitutes for each other. Grant is positively correlated with Af_Vest at 0.22. This is consistent with earlier evidence that firms make larger grants to managers when a larger proportion of previously granted stock options is exercisable (Core and Guay 2000). Meanwhile, Curr_Vest and Af_Vest are strongly correlated ($=0.42$); the same for Grant and Bef_Vest.

Table 3**Correlation matrix**

This table reports Pearson correlation statistics computed for the variables used in analyses. See Section 3.3 for more details on variable definitions. p-values are reported in the brackets. *, **, and *** corresponds to 10%, 5% and 1% significance levels (two-tailed).

Panel A: Variables for Equation (2) ⁵⁰

	ABS_BT	ABS_ITD	ABS_ACC	PVSO%	TSO%	ROA	LEV	GROW	LNMV	MTB
ABS_BT	1									
ABS_ITD	0.116*** (0.000)	1								
ABS_ACC	0.123*** (0.000)	-0.058* (0.056)	1							
PVSO%	0.037 (0.206)	0.085*** (0.004)	0.068** (0.025)	1						
TSO%	0.049* (0.098)	-0.029 (0.329)	0.014 (0.657)	-0.177*** (0.000)	1					
ROA	-0.565*** (0.000)	-0.012 (0.678)	-0.007 (0.830)	-0.048* (0.099)	-0.092*** (0.002)	1				
LEV	-0.054* (0.068)	0.007 (0.824)	-0.145*** (0.000)	0.016 (0.592)	-0.065** (0.027)	-0.129*** (0.000)	1			
GROW	0.030 (0.313)	0.051* (0.084)	-0.003 (0.918)	0.072** (0.014)	-0.007 (0.805)	-0.019 (0.521)	0.052* (0.079)	1		
LNMV	-0.106*** (0.000)	-0.064** (0.028)	0.033 (0.279)	0.120*** (0.000)	0.086*** (0.003)	0.109*** (0.000)	0.132*** (0.000)	-0.061** (0.037)	1	
MTB	0.022 (0.458)	-0.014 (0.643)	0.155*** (0.000)	0.004 (0.909)	-0.024 (0.410)	0.104*** (0.000)	0.276*** (0.000)	0.010 (0.739)	0.207*** (0.000)	1

⁵⁰ Multicollinearity diagnosis is performed. A high pairwise correlation (i.e. greater than 0.80) or the value of variance inflation factor (VIF) greater than 4 or 5 indicates that multicollinearity may be a threat in multivariate regressions. But that is not case in the sample of current study.

Panel B: Variables for Equation (4)

	BTD	ITD	ACC	Grant	Bef_Vest	Curr_Vest	Af_Vest	LEV	GROW	MTB	TURN	TSO
BTD	1											
ITD	0.372*** (0.000)	1										
ACC	0.002 (0.950)	-0.068** (0.024)	1									
Grant	-0.075** (0.011)	-0.019 (0.523)	-0.052* (0.087)	1								
Bef_Vest	-0.129*** (0.000)	-0.064** (0.028)	-0.049 (0.105)	0.565*** (0.000)	1							
Curr_Vest	-0.047 (0.111)	0.001 (0.970)	0.023 (0.460)	0.314*** (0.000)	0.311*** (0.000)	1						
Af_Vest	-0.027 (0.354)	0.051* (0.082)	-0.012 (0.691)	0.219*** (0.000)	0.231*** (0.000)	0.418*** (0.000)	1					
LEV	-0.060** (0.039)	0.017 (0.560)	-0.184*** (0.000)	0.024 (0.424)	0.010 (0.728)	-0.013 (0.666)	0.013 (0.664)	1				
GROW	-0.012 (0.675)	-0.032 (0.278)	-0.131*** (0.000)	0.058** (0.048)	0.050* (0.088)	0.058** (0.048)	0.012 (0.673)	0.042 (0.147)	1			
MTB	-0.042 (0.149)	-0.012 (0.677)	0.136*** (0.000)	-0.045 (0.121)	-0.042 (0.153)	0.017 (0.554)	0.016 (0.580)	0.280*** (0.000)	-0.037 (0.206)	1		
TURN	-0.145*** (0.000)	-0.079*** (0.000)	0.077** (0.011)	0.008 (0.791)	0.033 (0.257)	0.060** (0.040)	0.030 (0.306)	0.188*** (0.000)	-0.008 (0.786)	0.253*** (0.000)	1	
TSO%	0.021 (0.532)	0.046 (0.177)	-0.018 (0.611)	-0.034 (0.243)	-0.105*** (0.000)	-0.099*** (0.001)	-0.080*** (0.007)	-0.102*** (0.003)	0.036 (0.285)	-0.073** (0.029)	-0.079** (0.020)	

Panel C: Variables for Equation (3)

	RET	Δ NI	D_PVSO	D_TSO	LMNV	MTB
RET	1					
Δ NI	0.106*** (0.000)	1				
D_PVSO	-0.038 (0.185)	0.040 (0.166)	1			
D_TSO	0.011 (0.692)	0.034 (0.240)	-0.145*** (0.000)	1		
LMNV	0.050* (0.086)	-0.010 (0.726)	-0.056* (0.054)	0.161*** (0.000)	1	
MTB	0.175*** (0.000)	-0.006 (0.834)	-0.083*** (0.004)	-0.040 (0.165)	0.135*** (0.000)	1

3.5 EMPIRICAL RESULTS AND DISCUSSION

This section documents the results of the empirical analyses. Section 3.5.1 reports on the relation between PVSO incentives and earnings management. Section 3.5.2 evaluates the associations between PVSO composition and earnings management.

3.5.1 PVSO Incentives and Earnings Management

Table 4 presents the empirical results from Equation (2), using the accounting accrual and tax-based proxies of earnings management. Throughout this paper, the standard errors on the regression coefficients are Newey-West adjusted to correct for heteroskedasticity and auto-correlation (Newey and West, 1987). F-statistics on Equation (2) show that the models are significant in explaining the variance of each dependent variable (p -value<0.01).

Panel A reports the OLS results for Equation (2). Three specifications are presented, each with an alternative proxy of earnings management as the dependent variable: 1) the absolute value of book-tax income difference (ABS_BT D), 2) the deferred part in income tax expense (ABS_ITD), 3) abnormal accruals (ABS_ACC). The coefficient on the test variable PVSO% is

Table 4
Empirical results on PVSO incentives and earnings management
(with direct earnings management measures)

This table presents estimates from an OLS regression of direct earnings management measures on PVSO and TSO compensations. See Section 3.3 for more details on variable definitions. Panel A reports OLS regression results on Equation (2); Panel B reports results of Wald tests on γ_1 and γ_2 in Equation (2). Newey-West HAC standard errors are reported in the brackets. Significance levels are based on one-tailed tests where there is a prediction of the sign of the coefficient and based on two-tailed tests otherwise, *, **, and *** correspond to 10%, 5% and 1% significance levels, respectively. Coefficients on industry dummies and year dummies are not reported for brevity. The following model is estimated:

$$EM_PROXY_{j,t} = \gamma_0 + \gamma_1 PVSO\%_{j,t} + \gamma_2 TSO\%_{j,t} + \beta CONTROL_{j,t} + year_dummy + industry_dummy + \varepsilon_{j,t} \quad (2)$$

Panel A: Empirical results on Equation (2)

	Dependent Variable		
	ABS_BT D	ABS_IT D	ABS_ACC
Constant	0.331*** (0.118)	0.001 (0.001)	0.149*** (0.056)
PVSO%	0.025** (0.014)	0.002*** (0.001)	0.020** (0.012)
TSO%	0.006 (0.009)	0.001 (0.001)	-0.003 (0.012)
LNMV	-0.003** (0.001)	-0.000 (0.000)	0.002 (0.002)
ROA	-0.413*** (0.049)	0.004 (0.003)	
LEV	-0.060*** (0.016)	0.000 (0.001)	-0.096*** (0.016)
GROW			0.009** (0.004)
MTB	0.003*** (0.000)	0.000 (0.000)	0.003*** (0.001)
Year Dummies	Yes	Yes	Yes
Industry Dummies	Yes	Yes	Yes
Sample size	1,139	1,139	1,081
Adjusted R-square	29.09%	7.59%	12.99%
F-value	22.22***	5.25***	8.33***

Panel B: Wald tests on γ_1 and γ_2 in Equation (2)

Null hypothesis	ABS_BT D		ABS_IT D		ABS_ACC	
	Value	Probability	Value	Probability	Value	Probability
$\gamma_1 < \gamma_2$						
t-statistics	1.283	0.100	1.306	0.096	1.463	0.072

significant and positive in all specifications ($p\text{-value} < 0.05$), which implies that greater PVSO holdings are associated with higher levels of book-tax income difference, deferred income tax expense, and abnormal accruals. In particular, in the ABS_ACC regression, the coefficient on PVSO% is 0.020 ($p\text{-value} < 0.05$). This result shows that, for an average firm in the sample, when managerial PVSO holdings increase by 1% relative to total compensation, the firm reports higher abnormal accruals by an amount equivalent to 0.43% of pre-tax net income.⁵¹ The positive association between PVSO holdings and earnings management proxies supports the first hypothesis that managers are more active in managing earnings when they hold a greater part of their compensation in PVSOs. The results also show that after controlling for PVSO% the variable TSO% is not significant in any of the model specifications. I perform Wald tests to compare the coefficient on PVSO% with the corresponding coefficient on TSO%. The statistics are presented in Panel B. The results show that the coefficient on PVSO% is greater than the coefficient on TSO% with $p\text{-value} < 0.10$. Thus, relative to TSOs, PVSOs are more closely associated with the level of earnings management. This finding supports H2 that relative to TSOs, PVSOs provide managers with greater incentive to manipulate earnings.

The signs of the coefficients on the control variables are generally consistent with prior literature (Chung and Kallapur, 2003; Reynolds and Francis, 2005). Specifically, in the specification with ABS_BT D, the coefficients on LNMV and ROA are significant and negative, implying that large firms and firms with higher profitability will have a lower book-tax income difference. The positive association between ABS_BT D and MTB suggests that managers in high growth firms engage in more intensive earnings management. Larger growth opportunities (GROWTH and MTB) are associated

⁵¹ The average total assets are £3,357 million and the average net income before tax and extraordinary items is £156 million. The coefficient on PVSO% is 0.020, indicating that when PVSO% increases by 1%, ABS_ACC will increase by 0.020%. Thus, an average firm will report higher abnormal accruals equivalent to 0.43% [i.e. $0.020\% \times 3357/156 = 0.43\%$] of pretax income if PVSO% increases by 1%.

with greater abnormal accruals. The negative coefficient on LEV is also consistent with prior findings (Cheng and Warfield, 2005; Wang, 2006)⁵².

Equation (3) examines the earnings informativeness from regressing annual returns on reported earnings.⁵³ Empirical results are reported in Panel A of Table 5. Models are significant at the 1% level. In Model (3.1), the coefficient on ΔNI is 0.863 and significant at $p < 0.01$. The coefficient on the test variable $\Delta NI * D_PVSO$ is -0.532 at $p < 0.05$. This suggests that the reported earnings are less informative in firms with PVSO awards and the association between earnings change and contemporary returns is 61.65% [i.e. $0.532/0.863$] lower than that of firms without PVSO rewards. Model (3.2) includes control variables. The coefficient on $\Delta NI * D_PVSO\%$ is -0.504 and significant at $p < 0.05$. This result implies that greater PVSO holdings are associated with less informative earnings. In particular, for an average firm, with PVSO grants, the association between earnings and market returns is only 40% of the previous level [i.e. $(0.845 - 0.504)/0.845$]. Overall, the results provide evidence that PVSO compensation is associated with lower level of earnings informativeness and suggest the existence of opportunistic earnings management.

Panel B of Table 5 presents the results on the Wald tests, where the coefficient on PVSO test variable, i.e. $\Delta NI * D_PVSO$, is assumed to be greater than the coefficient on TSO test variable, i.e. $\Delta NI * D_TSO$. The null hypothesis is rejected at $p < 0.10$ in both model specifications, which is consistent with the earlier findings using earnings management proxies and suggests that PVSOs are associated with less informative earnings relative to their TSO counterparts.

In summary, the results show that PVSO compensation is associated with more earnings management. Comparing PVSO compensation with TSO compensation, the results support the conjecture that PVSOs provide managers with greater incentives to use their discretions over reported earnings.

⁵² Excluding LEV does not change the signs and significance levels of the test variables.

⁵³ The statistics from one-way ANOVA and mean comparisons show that there is no significant difference between the ROA of PVSO users and that of non-PVSO users. Specifically, the null hypothesis of equal variances is not rejected

Table 5
Empirical results on PVSO incentives and earnings management
(with indirect earnings management measures)

This table presents estimates from an OLS regression of returns on PVSO and TSO compensations. See Section 3.3 for more details on variable definitions. Panel A reports OLS regression results on Equation (3); Panel B reports results of Wald tests on λ_4 and λ_5 in Equation (3). Newey-West HAC standard errors are reported in the brackets. Significance levels are based on one-tailed tests where there is a prediction of the sign of the coefficient and based on two-tailed tests otherwise, *, **, and *** correspond to 10%, 5% and 1% significance levels, respectively. Coefficients on industry dummies and year dummies are not reported for brevity. The following model is estimated:

$$RET_i = \lambda_0 + \lambda_1 \Delta NI_i + \lambda_2 D_PVSO_i + \lambda_3 D_TSO_i + \lambda_4 \Delta NI_i * D_PVSO_i + \lambda_5 \Delta NI_i * D_TSO_i + \psi CONTROL_i + year_dummy + industry_dummy + \varepsilon_i \quad (3)$$

Panel A: Empirical results on Equation (3)

	RET model with ΔNI and D_PVSO , without controls	RET model with ΔNI and D_PVSO , with controls
	(3.1)	(3.2)
Constant	0.420** (0.172)	0.319 (0.220)
ΔNI	0.863*** (0.317)	0.845*** (0.321)
D_PVSO	-0.051 (0.048)	-0.033 (0.043)
D_TSO	0.020 (0.053)	-0.173 (0.136)
$LN MV$		0.004 (0.015)
MTB		0.008 (0.006)
$\Delta NI * D_PVSO$	-0.532** (0.290)	-0.504** (0.302)
$\Delta NI * D_TSO$	-0.165 (0.134)	-0.173 (0.136)
Industry Dummies	Yes	Yes
Year Dummies	Yes	Yes
Sample size	1,191	1,191
Adjusted R-square	4.18%	6.11%
F-value	3.73***	4.69***

($\chi^2=0.570$ with p-value=0.24), and neither is the null hypothesis of equal means (t-value=1.169 with p-value=0.24).

Panel B: Wald tests on λ_4 and λ_5 in Equations (3)

t-statistics	Null hypothesis: $\lambda_4 > \lambda_5$	
	Value	Probability
RET model (1)	1.300	0.097
RET model (2)	1.290	0.099

3.5.2 PVSO Composition and Earnings Management

The empirical results for the third hypothesis are summarized in Table 6. Since the conjecture made in H3 implies the directions of earnings management, the values of book-tax income difference, deferred tax expense and abnormal accruals are used as the proxy for earnings management. F-statistics show that all models are significant at 1% level.

Panel A presents the empirical results on Equation (4). Consistent results on the Wald tests are obtained although the coefficients and significance levels of PVSO tranches are subject to the model specifications. Panel B summarizes the statistics on the Wald tests. The null hypothesis states that each PVSO composition is associated with earnings management to the same extent. Throughout all the specifications, the null hypothesis is rejected at conventional levels (e.g. $p < 0.10$). Further tests show that γ_2 and γ_3 are significantly greater than γ_4 in the BTD and ITD specifications, and significantly greater than γ_1 in the ACC specification (i.e. $p < 0.10$). The results indicate that relative to PVSOs newly granted and PVSOs after vesting, a closer relationship exists between earnings-increasing manipulation and managerial holdings of PVSOs with performance period ending in the current year and afterwards. But γ_2 and γ_3 do not differ from each other at a statistically significant level.

Table 6
Empirical results on PVSO composition and earnings management

This table presents estimates from an OLS regression of earnings management measures on PVSO composition. See Section 3 for more details on variable definitions. Panel A reports OLS regression results on Equation (4); Panel B reports results of Wald tests on γ_1 , γ_2 , γ_3 and γ_4 in Equation (4). Newey-West HAC standard errors are reported in the brackets. Significance levels are based on one-tailed tests where there is a prediction of the sign of the coefficient and based on two-tailed tests otherwise, *, **, and *** correspond to 10%, 5% and 1% significance levels, respectively. Coefficients on industry dummies and year dummies are not reported for brevity. The following model is estimated:

$$EM_PROXY_{j,t} = \gamma_0 + \gamma_1 Grant_{j,t} + \gamma_2 Bef_Vest_{j,t} + \gamma_3 Curr_Vest_{j,t} + \gamma_4 Af_Vest_{j,t} + \gamma_5 TSO\% + \beta CONTROL_{j,t} + year_dummy + industry_dummy \quad (4)$$

Panel A: Empirical results on Equation (4)

	Dependent Variable		
	BTD	ITD	ACC
Constant	-0.035 (0.031)	-0.002 (0.001)	0.041 (0.055)
Grant	0.056 (0.065)	0.001 (0.004)	-0.183** (0.080)
Bef_Vest	0.021 (0.015)	-0.001 (0.001)	0.001 (0.031)
Curr_Vest	0.006 (0.035)	0.003 (0.003)	0.033 (0.053)
Af_Vest	-0.115** (0.048)	-0.006** (0.002)	0.054 (0.042)
TSO%	-0.030* (0.023)	0.000 (0.001)	0.009 (0.020)
LEV	-0.025 (0.018)	0.000 (0.001)	-0.101*** (0.027)
GROW	0.000 (0.001)	-0.000** (0.000)	-0.001 (0.001)
MTB	-0.000 (0.000)	0.000 (0.000)	0.001 (0.001)
TURN	0.001 (0.004)	-0.001** (0.000)	0.007 (0.006)
LNMV	0.007*** (0.002)	0.000*** (0.000)	0.000 (0.003)
Year Dummies	Yes	Yes	Yes
Industry Dummies	Yes	Yes	Yes
Sample size	1,147	1,147	1,081
Adjusted R-square	6.40%	2.71%	9.48%
F-value	4.01***	2.23***	5.35***

Panel B: Wald tests on γ_1 , γ_2 , γ_3 and γ_4 on Equation (4)

Null hypothesis	BTD		ITD		ACC	
	Value (F-value or t-value)	Probability	Value (F-value or t-value)	Probability	Value (F-value or t-value)	Probability
$\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4$ (F-value)	3.229	0.001	2.081	0.038	2.223	0.026
$\gamma_1 = \gamma_2$ (t-value)	-	Not sig.	-	Not sig.	4.350	<0.001
$\gamma_1 = \gamma_3$ (t-value)	-	Not sig.	-	Not sig.	6.570	<0.001
$\gamma_1 = \gamma_4$ (t-value)	1.592	<0.100	-	Not sig.	-4.420	<0.001
$\gamma_2 = \gamma_3$ (t-value)	-	Not sig.	-	Not sig.	-	Not sig.
$\gamma_2 = \gamma_4$ (t-value)	2.627	0.009	1.640	0.100	-	Not sig.
$\gamma_3 = \gamma_4$ (t-value)	1.908	0.057	2.319	0.021	-	Not sig.

Collectively, the results support the third hypothesis, which says that the association between PVSOs and earnings management varies among PVSO tranches and the managers may construct earnings management strategies on the basis of how far the PVSOs are to the end of the performance period. In particular, compared with other PVSO tranches, PVSOs with the performance period ended in the current year generally gain a higher priority in earnings-increasing management decisions.

The coefficient on LNMV is positive at $p < 0.01$ in the BTD and ITD regressions, suggesting that firms with larger market size will generate book income greater than tax income and greater deferred tax income. Again, leverage ratio is significantly and negatively related with abnormal accruals. This result implies that firms with more leverage will engage in less earning-increasing management.⁵⁴

⁵⁴ When leaving out LEV, the signs and significance levels on the test variables do not change.

3.6 ADDITIONAL ANALYSIS

In this section, I perform two types of additional analyses to check the robustness of the prior findings. Firstly, I focus on first adoptions of PVSO plans. Next, I perform several validity tests.

3.6.1 First Adoptions of PVSO plans

Comparing firms in the post- and pre-adoption periods efficiently controls for any time-invariant firm-level fixed effects⁵⁵. For example, managerial ability/talent can be thought of as an omitted variable that affects both earnings management decisions and PVSO compensation. Therefore, in this section, I focus on firms that adopted PVSO compensation plans for the first time during the observation period, i.e. from 1997 to 2004, and compare the levels of earnings management before and after-adoption. The adoption sample consists of 251 firm-year observations from 46 firms. Panel A of Table 7 presents the frequency of the adoptions. The results show that most adoptions took place in 2001 and 2002.

To examine the potential difference in earnings management of firms before and after the first adoption of PVSO plans, a two-staged procedure is employed. Following Barth et al. (2006b), in the first stage, I control for economic factors that might be correlated with differences in accounting quality and the level of earnings management. Prior literature (e.g., Barth et al., 2006a) shows that accounting quality (a counter concept of earnings management) is likely to be sensitive to a variety of factors that reflecting the change in economic environment but not earnings management *per se*. In this vein, earnings management measurements are regressed on

⁵⁵ The fixed-effect bias may be thought of as arising from an omitted variable problem (Verbeek, 2004).

determinant variables to control for the factors other than the use of PVSOs in influencing managerial decisions on earnings management:

$$EM_PROXY_{j,t} = \theta_0 + \theta_1 LNMV_{j,t} + \theta_2 LEV_{j,t} + \theta_3 TURN_{j,t} + \theta_4 GROW_{j,t} + \theta_5 MTB_{j,t} + \theta_6 DISSUE_{j,t} + \theta_7 EISSUE_{j,t} + \theta_8 ROA_{j,t} + \theta_9 TSO\% + year + industry + \varphi_{j,t} \quad (5)$$

where

$EM_PROXY_{j,t}$ = the proxies of earnings management for firm j in year t , including ABS_ACC , ABS_BTD , ABS_ITD ;

$DISSUE_{j,t}$ = the percentage change in total liabilities (Compustat #118) during year t for firm j ;

$EISSUE_{j,t}$ = the percentage change in common stock during year t for firm j ; and other variables were defined earlier.

The estimated residuals from the first stage, $\hat{\varphi}_{j,t}$, capture the portion of managed earnings that cannot be explained by general economic factors. In the second stage, comparisons are made in the absolute value of $\hat{\varphi}_{j,t}$ between the *ex ante* and the *ex post*-adoption periods. The results are summarized in Panel B of Table 7.

Statistics provide evidence in general consistent with the previous results. Before adopting PVSO compensation plans, for an average firm, the level of earnings management is not greater than 0 at conventional levels. However, after PVSO compensation adoption, deferred income tax and abnormal accruals are greater than 0 at $p < 0.10$ or better, suggesting that managers are more active in manipulating earnings via deferred tax and/or abnormal accruals in the *ex post* period. But no significant earnings management has been detected in the ABS_BTD specification and the difference in the level of abnormal accruals is not significant for pre- and post-adoption periods⁵⁶. A series of nonparametric tests is performed to compare the $|\hat{\varphi}_{j,t}|$ between the *ex ante* period and the *ex post* period. Panel C of Table 7 presents the statistics. The equal distribution hypothesis in the *ex ante* and *ex post* periods is rejected at $p < 0.10$ in all specifications⁵⁷. The median tests show

⁵⁶ This might be subject to the efficiency of the abnormal accrual model in detecting earnings management.

⁵⁷ Since the results from the Shapiro normality tests reject the normal distribution of $|\varphi_{j,t}|$ in the three models, Kruskal

Table 7

Empirical results for ex ante-adoption Period and ex post-adoption period

This table reports results on earnings management comparison between ex ante-adoption and ex post-adoption periods. See Section 3.3 and Section 3.6 for more details on variable definitions. Panel A reports the number of PVSO first adoptions in each year from 1997 to 2004. Panel B reports statistics of $\varphi_{j,t}$, the proxy of earnings management in ex ante and ex post-adoption periods, where $\varphi_{j,t}$ is residual term from the model:

$$EM_PROXY_{j,t} = \theta_0 + \theta_1 LNMV_{j,t} + \theta_2 LEV_{j,t} + \theta_3 TURN_{j,t} + \theta_4 GROW_{j,t} + \theta_5 MTB_{j,t} + \theta_6 DISSUE_{j,t} + \theta_7 EISSUE_{j,t} + \theta_8 ROA_{j,t} + \theta_9 TSO\% + year_dummy + industry_dummy + \varphi_{j,t} \quad (5)$$

Panel C presents results on comparisons absolute value of $\varphi_{j,t}$ between ex ante and ex post-adoption periods. Panel D reports estimates of return-earnings regressions as followings:

$$RET_t = \lambda_0 + \lambda_1 \Delta NI_t + \lambda_2 D_PVSO_t + \lambda_3 D_TSO_t + \lambda_4 \Delta NI_t * D_PVSO_t + \lambda_5 \Delta NI_t * D_TSO_t + \psi CONTROL_t + year_dummy + industry_dummy + \varepsilon_t \quad (3)$$

$$RET_t = \lambda_0 + \lambda_1 \Delta NI_t + \lambda_2 D_PVSO_t + \lambda_3 \Delta NI_t * D_PVSO_t + \psi CONTROL_t + year_dummy + industry_dummy + \varepsilon_t \quad (6)$$

Newey-West HAC standard errors are reported in the brackets. Significance levels are based on one-tailed tests where there is a prediction of the sign of the coefficient and based on two-tailed tests otherwise, *, **, and *** correspond to 10%, 5% and 1% significance levels, respectively. Coefficients on industry dummies and year dummies are not reported for brevity. Panel E reports results on Wald tests on λ_4 and λ_5 in Equations (3).

Panel A: Number of adoptions in each year

Year	1998	1999	2000	2001	2002	2003	2004	Total
Frequency	1	1	5	16	10	7	6	46
(%)	2.17	2.17	10.87	34.78	21.74	15.22	13.04	100.00

Panel B: $|\varphi_{j,t}|$ from Equation (5) in the ex ante and the ex post periods

		ABS_BT D	ABS_IT D	ABS_ACC
<i>ex ante</i>	Mean	0.037	0.002	0.051
	Median	0.021	0.002	0.049
	St.dev	0.064	0.002	0.077
	t-value			
	(median)	0.313	1.113	0.623
<i>ex post</i>	Mean	0.045	0.003	0.065
	Median	0.027	0.003	0.051
	St.dev	0.059	0.001	0.035
	t-value			
	(median)	0.455	2.233**	1.327*

and Wallis tests are performed to compare the distributions of $|\hat{\varphi}_{j,t}|$.

Panel C: Comparisons on variances, distributions and medians

	ABS_BT D		ABS_IT D		ABS_ACC	
	Value	Probability	Value	Probability	Value	Probability
Kruskal-Wallis tests (χ -squared)						
Null hypothesis: Equality of populations	5.601	0.018	29.918	<0.001	5.755	0.016
Median tests (χ -squared)						
Null hypothesis: Equality of medians	0.903	Not sig.	27.529	<0.001	2.835	0.092

Panel D: Empirical results on Equation (3) and Equation (6)

	Δ NI, D_PVSO and D_TSO, without controls	Δ NI, D_PVSO and D_TSO, with controls	Δ NI and D_PVSO, without controls	Δ NI and D_PVSO, with controls
	(3.3)	(3.4)	(6.1)	(6.2)
Constant	0.264* (0.158)	0.487*** (0.159)	0.230* (0.124)	0.365** (0.144)
Δ NI	1.087*** (0.383)	0.645*** (0.240)	0.994*** (0.367)	0.720*** (0.243)
D_PVSO	-0.057 (0.084)	-0.056 (0.084)	-0.057 (0.083)	0.026 (0.074)
D_TSO	-0.085 (0.146)	-0.002 (0.080)		
Δ NI*D_PVSO	-0.934*** (0.364)	-0.497*** (0.244)	-0.945*** (0.363)	-0.668*** (0.249)
Δ NI*D_TSO	-0.118** (0.052)	-0.102*** (0.022)		
TSO%				0.234 (0.195)
LNMV		-0.063*** (0.018)		-0.042** (0.019)
MTB		0.078*** (0.012)		0.036 (0.025)
Industry Dummies	Yes	Yes	Yes	Yes
Year Dummies	Yes	Yes	Yes	Yes
Sample size	251	251	251	240
Adjusted R-square	6.03%	59.80%	6.49%	22.94%
F-value	2.23***	25.79***	2.58***	6.08***

Panel E: Wald tests on λ_4 and λ_5 in Equations (3)

t-statistics	Null hypothesis: $\lambda_4 > \lambda_5$	
	Value	Probability
RET model (3.3)	2.336	0.010
RET model (3.4)	1.605	0.055

that the median of $|\hat{\varphi}_{j,t}|$ from both ABS_ITD and ABS_ACC specifications is in general greater in the *ex post* period relative to that in the *ex ante* period. Thus, the findings suggest that firms manage earnings more intensively after PVSOs are introduced into managerial compensation for the first time. Specifically, after adoption an average manager will generate more abnormal accruals and produce a larger deferred portion in income tax. However, no significant difference has been found in the ABS_BT D specification between pre- and post-adoption periods.

3.6.2 Validity Tests

As the first validity test, I examine whether earnings informativeness is different in the *ex post* period compared to the *ex ante* period. The following model is employed:

$$RET_t = \lambda_0 + \lambda_1 \Delta NI_t + \lambda_2 D_PVSO_t + \lambda_3 \Delta NI_t * D_PVSO_t + \psi CONTROL_t + year_dummy + industry_dummy + \varepsilon_t \quad (6)$$

where

D_PVSO_t = the dummy variable that equals 1 for years *ex post* PVSO adoption and 0 for the period prior to adoption;

$CONTROL_{j,t}$ = control variables include LNMV, MTB and TSO%.

Furthermore, to compare PVSO compensation with TSO compensation, Equation (3) is also employed. The empirical results are reported in Panel D of Table 7. Models (3.3) and (6.1) only control for the year and industry fixed effects; in Models (3.4) and (6.2) firm characteristics such as size and growth are also controlled for. F-statistics show that all models are statistically significant in explaining the variance of contemporary market returns with $p < 0.01$. The coefficient

on the variable of interest $\Delta NI * D_PVSO$ is negative with $p < 0.01$ in all model specifications, suggesting a decline of earnings informativeness after a firm adopts a PVSO compensation plan. In particular, in Model (6.2), the coefficient on ΔNI is 0.720 with $p < 0.01$ and the coefficient on $\Delta NI * D_PVSO$ is -0.668 with $p < 0.01$. This result suggests that for an average firm in the sample, the correlation between firm reported earnings and contemporary market returns decreases by nearly 93% [i.e. $0.668/0.720$] after the first adoption of PVSO compensation plans. Model (3.4) includes a TSO dummy, D_TSO , indicating the presence of TSO compensation in managerial compensation. The coefficient on ΔNI is 0.645 and significant at $p < 0.01$. The coefficient on $\Delta NI * D_PVSO$ is -0.497 with $p < 0.01$, implying that *ceteris paribus*, for an average firm, in the *ex post* adoption period, the informativeness of firm reported earnings decreases dramatically and is only 23% of the pre-adoption level [i.e. $(0.645 - 0.497)/0.645$]. I also perform Wald tests to compare the effect of the two types of stock option plans (i.e. TSOs vs. PVSOs) on the return-earnings relation. The results are reported on Panel E. The null hypothesis of greater return-earnings association in post-adoption period is rejected at $p < 0.10$ in both Model (3.3) and Model (3.4), which suggests that PVSO adoptions are associated with less informative earnings relative to their TSO counterparts. In particular, in Model (3.4) where firm characteristics (i.e. firm size and growth rate) are controlled for, for an average firm, the return-earnings association reduces to 0.148 [i.e. $0.645 - 0.497$] in the PVSO adoption period, which is 27% [i.e. $0.148/(0.645 - 0.102)$] of the return-earnings relation in the presence of TSO compensation.

Next, I focus on the *ex post*-adoption period and examine the association between PVSO holdings and the level of earnings management. Untabulated results are qualitatively consistent with prior findings. In particular, the coefficient on $PVSO\%$ is positive in Equation (2), suggesting that the level of earnings management increases with PVSO holdings. I also replicate the tests on PVSO composition for the *ex post*-adoption period. Again, previous results are confirmed, which indicates that managers perceive different incentive from each PVSO tranche to manage earnings.

The Black-Scholes stock option fair-value model may overestimate the value of PVSOs because in the model neither vesting targets nor vesting probability is taken into account. To test the restriction on the results, I replicate the tests using various discount rates, as implied in prior studies (Conyon et al., 2005; Kuang and Suijs, 2006)⁵⁸. The results (untabulated) show that prior findings are robust to the valuation adjustments.

3.7 CONCLUSIONS

Firms base stock option compensation on performance targets in order to tighten the link between managers' pay and shareholder wealth. With the increasing use of performance-vested stock options on both sides of the Atlantic, the incentive effects of such stock options receive ever more attention. One undesired economic consequence from PVSO compensation can be that managers will exploit their accounting discretion and manage earnings to meet the performance targets.

Using observations from the 244 largest non-financial firms in the UK from 1997 to 2004, I find that PVSO compensation is positively associated with the level of earnings management. Specifically, firms have higher levels of abnormal accruals, increased book-tax income differences and more deferred tax income when the importance of PVSOs in total compensation of managers increases. The empirical results also show that PVSO compensation is associated with a weaker return-earnings relation, which suggests that the market may be aware of the effects of PVSO compensation and discount the informativeness of reported earnings. When categorizing PVSOs on the basis of how far removed they are from the end of performance period, the empirical results show that PVSOs at different maturity phases vary with respect to the extent to which they are related to earnings management. In particular, managers perceive incentive to

⁵⁸ Conyon et al. (2005) employ 80% discount rate to adjust for the valuation deviation due to the vesting probability of

manage earnings upward when larger proportion of PVSOs is going to vest during the current year.

This study is subject to several limitations: first, the results are derived from a sample consisting of large firms only and thus implications need to be drawn with caution. Nevertheless to the extent that large firms are of most concern to the shareholders, the current study sheds lights on the incentive effects of stock options with vesting targets. Second, the validity of the results on the abnormal accruals relies on the efficiency of the accrual estimation model. I measure managerial discretion over accounting earnings using conventional accounting accruals, taxable-and reported-income difference, and deferred tax expense, and inferences are based on consistent results across specifications. What's more, since the vesting probability is strictly smaller than one, the Black-Scholes fair value model might over-estimate the value of PVSO to managers. No consensus, however, exists about the adjustment method (Conyon et al., 2006), neither for traditional stock option compensation (Hall and Murphy, 2002). Nevertheless the consistent results from the tests using discounted PVSO value could to some extent mitigate the overestimation problem. Future research could explore how managers value PVSOs and TSOs differently and how firm-level and managerial individual-level features may affect the valuation.

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performance-vested equity compensation; As indicated in Kuang and Suijs (2006), the optimal vesting probability for PVSOs is above 72%.

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3.A DEFINITIONS OF STOCK OPTION COMPOSITION

Take 2003 as an example:

Figure 1:

Figure 1 demonstrates how PVSΟ portfolios are broken down into four components. Categorization is based on how far the PVSΟs are to the end of the performance period. Grant is PVSΟs granted during 2003 fiscal year. Af_Vest stands for PVSΟs with performance period ended before the middle of 2003. In other words, evaluation of the option vesting was based on a firm’s performance before 2003. Vest03 refers to PVSΟs with a performance period ended after the middle of 2003 and before the middle of 2004. Therefore, boards decided whether managers were eligible to exercise these options by reviewing the firm’s improvements on predetermined performance objectives for previous three years ended in 2003 fiscal year. Bef_Vest is PVSΟs with performance period ended after the middle of 2004, excluding PVSΟs newly granted during 2003. So for these stock options, vesting decision can only be made after 2003 fiscal year.

Chapter 4: Incentive Effects of Performance-vested Stock Option*

4.1 INTRODUCTION

Vesting of traditional stock options is in general contingent upon time lapse only. A major criticism on this way of vesting concentrates on the weak link between the manager's benefit from such stock options and the improvements in a firm's economic performance. Opponents of traditional stock option plans argue that managers' benefits from traditional stock options may merely mirror the price-increases in a bull market. Managers may pocket windfalls even if they underperform compared to the market average or their peers. In response to public demand for compensation reforms, several European countries issue Corporate Governance Codes that recommend stock option plans to be subject to "challenging performance criteria". Examples include the Combined code in the UK and the Corporate Governance Codes in Germany and the Netherlands⁵⁹. These recommendations met with rapid implementation, especially in the UK. In 1997, almost 60% of 200 largest UK firms operating stock option schemes for the board had performance criteria attached (Conyon et al., 2000). In 2003, 90% of FTSE top 250 non-financials having executive stock option plans included performance targets to stock option compensation. Also the US witnesses an increasing use of options with performance hurdles (Gerakos et al., 2005). In 2005, 30 out of 100 major U.S. corporations based a portion of their equity grants to CEOs on performance targets, compared to 23 in 2004 and 17 in 2003. Peter Chingos, head of the U.S. executive-compensation practice at Mercer, predicts that by the end of 2006 more than half

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⁵⁹Code Tabaksblat in the Netherlands; Section 4.2.3 of Corporate Governance Code in Germany.

of these firms will issue performance-based equity compensation to their senior managers.⁶⁰ In addition, U.S. institutional investors and other activist stakeholder groups become increasingly active in promoting a stronger link between executive pay and firm performance. The AFSCME pension fund, for instance, submitted proposals to companies to give shareholders voting rights on executive compensation plans, as they believe their generous compensation plans did not match the companies' performance.⁶¹

Amid performance targets attached to option vesting, earnings growth is the most widely adopted one. Conyon et al. (2000) find that in 1997, 72% of 200 largest UK firms with performance-vested stock option plans granted stock options with earnings per share targets. Coakley and Iliopoulou (2004) report that the most widely adopted performance criterion requires that growth in earnings per share (EPS) over the 3-year period between the grant date and vesting date must exceed the growth in the UK Inflation Index by a total of 3 to 6% (i.e. 1 to 2% annually). The next most frequently used performance criterion is a market-based measure, namely total shareholder return (TSR). When this measure is applied, option vesting usually depends on the firm's market return relative to the performance of a peer group.⁶²

Notwithstanding the extensive application of performance-vested stock options, and the proposition from public policies and media that performance constraints provide better incentives to managers, there is little theoretical knowledge about managerial incentives that such constraints provide; in particular, the difficulty level of performance targets.

This paper examines the underlying rationale of Corporate Governance Codes in promoting performance-vested stock options. We employ an agency setting to compare the incentive effects of performance-vested stock options to those of traditional stock options⁶³. We

⁶⁰ "U.S. boards tie CEO pay to results", *Wall Street Journal*, February 22, 2006,

⁶¹ "Activists sink claws into executives' pay", *Wall Street Journal*, February 27, 2006,

⁶² This might be due to the different accounting treatment of market-based performance targets (e.g. achieving a specified share price or a specified target based on a comparison of the entity's share price with an index of share prices of other entities) and non-market performance targets (e.g. revenues or profits).

⁶³ However, our focus is not on the design of an optimal compensation contract.

find that performance-vested stock options induce higher managerial effort than traditional stock options when performance targets are not set too difficult. Higher effort results when the marginal benefit of effort from performance-vested stock options is higher than the marginal benefit of effort from traditional stock options. The marginal benefit of effort from performance-vested stock options consists of two parts. First, additional effort increases the value of the stock option. Since this benefit only accrues to the manager when the stock options vest, this benefit is lower for performance-vested stock options than for traditional stock options. Second, additional effort increases the probability that the stock options vest. Since traditional stock options do not have this benefit, the marginal benefit of performance vested stock options exceeds the marginal benefit of traditional stock options when the marginal vesting probability is sufficiently high. In our model, this occurs when targets are not too difficult. We further show that for appropriate target difficulties the principal prefers the use of performance-vested stock options over traditional stock options. This result is robust to costly manipulation of the performance measure by the manager.

We also extend our comparisons to performance cash bonuses, i.e. the manager receives a cash bonus if and only if a prespecified performance target is met. The principal's preference between performance-vested stock options and cash bonuses with the same present value depends on the manager's risk aversion and firm risk. Performance-vested stock options still dominate when the manager is not too risk averse and/or the firm is not too risky. The explanation is straightforward. The benefit of stock options compared to a cash bonus relates to the incentives that stock options provide. Higher managerial effort increases the value of the stock option but not the magnitude of the bonus. The cost of stock options compared to a cash bonus is that stock options impose more risk on the manager. The future value of the stock option is risky while the magnitude of the cash bonus is known in advance. Hence, as long as the manager is not too risk averse and/or the firm is not too risky, the benefit of stock options outweighs the cost.

Numerical results further indicate a vesting probability of at least 70% when performance

targets reside at the optimal level, echoing the consensus in the goal-setting literature that states that "tight, but achievable" targets are associated with performance benefits (Locke and Latham, 2002; Merchant and Manzoni, 1989). Empirical evidence is supportive of this high vesting probability. Conyon and Murphy (2000) find that among 510 largest UK firms, 80% achieved average EPS growth of 2% between 1992 to 1997, satisfying the common criterion for option vesting. Noticeably, one commonly interprets such high vesting probabilities as performance targets being too easy. In contrast, we show that it is also consistent with optimal performance targets.

The remainder of the paper is organized as follows. Section 4.2 discusses related literature. Section 4.3 describes the setting of our model. In Section 4.4, we analyze the incentive effects of performance-vested stock options and traditional stock options. In Section 4.5, we investigate the principal's choice of compensation contracts. Section 4.6 discusses implications of our results on optimal target difficulty. Finally, Section 4.7 concludes.

4.2 RELATED LITERATURE

The use of piecewise incentive components, such as stock options, in compensation contracts has been widely discussed in the incentive literature. Valuation literature shows that managers' valuation of stock options is strictly lower than the market valuation of the options. Holding unhedged options, managers are exposed to additional incentive-related risk, resulting in additional economic costs (Hall and Murphy, 2002b; Jeter, 2002). In response, other studies point out that incentive effects of one component of the compensation package depends on how the other components are concurrently adjusted (Lambert, Larcker, and Verrecchia, 1991). Consistent with this view, Hemmer (1993) constructs a compensation package in which cash bonus serves as an insurance for stock options such that management compensation is insensitive to fluctuations in the stock price. In an agency setting, he shows that agency costs can be avoided by including such

hedged options in the compensation package so that it will never be beneficial for the manager to shirk. Hemmer, Kim, and Verrecchia (1999) further outline circumstances under which optimal compensation contracts are convex. They find that convexity in managerial compensation is optimal when the manager is not too risk averse and his absolute risk aversion is declining. Dittman and Maug (2005) discuss the validity of a widely used principal agent model with constant relative risk aversion and lognormal stock prices. In contrast to the model's prediction that stock options are not part of an optimal contract, they find that, on average, CEOs hold options on 1.3% of their companies.

Dutta (2003) shows firms must use stock options to retain valuable managerial human capital. Arya and Mittendorf (2005) discuss the efficiency of stock options in matching managerial pay to capability. In their model, both the likelihood of option exercise and firm market price at exercise are tied to managerial capability. Only gifted managers are willing to accept compensation packages with a generous offer of stock options so that incapable managers are screened out.

Another string of studies examines the role of equity compensation, such as stock options, in curbing managers' opportunism in decision making (Dow et al., 2005; Barron and Waddell, 2003). Barron and Waddell (2005) discuss the trade-off between evaluation effort and decision precision with stock option compensation. They show that stock option compensation provides managers with greater incentives to determine the true value of an investment plan.

Prior studies on incentive effects of nontraditional stock options do not employ an agency setting but use the Black-Scholes model for valuation purpose. Johnson and Tian (2000) investigate the pricing and incentive properties of six nontraditional stock options, including premium options, performance-vested options on the basis of market price, reprisable options, purchased options, reload options and indexed options. They use the partial derivatives with respect to stock price to measure the incentive effects of option plans. Except the reprisable

option, five of the nontraditional options provide greater incentives than the traditional option does and the greatest incentive is from the indexed stock option. Using a similar methodology, Camara (2001) discusses the incentive effects of executive stock options that condition vesting on the firms' market price relative to their peers' performance. In contrast to the conjecture on the efficiency of relative performance evaluation (RPE) (Holmstrom, 1982), Camara illustrates the inefficiency of this self-imposed constraint, indicating that relative performance incentives (RPIs) do not provide stronger incentives to increase shareholder wealth in comparison with absolute performance incentives (APIs). From a research design perspective, our study is closely related to Feltham and Wu (2001) and Lambert and Larcker (2005) who compare the incentive effects of traditional stock options with those of restricted stocks in an agency setting.

Camara and Henderson (2005) discuss the effects of managerial discretion on the value of performance-vested stock options to managers and the cost of their options to firms. They assume that performance manipulation follows a stochastic process and ignore the possible incentive effects of performance-vested stock options. They find that both the manager's valuation of stock options received and the firm's cost of stock options granted are affected by the manager's manipulation strategy. In particular, when manipulation only affects the mean of the performance measure, manipulation benefits the manager but does not harm the firm. Our paper also considers the incentive effects of manipulation of performance measures in an agency setting.

4.3 SETTING OF THE MODEL

Consider a risk-neutral principal that hires a manager to operate a firm for two periods. At $t=0$, a compensation contract $\tilde{w}$ is designed to provide the manager with incentives and is assumed to consist of two parts: a fixed salary and (performance-vested) stock options. The evaluation period runs from $t=0$ to $t=1$ and the vesting decision is made at $t=1$ when performance

measure $\tilde{x}$ is publicly observed. In particular, if the performance measure $\tilde{x}$ does not meet the predetermined target L , then the options will expire at once and the manager's right of exercising will be bereaved. If the predetermined target L is attained, the manager will be eligible to exercise the options at $t=2$, at which time the firm's terminal value $\tilde{c}$ is publicly observed (cf. Feltham and Wu, 2001; Lambert and Larcker, 2005). We assume that terminal value $\tilde{c}$ satisfies $\tilde{c} = m + \tilde{\varepsilon}$, where $\tilde{\varepsilon}$ is normally distributed with mean zero and standard deviation σ . To maintain the simplicity of our model, $\tilde{x}$ and $\tilde{\varepsilon}$ are independent by assumption.

Managerial effort $a \geq 0$ is not observable to the principal. The manager's personal cost of taking action a equals $\psi(a) = \frac{1}{2}a^2$. Managerial effort influences both terminal value $\tilde{c}$ and the performance measure $\tilde{x}$. We assume that the mean m of $\tilde{c}$ is a function of managerial effort, namely $m(a) = a$. In contrast to Feltham and Wu (2001), we mainly focus on the case where a does not influence risk σ . We further assume that the interdependence between $\tilde{x}$ and a is such that the probability of vesting can be represented by $P(\tilde{x}(a) \geq L) = 1 - e^{-\frac{L-a}{\sigma}} =: p(a)$. The higher L , the more difficult it is to meet the vesting criteria⁶⁴. Traditional stock options are characterized by $p(a) = 1$, which arises when L approaches 0.⁶⁵ Observe that when the manager exerts no effort, the vesting probability equals zero. Thus, even when targets are relatively easy, the manager has to exert some non-negative effort to meet the performance targets with positive probability.

In practice, we observe that firms link option vesting to improvements in accounting- and/or market-based performance objectives. In our model, $\tilde{x}$ represents the performance measure. In case of $\tilde{x}$ representing a market-based performance measure, $\tilde{x}$ should be a

⁶⁴In practice, partial vesting is possible. For simplification, we assume that vesting is binary.

function of terminal value $\tilde{c}$. When $\tilde{x}$ represents an accounting performance measure, $\tilde{x}$ is not necessarily a function of $\tilde{c}$ any more. The conventional wisdom is that accounting measures provide information about $\tilde{c}$, implying that $\tilde{x}$ and $\tilde{c}$ should be correlated. In our setting, $\tilde{x}$ and $\tilde{c}$ are related through managerial effort a . Hence, we may justifiably interpret $\tilde{x}$ as an accounting measure. Moreover, $\tilde{x}$ can represent both an absolute performance measure as well as a relative performance measure. Relative performance measure specification can be considered in a multi-firm model. In equilibria, manager i would then take the other managers' effect choices as given when deciding on his own effort choice. Hence, manager i 's decision problem is structurally similar to the one with absolute performance measures. Empirical evidence shows that the overwhelming majority of companies award incentive stock options with accounting-based performance targets and the most widely adopted performance criterion among UK firms is growth of earnings per share (Conyon et al., 2000; Camara and Henderson, 2005). The next largest category is a market-based measure, namely total shareholder return, but its usage is low⁶⁶.

The compensation contract that the principal offers the manager at $t = 0$ is characterized by the parameters $\{f, \beta, k, L\}$. At $t=2$, it pays compensation

$$\tilde{w}(a) = \begin{cases} f, & \text{if } \tilde{x}(a) < L \\ f + \beta \max\{\tilde{c}(a) - k, 0\}, & \text{if } \tilde{x}(a) \geq L \end{cases} \quad (1)$$

where f is a fixed wage; $\beta \in [0, 1]$ represents the proportion of stock options granted to the manager and $k \geq 0$ denotes the exercise price. We assume that exercising options only takes place at $t=2$ so that the value of an option equals $\max\{\tilde{c} - k, 0\}$.

⁶⁵For completeness, define $P(\tilde{x}(0) \geq 0) = 1$.

⁶⁶Conyon et al. (2000) investigate executive compensation of 200 largest UK firms in 1997. 71.93% of their sample firms conditioned option vesting solely upon the growth of earnings per share. Only 11.40% used total shareholder

Like in Feltham and Wu (2001), the manager is assumed to have the following mean-variance utility function:

$$U(\tilde{w}(a), a) = E(\tilde{w}(a)) - \rho \text{Var}(\tilde{w}(a)) - \psi(a) \quad (2)$$

where $\rho > 0$ measures the manager's risk aversion. Finally, we assume that the discount rate equals zero and that the firm is fully financed by equity.

4.4 THE MANAGER'S CHOICE OF EFFORT

For a given compensation package $\{f, \beta, k, L\}$, the manager's choice of effort a_{po}^* maximizes his utility from taking this effort:

$$a_{po}^* \in \underset{a}{\operatorname{argmax}} U(\tilde{w}(a), a) \quad (3)$$

Denote by $m_k(a)$ and $\sigma_k^2(a)$ the expected value and variance of an option on the future cash flow $\tilde{c}$ with exercise price k , respectively. Using that terminal value $\tilde{c}$ is normally distributed with mean a and variance σ^2 , we obtain that

$$m_k(a) = E(\max\{\tilde{c} - k, 0\}) = \sigma[\phi - (1 - \Phi)\xi], \quad (4)$$

$$\begin{aligned} \sigma_k^2(a) &= \text{Var}(\max\{\tilde{c} - k, 0\}) \\ &= \sigma^2[(1 - \Phi - \phi^2) - \phi(2\Phi - 1)\xi + \Phi(1 - \Phi)\xi^2], \end{aligned} \quad (5)$$

where $\xi = \frac{k - m(a)}{\sigma}$, $\phi = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}\xi^2}$ and $\Phi = \int_{-\infty}^{\xi} \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}t^2} dt$ (Greene, 1993; see also Feltham

and Wu, 2001). Hence,

$$\begin{aligned} E(\tilde{w}(a)) &= f + (1 - e^{-\frac{\beta}{L}})\beta m_k(a) \\ \text{Var}(\tilde{w}(a)) &= E(\tilde{w}^2(a)) - E(\tilde{w}(a))^2 \\ &= (1 - e^{-\frac{\beta}{L}})\beta^2(\sigma_k^2(a) + m_k^2(a)) - (1 - e^{-\frac{\beta}{L}})^2\beta^2 m_k^2(a). \end{aligned}$$

return for this purpose.

The first-order condition of the optimization problem in (3) implicitly defines a_{PO}^* as a solution of the equation $a = v(a, L)$ where

$$\begin{aligned}
 v(a, L) &= \frac{\partial}{\partial a} E(\tilde{w}(a)) - \rho \frac{\partial}{\partial a} Var(\tilde{w}(a)) \\
 &= \frac{1}{L} e^{-\frac{a}{L}} \beta m_k(a) + (1 - e^{-\frac{a}{L}}) \beta \frac{\partial m_k(a)}{\partial a} \\
 &\quad - \rho \beta^2 \left[\frac{1}{L} e^{-\frac{a}{L}} (\sigma_k^2(a) + m_k^2(a)) + (1 - e^{-\frac{a}{L}}) \left(\frac{\partial \sigma_k^2(a)}{\partial a} + 2 \frac{\partial m_k(a)}{\partial a} m_k(a) \right) \right. \\
 &\quad \left. - 2(1 - e^{-\frac{a}{L}}) \frac{1}{L} e^{-\frac{a}{L}} m_k^2(a) - 2(1 - e^{-\frac{a}{L}})^2 \frac{\partial m_k(a)}{\partial a} m_k(a) \right]. \quad (6)
 \end{aligned}$$

For simplicity, we assume that stock options are granted at the money (cf. Feltham and Wu, 2001)⁶⁷. Given rational expectations, this means that the exercise price k equals the mean of terminal value $m(\hat{a})$, where $\hat{a}$ is the anticipated effort level, i.e. $\hat{a} = a_{PO}^*$. Using that

$k = m(a_{PO}^*) = a_{PO}^*$, it follows that $\xi = 0$, $\phi = \frac{1}{\sqrt{2\pi}}$, and $\Phi = \frac{1}{2}$. Furthermore, it follows that

$\frac{\partial m_k(a)}{\partial a} = 1 - \Phi$, and $\frac{\partial \sigma_k^2(a)}{\partial a} = 2\Phi m_k(a) = m_k(a)$. Hence, $v(a, L)$ reduces to

$$\begin{aligned}
 v(a, L) &= \frac{1}{2} \beta (1 - e^{-\frac{a}{L}}) + \frac{\beta \sigma}{L \sqrt{2\pi}} e^{-\frac{a}{L}} \\
 &\quad - \rho \beta^2 \left[\frac{\sigma}{\sqrt{2\pi}} (1 + e^{-\frac{a}{L}})(1 - e^{-\frac{a}{L}}) - \frac{\sigma^2}{\pi} (1 - e^{-\frac{a}{L}}) \frac{e^{-\frac{a}{L}}}{L} + \frac{\sigma^2 e^{-\frac{a}{L}}}{2L} \right]. \quad (7)
 \end{aligned}$$

If traditional stock options are issued, option vesting is independent of reported performance. Since the vesting probability $p(a)$ equals 1, traditional stock options correspond

to the limiting case $L = 0$. Since $\lim_{L \rightarrow 0} v(a, L) = \frac{1}{2} \beta - \frac{\rho \beta^2 \sigma}{\sqrt{2\pi}}$ is independent of a , traditional stock

options induce the effort level

⁶⁷Observe that granting stock options at the money is suboptimal from the principal's perspective. The principal is better off by granting them in the money (Hall and Murphy, 2002a). We justify this assumption as it corresponds to common business practice.

$$a_{TO}^* = \frac{1}{2}\beta - \frac{1}{2}\rho\beta^2 \frac{2\sigma}{\sqrt{2\pi}} \quad (8)$$

When performance-vested stock options are issued, the situation becomes more complex. Lambert and Larcker (2005) indicate one undesired feature of using the first-order-condition approach to solve the optimization problem. With stock option compensation, the manager's expected utility may become bimodal due to the convexity of an option's payoff. In that case, multiple solutions to the first-order condition may exist. Consequently, solving the first-order condition is no longer sufficient for determining the manager's optimal effort level. A solution can just be a local maximum or even a (local) minimum. We therefore analyze the first-order condition $a = v(a, L)$ in more detail to derive additional conditions under which a solution of $a = v(a, L)$ maximizes the manager's utility.

First, observe that choosing zero effort is a local maximum for the manager when his utility function is decreasing at $a = 0$, i.e. $\frac{\partial U(\tilde{w}, 0)}{\partial a} \leq 0$. Since we need to rule out this case, it is necessary to assume that $\beta < \frac{2}{\rho\sigma\sqrt{2\pi}}$. The reason we need to rule out $a = 0$ as a local maximum is that any solution a to the first order condition $a = v(a, L)$ is implicitly defined. This makes it difficult if not impossible to check whether managerial effort a yields a higher utility than exerting no effort (i.e. whether $U(\tilde{w}(a), a) \geq U(\tilde{w}(0), 0)$). Notice that the principal can always choose β such that this inequality is satisfied⁶⁸.

Lemma 1: Let $\beta < \frac{2}{\rho\sigma\sqrt{2\pi}}$. If there exists $a^ > a_{TO}^*$ satisfying $v(a^*, L) = a^*$, then a^* is unique and a^* is the global maximum of $U(\tilde{w}(a), a)$, i.e. $a_{PO}^* = a^*$.*

Lemma 1 implies that when performance-vested stock options with target difficulty L induce higher managerial effort than traditional options, the first order condition $a = v(a, L)$ is

⁶⁸In Section 4 it becomes clear though that this assumption is not restrictive.

necessary and sufficient. Hence, we can safely replace (3) by $a_{PO}^* = v(a_{PO}^*, L)$.

Since $\lim_{a \rightarrow \infty} v(a, L) = a_{TO}^*$, it follows from the continuity of $v(a, L)$ that there exists $a > a_{TO}^*$ satisfying $a = v(a, L)$ whenever $v(a_{TO}^*, L) > a_{TO}^*$. Lemma 1 then implies that $a_{PO}^* = a > a_{TO}^*$. Hence, for performance-vested stock options with target difficulty L , $v(a_{TO}^*, L) > a_{TO}^*$ is a sufficient condition to induce higher managerial effort than traditional stock options. Lemma 2 below states that it is also a necessary condition.

Lemma 2: Let $\beta < \frac{2}{r\sigma\sqrt{2\pi}}$ and let a_{PO}^ be the global maximum of $U(\tilde{w}(a), a)$ for given target difficulty L . Then $a_{PO}^* > a_{TO}^*$ if and only if $v(a_{TO}^*, L) > a_{TO}^*$.*

The next proposition states which difficulty levels satisfy $v(a_{TO}^*, L) > a_{TO}^*$ and thus induce higher effort than traditional stock options.

Proposition 1: Let $\beta < \frac{2}{\rho\sigma\sqrt{2\pi}}$. Performance-vested stock options induce higher effort than traditional stock options if and only if targets are not too difficult, that is, $a_{PO}^ > a_{TO}^*$ if and only if $L < L^0$ where $L^0 > 0$ is such that $v(a_{TO}^*, L^0) = a_{TO}^*$. It holds that $L^0 \leq \frac{2\sigma}{\sqrt{2\pi}}$. Furthermore, the optimal target difficulty L^* that maximizes a_{PO}^* is characterized by the following two conditions:*

$$e^{-\frac{a_{PO}^*}{L^*}} = \frac{\left(\rho\beta^2\sigma^2 a_{PO}^* \frac{\pi-2}{2} - \frac{\beta\sigma a_{PO}^*}{\sqrt{2\pi}}\right) - L^* \left(-\frac{\sigma\beta}{\sqrt{2\pi}} - \frac{\sigma\beta}{2} + \rho\beta^2\sigma^2 \frac{\pi-2}{2\pi}\right)}{L^* \rho\beta^2\sigma \left(\frac{\sigma}{\pi} + \frac{2a_{PO}^*}{\sqrt{2\pi}} - \frac{2\sigma a_{PO}^*}{L^*\pi}\right)} \quad (9)$$

$$v(a_{PO}^*, L^*) > 0. \quad (10)$$

Proposition 1 implies that even very easy targets induce higher managerial effort than no targets at all. This result may seem surprising. Recall though that we assumed the vesting probability $p(a)$ to be such that $p(a) = 1 - e^{-\frac{a}{L}}$. Since the vesting probability equals zero when

the manager exerts no effort, even very easy targets provide incentives to the manager.

The intuition that performance-vested stock options can induce higher effort than traditional stock options is best explained by considering a risk neutral manager. The utility of compensation package $\tilde{w}$ for a risk neutral manager equals $p(a)\beta m_k(a) - \psi(a)$. For traditional stock options, it holds that $p(a) = 1$ so that the first-order condition reads

$$\beta \frac{\partial m_k(a)}{\partial a} = \frac{\partial \psi(a)}{\partial a}$$

The left-hand side represents the marginal benefit of effort, the right-hand side the marginal cost. When marginal benefit exceeds marginal cost, the manager increases effort; when marginal benefit is less than marginal cost, the manager decreases effort.

Next, consider the first-order condition for performance-vested stock options:

$$p(a)\beta \frac{\partial m_k(a)}{\partial a} + \frac{\partial p(a)}{\partial a} \beta m_k(a) = \frac{\partial \psi(a)}{\partial a} \quad (11)$$

The marginal benefit of effort now consist of two parts. The effect of effort on the value of the stock option $p(a)\beta \frac{\partial m_k(a)}{\partial a}$, and the effect of effort on the vesting probability $\frac{\partial p(a)}{\partial a} \beta m_k(a)$. Since $p(a) \leq 1$, imposing vesting criteria reduces the expected compensation $p(a)\beta m_k(a)$. Consequently, it reduces the marginal benefit $p(a)\beta \frac{\partial m_k(a)}{\partial a}$ of effort with respect to the stock option value. This, however, is only one part of the marginal benefit of effort. The marginal benefit can still exceed the marginal cost and thus increase managerial effort if the marginal vesting probability $\frac{\partial p(a)}{\partial a}$ is sufficiently high.

The use of stock options to add convexity to compensation contracts are commonly mentioned as optimal when there is a link between a manager's choice of effort and the firm's risk (Hemmer et al., 1999; Feltham and Wu, 2001). If we assume a positive relationship between managerial effort and the riskiness of the firm's operations, i.e. $\sigma(a)$ is increasing in a , then

the first-order condition of optimization problem in (3) defines a_{po}^* as a solution to the equation

$a = \hat{v}(a, L)$ where

$$\hat{v}(a, L) = v(a, L) + \frac{\frac{\partial \sigma(a)}{\partial a}(1 - e^{-\frac{a}{L}})}{\sqrt{2\pi}} \left[\beta - \rho\beta^2 \frac{2\sigma(a)}{\sqrt{2\pi}} (\pi - 1 + e^{-\frac{a}{L}}) \right]. \quad (12)$$

and $v(a, L)$ is the same as defined in (7).⁶⁹

Proposition 2: When effort affects risk, the principal can induce higher managerial effort by using performance-vested stock options than by using traditional stock options.

The intuition of Proposition 2 is similar to that of Proposition 1 (cf. (11)).

The mean-variance utility function of the manager that we consider is consistent with an exponential (Von Neumann-Morgenstern) utility function only for normally distributed payoffs. In the following, we analyze the manager's choice of effort when the manager is an expected utility maximizing agent, that is, $a_{po}^* \in \arg\max EU(\tilde{w}(a)) - \psi(a)$ using that $EU(\tilde{w}(a)) = p(a, L)EU(f + \tilde{y}(a)) - \psi(a)$, with $\tilde{y}(a) = \beta \max\{\tilde{c}(a) - k, 0\}$ representing payoff of the option. The first-order condition of the manager's final utility with respect to a yields:

$$\frac{\partial p(a, L)}{\partial a} EU(f + \tilde{y}(a)) + p(a, L) \frac{\partial EU(f + \tilde{y}(a))}{\partial a} = \frac{\partial \psi(a)}{\partial a}. \quad (13)$$

If the left-hand side of (13) is increasing in L at $L=0$, it is clear that performance-vested stock options can induce higher managerial effort than traditional stock

⁶⁹Since $\frac{\partial m_k(a)}{\partial a} = \frac{\partial \sigma(a)}{\partial a} \frac{1}{\sqrt{2\pi}} + \frac{1}{2}$ and $\frac{\partial \sigma_k^2(a)}{\partial a} = \sigma \frac{\partial \sigma(a)}{\partial a} \frac{\pi-1}{\pi} + \frac{\sigma}{\sqrt{2\pi}}$, equation (6) reduces to

$$\begin{aligned} \hat{v}(a, L) = & \frac{1}{2} \beta (1 - e^{-\frac{a}{L}}) + \frac{\beta \sigma}{L \sqrt{2\pi}} e^{-\frac{a}{L}} + \frac{1}{\sqrt{2\pi}} \frac{\partial \sigma(a)}{\partial a} (1 - e^{-\frac{a}{L}}) \beta \\ & - \rho\beta^2 \left[\frac{\sigma}{\sqrt{2\pi}} (1 + e^{-\frac{a}{L}})(1 - e^{-\frac{a}{L}}) - \frac{\sigma^2}{\pi} (1 - e^{-\frac{a}{L}}) \frac{e^{-\frac{a}{L}}}{L} + \frac{\sigma^2 e^{-\frac{a}{L}}}{2L} \right] \\ & - \rho\beta^2 \left[(1 - e^{-\frac{a}{L}}) \sigma \frac{\partial \sigma(a)}{\partial a} - \frac{\sigma}{\pi} \frac{\partial \sigma(a)}{\partial a} (1 - e^{-\frac{a}{L}})^2 \right]. \end{aligned}$$

options. This condition holds when

$$-\frac{\frac{\partial p(a,L)}{\partial a \partial L}}{\frac{\partial p(a,L)}{\partial L}} > \frac{\frac{\partial EU(f+\tilde{y}(a))}{\partial a}}{EU(f+y(a))} \quad (14)$$

at $L = 0$. Our assumption on vesting probability $p(a, L)$ implies that the left-hand side of (14) approaches infinity when L goes to 0, whereas the right-hand side is finite. The intuition remains the same as before. An increase in L increases levels of managerial effort only if the increase in $\frac{\partial p(a,L)}{\partial a} EU(f+\tilde{y}(a))$ exceeds the decrease in $p(a, L) \frac{\partial EU(f+\tilde{y}(a))}{\partial a}$. In other words, performance-vested stock options induce higher effort from the manager only when the increase in marginal vesting probability is greater than the decrease in marginal utility that results from a lower vesting probability $p(a, L)$.

Summarizing, performance-vested stock options increase the marginal benefit of effort relative to traditional stock options if the marginal probability of vesting is sufficiently high. In our model, this arises when targets are not too difficult.

4.5 THE PRINCIPAL'S CHOICE OF COMPENSATION CONTRACT

The previous section shows that performance-vested stock options can induce higher effort than traditional stock options. This, however, does not automatically imply that the principal prefers the use of performance-vested stock options over traditional ones. The principal only prefers higher effort levels if the benefit of additional effort outweighs the cost of inducing this additional effort. In this section, we analyze performance-vested stock options from the principal's perspective.

At $t=0$, the principal constructs a compensation contract to maximize her expected net profits from the firm. This maximization problem is subject to the participation constraint and the incentive compatibility constraint of the manager, that is

$$\max_{f, \beta, k, L} E[\tilde{c} - \tilde{w}(a_{PO}^*) | f, \beta, L] \quad (15)$$

$$\text{s.t. } U(\tilde{w}(a_{PO}^*), a_{PO}^*) \geq U^0 \quad (16)$$

$$a_{PO}^* \in \operatorname{argmax}_a U(\tilde{w}(a), a) \quad (17)$$

where U^0 is the manager's reservation utility.

Since the participation constraint is binding, we have that

$$E(\tilde{w}) = U^0 + \rho \operatorname{Var}(\tilde{w}(a_{PO}^*)) + \psi(a);$$

Substituting this constraint into the principal's objective function and using that

$E(\tilde{c}) = a_{PO}^*$, the principal's problem reduces to

$$\max_{\beta, L} a_{PO}^* - \psi(a_{PO}^*) - \rho \operatorname{Var}(\tilde{w}(a_{PO}^*)) \quad (18)$$

$$\text{s.t. } a_{PO}^* \in \operatorname{argmax}_a U(\tilde{w}(a_{PO}^*), a_{PO}^*)$$

The principal's choice variables are the grant size β and target difficulty L . Since we are interested in a comparison between traditional and performance-vested stock options, let us first focus on what the principal can achieve with traditional stock options (i.e. $L = 0$).

Lemma 3: For traditional stock options the optimal grant size β_{TO}^ satisfies $\beta_{TO}^* \leq \frac{\sqrt{2\pi}}{4\rho\sigma}$.*

From Lemma 3 we derive that $\beta_{TO}^* < \frac{2}{\rho\sigma\sqrt{2\pi}}$ so that Proposition 1 applies. This implies that the principal can offer the manager the compensation contract $\{\beta_{TO}^*, L^0\}$. This compensation contract grants performance-vested stock options and induces the same effort level as $\{\beta_{TO}^*, 0\}$ that grants traditional stock options. However, the contract $\{\beta_{TO}^*, L^0\}$ imposes less risk⁷⁰ on the manager than $\{\beta_{TO}^*, 0\}$ so that the principal strictly prefers the contract $\{\beta_{TO}^*, L^0\}$. Since $\{\beta_{TO}^*, 0\}$ is the optimal contract using traditional stock options, we obtain the following result:

Proposition 3: The principal strictly prefers performance-vested stock options to traditional stock options.

Recall from Proposition 1 that compared to traditional stock options, the principal can increase managerial effort by setting performance targets $L < L^*$. Increasing effort, however, does not automatically make the principal better off as performance targets also affect compensation risk. To analyze the overall effect of target difficulty L on the principal's payoff, consider the first order derivative of the principal's payoff function with respect to L :

$$\frac{\partial a_{PO}^*}{\partial L} \left(1 - \frac{\partial \psi}{\partial a} \right) - \rho \left[\frac{\partial Var(\tilde{w}(a_{PO}^*))}{\partial a} \frac{\partial a_{PO}^*}{\partial L} + \frac{\partial Var(\tilde{w}(a_{PO}^*))}{\partial L} \right] \quad (19)$$

Target difficulty L affects the principal's payoff in two ways. First, target difficulty affects the firm's cash flows through the effort choice a_{PO}^* of the manager. Second, target difficulty affects the risk premium that the principal has to pay to the manager. Since the risk premium depends on target difficulty L and managerial effort a_{PO}^* , we distinguish a direct effect on risk premium, i.e. $\frac{\partial Var(\tilde{w}(a_{PO}^*))}{\partial L}$, and an indirect effect, $\frac{\partial Var(\tilde{w}(a_{PO}^*))}{\partial a} \frac{\partial a_{PO}^*}{\partial L}$. One can show that the direct effect reduces risk and that the indirect effect increases risk for target difficulty levels $L < L^*$. Based on numerical analysis, we conjecture that the direct effect dominates the indirect effect. This then implies that for any $\beta < \frac{2}{\rho\sigma\sqrt{2\pi}}$ (and β_{TO}^* in particular), the principal's payoff is increasing in L for all target difficulty levels $L \leq L^*$. Consequently, the optimal target difficulty L^{**} for the principal satisfies $L^{**} > L^*$. The principal thus sets performance targets beyond the effort-maximizing level. Since this lowers the manager's efforts, one can interpret the result as the manager perceiving the performance target as very difficult to achieve.

⁷⁰Because $\frac{\partial Var(\tilde{w})}{\partial L} < 0$. See the proof of Proposition 3.

4.5.1 Manipulation of Performance Measures

Unintended consequences of executive stock options have drawn increased attention. A positive association between accounting accruals and option compensation has been documented, suggesting that when managers' potential total compensation is more closely tied to option holdings, problems from earnings management are more pronounced (Bergstresser and Philippon, 2005; Cheng and Warfield, 2005). Empirical evidence also shows that managers' stock option compensation is positively associated with serious negative consequences of earnings manipulation, such as misreporting, accounting fraud and shareholder litigation (Burns and Kedia, 2003; Johnson, Ryan, and Tian 2003; Peng and Roell, 2004).

With performance-vested stock options, managers benefit from the options only when performance targets are fulfilled. Performance measures, especially those based on accounting figures, may be subject to manipulation by the manager. Camara and Henderson (2005) analyze the effect of manipulation on performance-vested stock options in a non-agency setting. They focus on the manager's valuation of stock options received and the firm's cost of stock options granted. In their model, the effect of manipulation depends on whether manipulation affects the mean of the performance measure, the variance or both. In particular, they find that when manipulation only affects the mean, manipulation benefits the manager but does not harm the firm.

In this subsection, we introduce manipulation into our model. For simplicity, we assume a risk neutral manager (i.e. $\rho = 0$). Let m denote manipulative effort of the manager. The cost of manipulation equals $k(m) = \frac{1}{2}m^2$. The performance measure $\tilde{x}(a, m)$ depends on economic effort a and manipulative effort m . We assume that $\tilde{x}(a, m)$ is such that the vesting probability satisfies

$$P(\tilde{x}(a + m) \geq L) = 1 - e^{-\frac{a + \mu m}{L}} = p(a + \mu m)$$

where μ measures the level of managerial discretion in the performance measure $\tilde{x}(a, m)$. Higher values of μ indicate that manipulation of the performance measure is easier. At $t = 0$, given compensation package $\{f, \beta, k, L\}$, a risk-neutral manager's objective is to choose

$$a^*, m^* \in \operatorname{argmax}_{a, m \geq 0} (1 - e^{-\frac{a + \mu m}{L}}) \beta m_k(a) - \frac{1}{2} a^2 - \frac{1}{2} m^2$$

Proposition 4: Given β and k , performance-vested stock options induce higher (lower) effort than traditional stock options if and only if $L < \frac{2\sigma}{\sqrt{2\pi}} (L > \frac{2\sigma}{\sqrt{2\pi}})$. Furthermore, the optimal manipulation level m^ satisfies $m^* = \frac{\mu\sigma(2a_{PO}^* - \beta)}{2\sigma - L\sqrt{2\pi}}$. a_{PO}^* is decreasing in μ and when μ goes to infinity, a_{PO}^* approaches a_{TO}^* .*

Notice that even though performance-vested stock options still induce higher effort than traditional stock options, manipulation does come with a cost. Manipulation reduces the economic effort level that the principal can implement. The easier a performance measure can be manipulated, the lower the economic effort will be. Increasing the performance target L cannot fully compensate for this.

Coefficient μ measures how attractive manipulation is. When μ increases, manipulation becomes more attractive compared to economic effort in increasing vesting probability. Therefore, with increases in μ , the manager will engage in more manipulative effort and less economic effort. The decrease in economic effort imposes a negative impact on the principal's payoff. Moreover, the principal has to compensate the manager for the cost of manipulation. So the principal is worse if the performance measure can be manipulated.

4.5.2 Performance-vested Stock Options vs. Performance Cash Bonus

Prior analysis shows that performance-vested stock options dominate traditional stock options for incentive compensation purposes. Performance-vested stock options are similar to cash bonuses in that both forms of compensation depend on meeting predetermined performance targets. The difference is in the type of compensation received when targets are met. The magnitude/size of a cash bonus is known in advance while the value of the stock option is uncertain. Thus, performance-vested stock options impose more risk on the manager. But they also provide more incentives as the value of the option increases with managerial effort. In this section we compare performance-vested stock options to performance cash bonuses.

Suppose at $t=0$ the manager is provided with a compensation package consisting of two parts: a fixed salary and a cash bonus B , that is

$$\tilde{w}_{CB} = \begin{cases} f, & \text{if } \tilde{x}(a) < L \\ f + B, & \text{if } \tilde{x}(a) \geq L \end{cases}$$

The performance criterion applied to the cash bonus plan is the same as for performance-vested stock options. Thus, the likelihood of realizing the cash bonus is described by $P(\tilde{x}(a) \geq L) = 1 - e^{-\frac{a^2}{L}} = p(a)$.

At $t=0$, given a compensation package $\{f, B, L\}$, the manager's optimal effort maximizes his utility from exerting this effort. The optimization problem can be written as

$$a_{CB}^* \in \operatorname{argmax}_a f + (1 - e^{-\frac{a^2}{L}})B - \rho[(1 - e^{-\frac{a^2}{L}})e^{-\frac{a^2}{L}}B^2] - \psi(a) \quad (20)$$

The first-order condition of the manager's optimization problem in (17) implicitly defines the effort level a_{CB}^* by

$$\frac{B}{L} e^{-\frac{a_{CB}^{*2}}{L}} - \frac{\rho B^2}{L} \left[e^{-\frac{2a_{CB}^{*2}}{L}} - e^{-\frac{a_{CB}^{*2}}{L}} (1 - e^{-\frac{a_{CB}^{*2}}{L}}) \right] = a_{CB}^* \quad (21)$$

Proposition 6: When the manager is risk neutral (i.e. $\rho=0$) the principal can induce higher effort by offering performance-vested stock options than by offering a performance cash bonus.

The principal can choose to offer the manager performance-vested stock options with the expected value of the options equal to the cash bonus, i.e. $\beta m_k = B$. Performance-vested stock options outperform performance cash bonuses in motivating a risk-neutral manager. That is because managerial effort influences the value of the stock options but not the value of the cash bonus. When a cash bonus is provided, managerial effort only changes the success probability $p(a)$ of meeting the performance target and optimal effort a_{CB}^* is such that the marginal probability of meeting the performance target equals marginal cost, that is, $\frac{\partial p(a)}{\partial a} B = \frac{\partial \psi(a)}{\partial a}$. When performance-vested stock options are granted instead, the manager's marginal benefit consists of two parts, namely the marginal vesting probability, $\frac{\partial p(a)}{\partial a} \beta m_k$, and the marginal benefit from the option value, $p(a) \beta \frac{\partial m_k(a)}{\partial a}$. Since $\beta m_k = B$, the marginal benefit of performance-vested stock options exceeds the marginal benefit of cash bonus by

$$p(a) \beta \frac{\partial m_k(a)}{\partial a} = \frac{1}{2} \beta \left(1 - e^{-\frac{a}{L}} \right) > 0. \quad (22)$$

Hence, performance-vested stock options induce higher effort. Notice that the additional risk that performance-vested stock options impose on the manager does not affect his effort choice as the manager is risk neutral. When the manager becomes risk averse, however, performance-vested stock options result in an additional risk premium $p(a) \rho \beta^2 \sigma_k^2$. To compensate for the risk in the value of the stock options, the marginal cost of this risk premium equals

$$\rho \beta^2 \left[\frac{\partial p(a)}{\partial a} \sigma_k^2 + p(a) \frac{\partial \sigma_k^2}{\partial a} \right] = \rho \sigma \beta^2 \left[\frac{1}{\sqrt{2\pi}} \left(1 - e^{-\frac{a}{L}} \right) + \frac{\sigma e^{-\frac{a}{L}}}{L} \left(\frac{1}{2} - \frac{1}{2\pi} \right) \right] \quad (23)$$

Given the continuity of the first-order condition expression, we conjecture that performance-vested stock options induce higher managerial effort if the manager is not too risk averse and/or firm risk is not too high. When the value of $\rho\sigma$ is sufficiently low, the benefit of performance-vested stock options in (22) outweighs the cost in (23). When $\rho\sigma$ becomes sufficiently high, it is not clear which form of compensation is preferred. Although granting $\beta = \frac{B}{m_k}$ performance-vested stock option induces lower managerial effort than a cash bonus B , other grant sizes may induce higher managerial effort. This, however, remains an open question.

Recall that the principal's objective function equals $a^* - \psi(a^*) - \rho Var(\tilde{w})$. In case of a risk neutral manager, compensation risk is costless. Therefore, the principal's objective function reduces to $a^* - \psi(a^*)$. Since higher effort induced by performance-vested stock options enhances the principal's profit, the principal strictly prefers performance-vested stock options over performance cash bonuses when dealing with a risk neutral manager. When the manager becomes risk averse instead, imposing additional risk onto the manager will be priced and the principal's net profit decreases with the manager's degree of risk aversion and firm risk. But as long as the benefit from issuing options relative to cash bonuses outweighs the cost

$$\rho\beta^2\sigma^2 \left[\left(\frac{1}{2} - \frac{1}{2\pi} \right) \left(1 - e^{-\frac{1}{2}} \right) + \frac{1}{2\pi} \left[p(a_{PO}^*) - p(a_{CB}^*) - \left(p(a_{PO}^*)^2 - p(a_{CB}^*)^2 \right) \right] \right] ,$$

performance-vested stock options still outperform cash bonuses for maximizing the principal's interests. Again, this inequality is more likely to be satisfied when the manager's risk aversion ρ is relatively low and/or the firm's operating risk σ^2 is not too high.

4.6 DISCUSSION ON OPTIMAL TARGET DIFFICULTY

The high vesting probability of optimal target difficulty coheres with the consensus in Corporate Governance Codes on reforming equity compensation. For example, the UK Corporate

Governance Code (Combined Code, 2003), recommends that for optimum motivation all long-term incentive schemes, including executive stock option schemes, should be subject to "challenging performance criteria". Goal-setting literature interprets "challenging" targets as "tight, but achievable" ones, meaning that management will achieve these goals only if they exert a consistently high level of effort (Locke and Latham, 2002; Merchant and Manzoni, 1989). Implications from Proposition 2 demonstrate the "tight" attribute of optimal targets. As conjectured, it is in favor of the principal to grant stock options with target difficulty level higher than the level desired by the manager, i.e. $L^* > L^*$.

The issue of where to set the optimal target difficulty has been an object for debate in accounting and finance profession for decades (Merchant and Manzoni, 1989; Hansen et al., 2003; Jensen et al., 2004). Empirical evidence has documented an inverse U-shape relation between performance and target difficulty (Locke et al., 1981, 1988; Hirst and Lowy, 1990; Covalleski et al., 2003). A problem confronted with in empirical studies is where to set the optimal target difficulty and what the optimal achievability should look like to maximize a firm's economic performance. Residing on a setting of stock option compensation, our study presents a practical instrument to measure the optimal target difficulty, namely the vesting probability $p(a)$.

Assuming a risk neutral manager, one can show that managerial effort and the principal's net profits are optimized at L^* and $\beta^* = 1$. The choice of L^* depends solely on a firm's operation risk σ . In particular, when a firm is operating with a relatively low risk, the optimal contract is unique⁷¹. Figure 1 plots the vesting probability $p(a) = 1 - e^{-\frac{a^2}{L^*}}$ as a function of σ .

⁷¹For a risk neutral manager (i.e. $\rho = 0$) one can show that the effort maximizing target difficulty level L^* satisfies $L^* = \frac{2\sigma a_{PO}^*}{2\sigma + \sqrt{2\pi} a_{PO}^*}$. Substituting L^* , $\beta^* = 1$ and $\rho = 0$ in the first-order condition $a_{PO}^* = v(a_{PO}^*, L^*)$, uniquely defines a_{PO}^* as the solution of $a_{PO}^* = \frac{1}{2} + e^{-\left(1 + \frac{\sqrt{2\pi}}{2\sigma} a_{PO}^*\right)} \frac{\sigma}{\sqrt{2\pi} a_{PO}^*}$. Notice that a_{PO}^* is a function of σ . One can

Observe that the probability $p(a)$ decreases with firm risk σ , i.e. $\frac{\partial p(a)}{\partial \sigma} < 0$. This implies that an increase in firm risk, increases target difficulty L^* more than it increases effort a_{PO}^* . Remarkably, the vesting probabilities are at least 70%. Echoing the spirit of goal-setting literature, this scenario shows that option contracts with demanding but highly achievable targets, correspond to vesting probabilities of 70% or higher. Empirical evidence is consistent with this high vesting probability prediction. Conyon and Murphy (2000) find that 80% of the 510 largest UK firms achieved average EPS growth of 2% between 1992 to 1997 and 2% of EPS growth is the most common criterion for option vesting. Noticeably, high vesting probabilities do not necessarily mean that targets are too easy as is commonly believed. High vesting probabilities are also consistent with optimal targets.

Figure 1: The change of $P(a)$ with σ

Empirical evidence has documented highly achievable targets in budgeting. In a case study,

show that a_{PO}^* and L^* increase in σ . In particular, for $\sigma \geq \sigma^*$ where σ^* satisfies $\frac{\sqrt{2\pi}}{2\sigma^*} = e^{-\left(1+\frac{\sqrt{2\pi}}{2\sigma^*}\right)}$ (i.e. $\sigma^* \approx 4.50$), first best effort $a=1$ is implementable and the optimal contract is no longer unique. For $\sigma \geq \sigma^*$, any contract (β, L) that satisfies $\frac{1}{\beta} = \frac{1}{2} + e^{-\frac{1}{L}\left(\frac{\sigma}{\sqrt{2\pi}} - \frac{1}{2}\right)}$ is optimal as it implements first-best effort $a=1$. For $\sigma < \sigma^*$, the optimal contract is unique and is given by $\beta^* = 1$, $L = L^*$.

Merchant and Manzoni (1989) report target achievability rates exceeding 70%; Hirst and Lowy (1990) observe an above 80% success probability in meeting budget goals; more recently, Indjejikian and Matejka (2006) report that an average manager perceives a 68% achievability of a budgetary target. Results from our model are supportive of this trend. One can consider budget targets as being similar to the performance cash bonus contract as managers usually receive a reward for meeting the budget (i.e. achieving the performance budget). When a performance cash bonus is rewarded to a risk-neutral manager, a 62% success rate results at the optimal target difficulty level.⁷²

4.7 CONCLUSIONS

This paper assesses the incentive effects of performance-vested stock options, where the option vesting is contingent upon fulfilling a predetermined performance target. We derive an inverse U-shape relation between managerial effort and target difficulty. In other words, over-ambitious targets will not induce higher effort from the manager so that the principal will prefer traditional stock options instead. Switching to the principal's perspective, we find that performance-vested stock options outperform traditional stock options. In comparing performance-vested stock options to cash bonuses, we find that performance-vested stock options dominate. This superiority stands when the manager is not too risk averse and/or firm risk is not too high.

Our analysis is subject to some limitations. First, this paper examines the underlying rationale of attaching performance hurdles to stock option compensation and the focus is on

⁷²One can show that the principal's optimal target difficulty level satisfies $L^* = a_{CB}^*$ so that the success probability equals $p(a) = 1 - e^{-L^*} = 1 - e^{-1} \approx 62\%$. For a risk averse manager, one can show that the target difficulty level that maximizes managerial effort results in a success probability of at least 62%. In particular, this success probability is increasing with the manager's risk aversion.

comparing incentive properties between performance-vested stock options and their traditional counterparts. Designing an optimal compensation contract is not an issue here. Second, we assume that stock options are granted at the money. As discussed earlier, this is a suboptimal scenario. We justify this assumption as it is consistent with general business practice. Also, disclosing performance measures may provide valuable information to competitors, which may result in proprietary costs to the firm (Wagenhofer, 1990). The most frequently used performance measure is EPS, however. Since earnings is subject to mandatory disclosure, possible proprietary costs do not affect the principal's preference with respect to traditional and performance-vested stock options. Furthermore, in some cases the difference between performance-vested stock options and traditional stock options may sufficiently large to overcome possible proprietary costs. For the case of a risk neutral manager, for example, the highest implementable effort using traditional stock options equals $a_{TO}^* = \frac{1}{2}$ while performance-vested stock options may achieve first best effort $a_{PO}^* = 1$. Firms may grant performance-vested stock options rather than traditional stock options for reasons other than incentive effects. Examples of such reasons are accounting regulations (IFRS 2), institutional considerations (Gerakos et al., 2005), etc., which are not included into our model. Last, we focus on performance-vested stock options with accounting-based performance targets. Future research may investigate the incentive effects of options with market-based performance criterion.

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4.A PROOFS

Lemma A: Let $v(a, L)$ be defined as in (7). If there exists a_1 such that $\frac{\partial v(a, L)}{\partial a} = 0$ then

- (i) a_1 is unique and (ii) $\frac{\partial^2 v(a, L)}{\partial^2 a} = 0$ has a unique solution $a_2 > a_1$.

Proof of Lemma A:

We start with proving (i). Since

$$\frac{\partial v}{\partial a} = \frac{\beta}{L} e^{-\frac{t}{L}} \left[\frac{1}{2} - \frac{\sigma}{L} \left(\frac{1}{\sqrt{2\pi}} - \frac{\sigma\rho\beta}{2} + \frac{\sigma\rho\beta}{\pi} \right) \right] + \frac{2\beta}{L} \left(e^{-\frac{t}{L}} \right)^2 \sigma\rho\beta \left(\frac{\sigma}{L\pi} - \frac{1}{\sqrt{2\pi}} \right),$$

$\frac{\partial v}{\partial a} = 0$ implies

$$e^{-\frac{t}{L}} = \frac{\sigma \left[2\pi - \rho\beta\sigma\sqrt{2\pi}(\pi - 2) \right] - \pi\sqrt{2\pi}L}{4\rho\beta\sigma(\sigma\sqrt{2\pi} - L\pi)} =: c \quad (24)$$

Observe that the left-hand side is nonnegative and decreasing in a and the right-hand side is independent of a . Hence, if $c \leq 0$ there is no a solving (24) and if $c > 0$ there is a unique a solving (24).

To prove (ii), observe that the existence of a_1 implies $c > 0$. Then $\frac{\partial^2 v}{\partial^2 a} = 0$ yields

$$e^{-\frac{t}{L}} = \frac{1}{2} \frac{\sigma \left[2\pi - \rho\beta\sigma\sqrt{2\pi}(\pi - 2) \right] - \pi\sqrt{2\pi}L}{4\rho\beta\sigma(\sigma\sqrt{2\pi} - L\pi)} = \frac{1}{2} c \quad (25)$$

Let a_2 satisfies (25). Since $e^{-\frac{t}{L}}$ is decreasing in a , it follows that a_2 is unique.

Furthermore, $\frac{1}{2}c < c$ implies that $a_2 > a_1$. $\square$

Proof of Lemma 1:

First, observe that $\beta < \frac{2}{\rho\sigma\sqrt{2\pi}}$ implies $v(0, L) = \frac{\beta\sigma}{L\sqrt{2\pi}} - \frac{\rho\beta^2\sigma^2}{2L} > 0$. Since $\frac{\partial U(a)}{\partial a} = v(a, L) - a$, it holds that $\frac{\partial U(a)}{\partial a} > 0$ so that $a = 0$ cannot maximize the agent's utility. Hence, the optimal action a_{p0}^* satisfies $v(a_{p0}^*, L) = a_{p0}^*$.

Second, observe that if a^* is a local maximum, $\frac{\partial^2 U(a^*)}{\partial^2 a} < 0$ implies $\frac{\partial v(a^*, L)}{\partial a} < 1$.

Third, observe that Lemma A implies that the graph of $v(a, L)$ as a function of a is shaped like either one of the four cases depicted in Figure 2. To prove Lemma 1, we analyze these

four cases below.

Figure 2: Four cases of $v(a, L)$ as a function of a

Case I: There exists no a_1 such that $\frac{\partial v(a_1, L)}{\partial a} = 0$ and $\frac{\partial v(0, L)}{\partial a} > 0$. Using that $\lim_{a \rightarrow \infty} v(a, L) = \frac{1}{2} \beta - \frac{\rho \beta^2 \sigma}{\sqrt{2\pi}} = a_{TO}^*$ (cf. (8)), it follows that $v(a, L) < a_{TO}^*$ for all a . Hence, for any local maximum a^* it holds that $a^* = v(a^*, L) < a_{TO}^*$, which contradicts the assumption that $a^* > a_{TO}^*$.

Case II: There exists a_1 such that $\frac{\partial v(a_1, L)}{\partial a} = 0$ and $\frac{\partial v(0, L)}{\partial a} > 0$. If $a^* < a_1$, then $\frac{\partial v(a^*, L)}{\partial a} > 0$. Furthermore, Lemma A states that there exists precisely one $a_2 > a_1$, satisfying $\frac{\partial^2 v(a_2, L)}{\partial^2 a} = 0$. From $\frac{\partial v(a^*, L)}{\partial a} > 0$, $\frac{\partial v(a_1, L)}{\partial a} = 0$ and $a^* < a_1 < a_2$, it then follows that $\frac{\partial v(a, L)}{\partial a}$ is decreasing in a for all $a < a_2$. Thus, $v(a, L)$ is concave for all $a < a_2$. This implies that $v(a, L) \leq z(a)$ for all $a < a_2$ where $z(a) = v(a^*, L) + \frac{\partial v(a^*, L)}{\partial a}(a - a^*)$. Furthermore, since $v(a_1, L) \leq z(a_1)$, $v(a, L)$ is decreasing for all $a > a_1$ and $z(a)$ is increasing for all $a > a_1$, it follows that $v(a, L) \leq z(a)$ for all $a > a_1$. Hence $v(a, L) \leq z(a)$ for all a . Since $v(a^*, L) = a^*$ and $\frac{\partial v(a^*, L)}{\partial a} < 1$, it follows:

$$\text{for } a > a^* \text{ that } v(a, L) \leq z(a) = a^* + \frac{\partial v(a^*, L)}{\partial a}(a - a^*) < a^* + (a - a^*) = a.$$

Hence, there exists no $\alpha > a^*$ such that $v(\alpha, L) = \alpha$. Remains to be shown that there exists no other local maximum $\alpha < a^*$. Suppose such α does exist. Then by the same argument as above, we can show that there exists no $a > \alpha$ such that $v(a, L) = a$. Since $v(a^*, L) = a^*$ and $a^* > \alpha$, we have a contradiction. Hence, a^* is the global maximum.

If $a_1 < a^*$, we know that $v(a, L)$ is decreasing for $a > a^*$. Hence, $v(a, L) < v(a^*, L) = a^* < a$ so that no local maximum $a > a^*$ exists. Since $v(a, L)$ is decreasing for $a_1 < a < a^*$, it follows that $v(a, L) > v(a^*, L) = a^* > a$ so that no local maximum for $a_1 < a < a^*$ exists. Suppose a local maximum $\alpha < a_1$ exists. Then $\frac{\partial v(\alpha, L)}{\partial a} > 0$. We have shown above that if a local maximum α satisfies $\alpha < a_1$ and $\frac{\partial v(\alpha, L)}{\partial a} > 0$, then there exists no other local maximum $a > \alpha$. This contradicts that a^* is a local maximum. Hence, there exists no local maximum $\alpha < a_1$ so that a^* is the global maximum.

Case III: There exists no a_1 such that $\frac{\partial v(a_1, L)}{\partial a} = 0$ and $\frac{\partial v(0, L)}{\partial a} < 0$. Since $v(a, L)$ is a strictly decreasing function in a , a^* is uniquely defined, and thus the global maximum.

Case IV: There exists a_1 such that $\frac{\partial v(a_1, L)}{\partial a} = 0$ and $\frac{\partial v(0, L)}{\partial a} < 0$. If $a_1 > a^*$, it holds that $v(a, L) < a^*$ for all $a > a^*$. To see this recall that $v(a, L)$ is increasing for $a > a_1$ and that $\lim_{a \rightarrow \infty} v(a, L) = a_{TO}^*$. This implies that $v(a, L) < a_{TO}^*$ for all $a > a_1$. Since $v(a, L)$ is decreasing for $a^* < a \leq a_1$ and $v(a^*, L) = a^* > a_{TO}^*$ by assumption, it follows that $v(a, L) < a^*$ for all $a > a^*$. Hence, there exists no local maximum $a > a^*$. Since $v(a, L)$ is decreasing for $a < a^*$, we have that $v(a, L) > a^*$ for all $a < a^*$. Hence, there exists no local maximum $a < a^*$, so that a^* is the global maximum.

If $a_1 < a^*$, it follows from $\frac{\partial v(a^*, L)}{\partial a} > 0$ that $v(a, L)$ is increasing for all $a > a_1$. Since $\lim_{a \rightarrow \infty} v(a, L) = a_{TO}^*$, it holds that $v(a, L) < a_{TO}^*$ for all $a > a_1$. Hence, $a^* < a_{TO}^*$, which contradicts the assumption that $a^* > a_{TO}^*$. $\square$

Proof of Lemma 2:

If $v(a_{TO}^*, L) > a_{TO}^*$ we know from the continuity of $v(a, L)$ and $\lim_{a \rightarrow \infty} v(a, L) = a_{TO}^* < \infty$ that there exists $a > a_{TO}^*$ such that $v(a, L) = a$. Lemma 1 then implies that $a_{PO}^* = a^* > a_{TO}^*$. If $v(a_{TO}^*, L) < a_{TO}^*$, then $v(0, L) > 0$ implies that there exists $0 < a^* < a_{TO}^*$ that satisfies $v(a^*, L) = a^*$. Again, we distinguish the four cases in Figure 2 to show that there does not exist

$a > a_{TO}^*$ satisfying $v(a, L) = a$.

Case I: There exists no a_1 such that $\frac{\partial v(a_1, L)}{\partial a} = 0$ and $\frac{\partial v(0, L)}{\partial a} > 0$. Since $v(a, L)$ is increasing in a and $\lim_{a \rightarrow \infty} v(a, L) = a_{TO}^*$, it holds for $a > a_{TO}^*$ that $v(a, L) < a_{TO}^* < a$.

Case II: There exists a_1 such that $\frac{\partial v(a_1, L)}{\partial a} = 0$ and $\frac{\partial v(0, L)}{\partial a} > 0$. If $a_1 < a_{TO}^*$, then $v(a, L)$ is decreasing for $a > a_1$, so that $v(a, L) < v(a_{TO}^*, L) < a_{TO}^* < a$ for $a_{TO}^* < a$. If $a_1 > a_{TO}^*$, then $\frac{\partial v(a_{TO}^*, L)}{\partial a} > 0$.

We can show that $v(a, L) \leq z(a)$ for all a where $z(a) = v(a_{TO}^*, L) + \frac{\partial v(a_{TO}^*, L)}{\partial a}(a - a_{TO}^*)$. This follows from the fact that $v(a, L)$ is concave in a for $a < a_1$ and that $v(a_1, L) > v(a, L)$ for all a . Next, observe that $z(a_{TO}^*) = v(a_{TO}^*, L) < a_{TO}^*$ and that $v(0, L) > 0$ implies $z(0) > 0$. Again, concavity of $v(a, L)$ for $a < a_1$ yields $\frac{\partial v(a_{TO}^*, L)}{\partial a} \leq \frac{z(a_{TO}^*) - z(0)}{a_{TO}^*} < \frac{a_{TO}^* - 0}{a_{TO}^*} = 1$. Hence, for $a > a_{TO}^*$, it holds that $v(a, L) \leq z(a) < v(a_{TO}^*, L) + (a - a_{TO}^*) < a_{TO}^* + (a - a_{TO}^*) = a$.

Case III: There exists no a_1 such that $\frac{\partial v(a_1, L)}{\partial a} = 0$ and $\frac{\partial v(0, L)}{\partial a} < 0$. Then $v(a, L)$ is decreasing in a so that $v(a, L) < v(a_{TO}^*, L) < a_{TO}^* < a$ for all $a > a_{TO}^*$.

Case IV: There exists a_1 such that $\frac{\partial v(a_1, L)}{\partial a} = 0$ and $\frac{\partial v(0, L)}{\partial a} < 0$. If $a_1 < a_{TO}^*$, then $\frac{\partial v(a, L)}{\partial a} > 0$ for all $a > a_1$. Since $\lim_{a \rightarrow \infty} v(a, L) = a_{TO}^*$, it follows that $v(a, L) < a_{TO}^* < a$ for all $a > a_{TO}^*$. If $a_1 > a_{TO}^*$, then $\frac{\partial v(a_{TO}^*, L)}{\partial a} < 0$. Observe that $v(a, L)$ is decreasing for $a_{TO}^* < a \leq a_1$. Hence, $v(a, L) < v(a_{TO}^*, L) < a_{TO}^* < a$ for $a_{TO}^* < a \leq a_1$. In particular, $v(a_1, L) < v(a_{TO}^*, L) < a_{TO}^*$. Since $v(a, L)$ is increasing for $a > a_1$ and $\lim_{a \rightarrow \infty} v(a, L) = a_{TO}^*$, it follows that $v(a, L) < a_{TO}^*$ for $a > a_1$. Hence, $v(a, L) < a_{TO}^* < a$, for all $a > a_1$. $\square$

Lemma B: Let $\alpha_2 \alpha_3 - \alpha_1 \alpha_4 < 0$, where $\alpha_1 = -\frac{\sigma\beta}{\sqrt{2\pi}} - \frac{a\beta}{2} + \frac{\rho\beta^2\sigma^2}{2} - \frac{\rho\beta^2\sigma^2}{\pi}$, $\alpha_2 = \frac{\rho\beta^2\sigma^2}{2} - \frac{\rho\beta^2\sigma^2}{\pi} - \frac{\beta\sigma}{\sqrt{2\pi}}$, $\alpha_3 = \frac{\rho\beta^2\sigma^2}{\pi} + \frac{2\rho\beta^2\sigma a}{\sqrt{2\pi}}$ and $\alpha_4 = \frac{2\rho\beta^2\sigma^2}{\pi}$. The equation $e^{-x} = \frac{\alpha_2 x - \alpha_1}{\alpha_3 - \alpha_4 x}$ has at most 2 distinct solutions x_1 and x_2 . In particular, it holds that $x_1, x_2 > \frac{\alpha_1}{\alpha_4}$ or $x_1, x_2 < \frac{\alpha_1}{\alpha_4}$.

Proof of Lemma B:

Define $k(x) = \frac{\alpha_2 x - \alpha_1}{\alpha_3 - \alpha_4 x} - e^{-x}$. First, we show that there are at most 2 distinct solutions of $k(x) = 0$ on the interval $\left(\frac{\alpha_3}{\alpha_4}, \infty\right)$. Next, we show that there are at most 2 distinct solutions on the interval $\left(-\infty, \frac{\alpha_3}{\alpha_4}\right)$. We conclude by showing that $k(x) = 0$ cannot have solutions in both intervals simultaneously.

Consider the case that $x > \frac{\alpha_3}{\alpha_4}$. Observe that $\frac{\partial k(x)}{\partial x} = \frac{\alpha_2 \alpha_3 - \alpha_1 \alpha_4}{(\alpha_3 - \alpha_4 x)^2} + e^{-x}$. Then $\frac{\partial k(x)}{\partial x} = 0$ is equivalent to $x + \log(\alpha_1 \alpha_4 - \alpha_2 \alpha_3) = 2 \log(\alpha_4 x - \alpha_3)$. Since the left-hand side is linear in x and the right-hand side is concave and increasing in x , there are at most 2 distinct solutions $x_1 < x_2$ that solve $x + \log(\alpha_1 \alpha_4 - \alpha_2 \alpha_3) = 2 \log(\alpha_4 x - \alpha_3)$. Hence, $k(x)$ has at most 2 stationary points. Since $\lim_{x \downarrow \frac{\alpha_3}{\alpha_4}} \frac{\partial k(x)}{\partial x} < 0$, we can distinguish the following 7 cases:

(i) No stationary points. Since $\lim_{x \downarrow \frac{\alpha_3}{\alpha_4}} \frac{\partial k}{\partial x} < 0$, $k(x)$ is decreasing in x for all $x > \frac{\alpha_3}{\alpha_4}$.

From $x \rightarrow \infty \lim k(x) = -\frac{\alpha_2}{\alpha_4} > 0$ it follows that $k(x) = 0$ has no solution.

(ii) One stationary point $x_1 > \frac{\alpha_3}{\alpha_4}$. We further distinguish 2 cases:

(a) $\frac{\partial k(x)}{\partial x} < 0$ for all $x > \frac{\alpha_3}{\alpha_4}$. By the same argument as (i), $k(x) = 0$ has no solution.

(b) $\frac{\partial k(x)}{\partial x} < 0$ for $\frac{\alpha_3}{\alpha_4} < x < x_1$ and $\frac{\partial k(x)}{\partial x} > 0$ for $x > x_1$. So that $k(x_1)$ is the global minimum of $k(x)$. Observe that $\lim_{x \downarrow \frac{\alpha_3}{\alpha_4}} k(x) = +\infty$ and that $\lim_{x \rightarrow \infty} k(x) = -\frac{\alpha_2}{\alpha_4} > 0$. Hence, if $k(x_1) \geq 0$ there is at most one solution to $k(x) = 0$, namely, if $k(x_1) = 0$. If $k(x_1) < 0$, there is precisely one solution on the interval $\left(\frac{\alpha_3}{\alpha_4}, x_1\right)$ and there is precisely one solution on the interval (x_1, ∞) .

Summarizing, the equation $k(x) = 0$ has at most 2 solutions on the interval $\left(\frac{\alpha_3}{\alpha_4}, \infty\right)$.

(iii) Two stationary points $\frac{\alpha_3}{\alpha_4} < x_1 < x_2$. We distinguish 4 cases:

(a) $\frac{\partial k(x)}{\partial x} \leq 0$ for all $x > \frac{\alpha_3}{\alpha_4}$. Since $k(x)$ is decreasing in $x > \frac{\alpha_3}{\alpha_4}$ and $\lim_{x \rightarrow \infty} k(x) > 0$,

the equation $k(x) = 0$ has no solution on the interval $\left(\frac{\alpha_1}{\alpha_4}, \infty\right)$.

(b) $\frac{\partial k(x)}{\partial x} < 0$, for $x \in \left(\frac{\alpha_1}{\alpha_4}, x_1\right) \cup (x_2, \infty)$; $\frac{\partial k(x)}{\partial x} > 0$, for $x \in (x_1, x_2)$. Observe that $k(x) > 0$ for $x \geq x_2$ since $\lim_{x \rightarrow \infty} k(x) > 0$ and $\frac{\partial k(x)}{\partial x} \leq 0$ for $x \geq x_2$. If $k(x_1) > 0$ then $k(x) > 0$ for all $x > \frac{\alpha_1}{\alpha_4}$, so that $k(x) = 0$ has no solution. If $k(x_1) = 0$ then $k(x) > 0$ for all $x > \frac{\alpha_1}{\alpha_4}$ and $x \neq x_1$. Hence, x_1 is the only solution of $k(x) = 0$. If $k(x_1) < 0$ then $k(x) = 0$ has precisely one solution on the interval $\left(\frac{\alpha_1}{\alpha_4}, x_1\right)$ and precisely one solution on the interval (x_1, x_2) . Hence, $k(x) = 0$ has at most two distinct solutions on the interval $\left(\frac{\alpha_1}{\alpha_4}, \infty\right)$.

(c) $\frac{\partial k(x)}{\partial x} < 0$, for $x \in \left(\frac{\alpha_1}{\alpha_4}, x_2\right)$; $\frac{\partial k(x)}{\partial x} > 0$, for $x \in (x_2, \infty)$. Observe that $k(x_2)$ is the global minimum of k . Since $\lim_{x \downarrow \frac{\alpha_1}{\alpha_4}} k(x) = +\infty > 0$ and $\lim_{x \rightarrow \infty} k(x) > 0$, it follows that $k(x) = 0$ has no solution if $k(x_2) > 0$, one solution if $k(x_2) = 0$, and precisely two solutions if $k(x_2) < 0$, namely one on the interval $\left(\frac{\alpha_1}{\alpha_4}, x_2\right)$ and one on the interval (x_2, ∞) .

(d) $\frac{\partial k(x)}{\partial x} < 0$, for $x \in \left(\frac{\alpha_1}{\alpha_4}, x_1\right)$; $\frac{\partial k(x)}{\partial x} > 0$, for $x \in (x_1, \infty)$. Similar to (c).

Summarizing, on the interval $\left(\frac{\alpha_1}{\alpha_4}, \infty\right)$, the equation $k(x) = 0$ has at most 2 distinct solutions. In a similar way, one can show that $k(x) = 0$ has at most 2 distinct solutions on the interval $(-\infty, \frac{\alpha_3}{\alpha_4})$. However, if $k(x) = 0$ has a solution $x_1 < \frac{\alpha_1}{\alpha_4}$, then $k(x) = 0$ has no solution $x_2 > \frac{\alpha_1}{\alpha_4}$. To see this, observe that $\frac{\alpha_2 x - \alpha_1}{\alpha_3 - \alpha_4 x}$ is decreasing in x and that $\frac{\alpha_2 x - \alpha_1}{\alpha_3 - \alpha_4 x} < -\frac{\alpha_2}{\alpha_4}$ for $x < \frac{\alpha_1}{\alpha_4}$ and $\frac{\alpha_2 x - \alpha_1}{\alpha_3 - \alpha_4 x} > -\frac{\alpha_2}{\alpha_4}$ for $x > \frac{\alpha_1}{\alpha_4}$. Since e^{-x} is decreasing in x , we obtain the following contradiction for x_2 :

$$e^{-x_2} < e^{-x_1} = \frac{\alpha_2 x_1 - \alpha_1}{\alpha_3 - \alpha_4 x_1} < -\frac{\alpha_2}{\alpha_4} < \frac{\alpha_2 x_2 - \alpha_1}{\alpha_3 - \alpha_4 x_2} = e^{-x_2}.$$

Similarly, one can show that if $k(x) = 0$ has a solution $x_2 > \frac{\alpha_1}{\alpha_4}$ then there exists no $x_1 < \frac{\alpha_1}{\alpha_4}$ such that $k(x) = 0$ (i.e. $k(x) < 0$ for $x < \frac{\alpha_1}{\alpha_4}$). Consequently, $k(x) = 0$ has at most 2 distinct solutions x_1 and x_2 . In particular, it holds that $x_1, x_2 > \frac{\alpha_1}{\alpha_4}$ or $x_1, x_2 < \frac{\alpha_1}{\alpha_4}$. $\square$

Lemma C: Let $\beta < \frac{2}{\rho\sigma\sqrt{2\pi}}$. Then $v(a, L)$ is increasing in L for $L < L^*$ and $v(a, L)$

is maximal at $L = L^*$ where L^* satisfies

$$e^{-\frac{a}{L^*}} = \frac{\left(\rho\beta^2\sigma^2 a^* \frac{\pi-2}{2} - \frac{\beta\sigma a^*}{\sqrt{2\pi}}\right) - L^* \left(-\frac{\sigma\beta}{\sqrt{2\pi}} - \frac{a\beta}{2} + \rho\beta^2\sigma^2 \frac{\pi-2}{2\pi}\right)}{L^* \rho\beta^2\sigma \left(\frac{\sigma}{\pi} + \frac{2a^*}{\sqrt{2\pi}} - \frac{2\sigma a^*}{L^*\pi}\right)} \quad (26)$$

and

$$v(a^*, L^*) > 0. \quad (27)$$

Furthermore, if $v(a, L)$ is increasing in L for $L > L^*$, then $v(a, L) < 0$.

Proof of Lemma C:

Observe that

$$\begin{aligned} \frac{\partial v(a, L)}{\partial L} &= \frac{e^{-\frac{a}{L}}}{L^2} \left(-\frac{\sigma\beta}{\sqrt{2\pi}} - \frac{a\beta}{2} + \frac{\rho\beta^2\sigma^2}{2} - \frac{\rho\beta^2\sigma^2}{\pi} \right) \\ &\quad - \frac{e^{-\frac{a}{L}}}{L^3} \left(\frac{\rho\beta^2\sigma^2 a}{2} - \frac{\rho\beta^2\sigma^2 a}{\pi} - \frac{\beta\sigma a}{\sqrt{2\pi}} \right) + \frac{e^{-\frac{a}{L}}}{L^2} \left(\frac{\rho\beta^2\sigma^2}{\pi} + \frac{2\rho\beta^2\sigma a}{\sqrt{2\pi}} \right) \\ &\quad - \frac{e^{-\frac{a}{L}}}{L^3} \left(\frac{2\rho\beta^2\sigma^2 a}{\pi} \right) \end{aligned} \quad (28)$$

Substituting $x = \frac{a}{L}$, equation (28) can be rewritten as:

$$\frac{\partial v(a, L)}{\partial L} = \frac{1}{L^2} e^{-x} (\alpha_1 - \alpha_2 x + \alpha_3 e^{-x} - \alpha_4 x e^{-x})$$

where $\alpha_1 = -\frac{\sigma\beta}{\sqrt{2\pi}} - \frac{a\beta}{2} + \frac{\rho\beta^2\sigma^2}{2} - \frac{\rho\beta^2\sigma^2}{\pi}$, $\alpha_2 = \frac{\rho\beta^2\sigma^2}{2} - \frac{\rho\beta^2\sigma^2}{\pi} - \frac{\beta\sigma}{\sqrt{2\pi}}$,

$\alpha_3 = \frac{\rho\beta^2\sigma^2}{\pi} + \frac{2\rho\beta^2\sigma a}{\sqrt{2\pi}}$ and $\alpha_4 = \frac{2\rho\beta^2\sigma^2}{\pi}$. Note that $\alpha_3 > 0$ and $\alpha_4 > 0$. $\beta < \frac{2}{\rho\sigma\sqrt{2\pi}}$ implies

$\alpha_2 < 0$. Hence, $\frac{\partial v(a, L)}{\partial L} \geq 0$ if and only if

$$e^{-x} (\alpha_3 - \alpha_4 x) \geq \alpha_2 x - \alpha_1 \quad (29)$$

In particular, $\frac{\partial v(a, L)}{\partial L} = 0$ if and only if $e^{-x} = \frac{\alpha_2 x - \alpha_1}{\alpha_3 - \alpha_4 x}$.

Define $g(x) = e^{-x}$ and $h(x) = \frac{\alpha_2 x - \alpha_1}{\alpha_3 - \alpha_4 x}$. Observe that

$$\text{for } x > \frac{\alpha_3}{\alpha_4}; \quad \frac{\partial v(a, L)}{\partial L} \geq 0 \text{ if and only if } g(x) \leq h(x); \quad (30)$$

$$\text{for } x < \frac{\alpha_3}{\alpha_4} : \frac{\partial v(a, L)}{\partial L} \geq 0 \text{ if and only if } g(x) \geq h(x). \quad (31)$$

First, consider the case where $\alpha_2\alpha_3 - \alpha_1\alpha_4 \geq 0$. Then $g(x)$ is decreasing in x and $h(x)$ is increasing in x . Since $\lim_{x \downarrow \frac{\alpha_3}{\alpha_4}} h(x) = -\infty < 0 < g(\frac{\alpha_1}{\alpha_4})$ and $\lim_{x \rightarrow \infty} h(x) = -\frac{\alpha_2}{\alpha_4} > 0 = \lim_{x \rightarrow \infty} g(x)$; there exists precisely one $x_2 > \frac{\alpha_3}{\alpha_4}$ such that $g(x) = h(x)$ (i.e. $\frac{\partial v(a, L)}{\partial L} = 0$). Similarly, from $\lim_{x \uparrow \frac{\alpha_3}{\alpha_4}} h(x) = \infty > g(\frac{\alpha_1}{\alpha_4})$ and $\lim_{x \rightarrow -\infty} h(x) = -\frac{\alpha_2}{\alpha_4} < \infty = \lim_{x \rightarrow -\infty} g(x)$, there exists precisely one $x_1 < \frac{\alpha_3}{\alpha_4}$ such that $g(x) = h(x)$. Hence, statement (30) and (31) imply that $\frac{\partial v(a, L)}{\partial L} \geq 0$ for $x \leq x_1$ and $x \geq x_2$. Recall that $x = \frac{a}{L}$. If $x_1 \leq 0$, then $\frac{\partial v(a, L)}{\partial L} \geq 0$ for $L \leq \frac{a}{x_1} < 0$. Since $L \leq 0$ is not feasible, we have that $\frac{\partial v(a, L)}{\partial L} \geq 0$ for $L \leq \frac{a}{x_2}$. Hence, $v(a, L)$ is maximal at $L = \frac{a}{x_2}$. If $x_1 > 0$, then $\frac{\partial v(a, L)}{\partial L} \geq 0$ for $L \leq \frac{a}{x_2}$ and $L \geq \frac{a}{x_1}$. Since $\lim_{L \rightarrow \infty} v(a, L) = 0$, it follows that $v(a, L) \leq 0$ for $L \geq \frac{a}{x_1}$. From $v(a, 0) > 0$ it then follows that $v(a, L)$ is maximal for $L = \frac{a}{x_2}$.

Next, consider the case where $\alpha_2\alpha_3 - \alpha_1\alpha_4 < 0$. Then both $g(x)$ and $h(x)$ are decreasing in x . Lemma B states that $g(x) = h(x)$ has at most two distinct solutions. We can distinguish the following three cases:

(i) $g(x) = h(x)$ has no solution. Then for $x < \frac{\alpha_3}{\alpha_4}$ it holds that $g(x) > h(x)$ and for $x > \frac{\alpha_3}{\alpha_4}$ it holds that $g(x) < h(x)$. Hence, $\frac{\partial v}{\partial L} \geq 0$ for all $L \geq 0$. This, however, is not possible since $v(a, 0) > 0$ and $\lim_{L \rightarrow \infty} v(a, L) = 0$.

(ii) $g(x) = h(x)$ has precisely one solution x_1 . First, consider the case that $x_1 < \frac{\alpha_3}{\alpha_4}$. Then $g(x) \geq h(x)$ for all $x < \frac{\alpha_3}{\alpha_4}$ (and $g(x_1) = h(x_1)$). To see this, suppose there exists $\hat{x} < \frac{\alpha_3}{\alpha_4}$ such that $g(\hat{x}) < h(\hat{x})$. Since $\lim_{x \rightarrow -\infty} g(x) > \lim_{x \rightarrow -\infty} h(x)$ and $\lim_{x \uparrow \frac{\alpha_3}{\alpha_4}} g(x) > \lim_{x \uparrow \frac{\alpha_3}{\alpha_4}} h(x)$, the equation $g(x) = h(x)$ has a solution on the interval $(-\infty, \hat{x})$ and a solution on the interval $(\hat{x}, \frac{\alpha_3}{\alpha_4})$. This contradicts that $g(x) = h(x)$ has precisely one solution. Hence, $\frac{\partial v(a, L)}{\partial a} \geq 0$ for $\frac{a}{L} < \frac{\alpha_3}{\alpha_4}$. Since $g(x) = h(x)$ does not have a solution on the interval $(\frac{\alpha_3}{\alpha_4}, \infty)$, $\lim_{x \rightarrow \infty} g(x) < \lim_{x \rightarrow \infty} h(x)$ implies that

$g(x) \leq h(x)$ for all $x > \frac{\alpha_1}{\alpha_4}$, or equivalently, $\frac{\partial v(a, L)}{\partial a} \geq 0$ for all $\frac{a}{L} > \frac{\alpha_1}{\alpha_4}$. Like we showed in case

(i), $\frac{\partial v(a, L)}{\partial a} \geq 0$ for all $L \geq 0$ is not possible.

The case that $x_1 > \frac{\alpha_1}{\alpha_4}$ yields a similar result.

(iii) $g(x) = h(x)$ has two solutions. We distinguish two cases:

First, suppose $x_2 > x_1 > \frac{\alpha_1}{\alpha_4}$. Observe that $g(x) \geq h(x)$ for $x \in (-\infty, \frac{\alpha_1}{\alpha_4}) \cup [x_1, x_2]$ and that $g(x) < h(x)$ for $x \in (\frac{\alpha_1}{\alpha_4}, x_1) \cup (x_2, \infty)$. Using (30) and (31), we obtain that $\frac{\partial v(a, L)}{\partial L} \geq 0$ for $x \in (-\infty, x_1] \cup [x_2, \infty)$ and $\frac{\partial v(a, L)}{\partial L} < 0$ for $x \in (x_1, x_2)$. Recall that $x = \frac{a}{L}$ and $L \geq 0$, so that $\frac{\partial v(a, L)}{\partial L} \geq 0$ for $L \in [0, \frac{a}{x_2}] \cup [\frac{a}{x_1}, \infty)$ and $\frac{\partial v(a, L)}{\partial L} < 0$ for $L \in (\frac{a}{x_2}, \frac{a}{x_1})$. Furthermore, $\lim_{L \rightarrow \infty} v(a, L) = 0$ and $v(a, 0) > 0$ imply that $L_2 = \frac{a}{x_2}$ is the global maximum of $v(a, L)$. Since $\frac{\partial v(a, L)}{\partial L} \geq 0$ for $L > L_1 = \frac{a}{x_1}$ and $\lim_{L \rightarrow \infty} v(a, L) = 0$, L_1 is the global minimum and $v(a, L) \leq 0$ for all $L > L_1$.

Second, suppose $x_1 < x_2 < \frac{\alpha_1}{\alpha_4}$. Then $g(x) \geq h(x)$ for $x \in (-\infty, x_1] \cup [x_2, \frac{\alpha_1}{\alpha_4})$ and $g(x) < h(x)$ for $x \in (x_1, x_2) \cup (\frac{\alpha_1}{\alpha_4}, \infty)$. It follows from (30) and (31) that $\frac{\partial v(a, L)}{\partial L} \geq 0$ for $x \in (-\infty, x_1] \cup [x_2, \infty)$ and $\frac{\partial v(a, L)}{\partial L} < 0$ for $x \in (x_1, x_2)$. Since $x = \frac{a}{L}$ and $L \geq 0$, we need to distinguish between $x_2 < 0$, $x_1 < 0 < x_2$ and $x_1 > 0$ to derive the sign of $\frac{\partial v(a, L)}{\partial L}$.

If $x_2 < 0$, then $\frac{\partial v(a, L)}{\partial L} \geq 0$ for all $L \geq 0$. By the same argument as above, this is not possible. If $x_1 < 0 < x_2 < \frac{\alpha_1}{\alpha_4}$, then $\frac{\partial v(a, L)}{\partial L} \geq 0$ for $L \in [0, \frac{a}{x_2}]$ and $\frac{\partial v(a, L)}{\partial L} < 0$ for $L \in (\frac{a}{x_2}, \infty)$. Hence, $L = \frac{a}{x_2}$ is the global maximum of $v(a, L)$. Finally, if $x_1 > 0$, then $\frac{\partial v(a, L)}{\partial L} \geq 0$ for $L \in [0, \frac{a}{x_2}] \cup [\frac{a}{x_1}, \infty)$ and $\frac{\partial v(a, L)}{\partial L} < 0$ for $L \in (\frac{a}{x_2}, \frac{a}{x_1})$. From $\lim_{L \rightarrow \infty} v(a, L) = 0$ and $v(a, 0) > 0$, we derive that $L_2 = \frac{a}{x_2}$ is the global maximum of $v(a, L)$. Since $\frac{\partial v(a, L)}{\partial L} \geq 0$ for $L > L_1 = \frac{a}{x_1}$ and $\lim_{L \rightarrow \infty} v(a, L) = 0$, L_1 is the global minimum and $v(a, L) \leq 0$ for all $L > L_1$.

Summarizing, $v(a, L^*)$ is maximal at $L_2 = \frac{a}{x_2}$, where x_2 is the largest solution to $g(x) = h(x)$, that is $\frac{a}{L}$ satisfies (9). Notice that x_1 is also a solution to $g(x) = h(x)$. If $x_1 > 0$, then $L_1 = \frac{a}{x_1}$ is a minimum of $v(a, L)$. Since $\lim_{L \rightarrow \infty} v(a, L) = 0$, it holds that $v(a, \frac{a}{x_1}) < 0$. Hence, condition (10) ensures that the solution of $\frac{\partial v}{\partial L} = 0$ (cf. (9)) is the global maximum. $\square$

Proof of Proposition 1:

From Lemma 2 we know that $a^* > a_{TO}^*$ if and only if $v(a_{TO}^*, L) > a_{TO}^*$. We have shown above that $\frac{\partial v(a_{TO}^*, L)}{\partial L} > 0$ on the interval $(0, L^*)$. Furthermore, if $\frac{\partial v(a_{TO}^*, L)}{\partial L} > 0$ for some $L > L^*$, then $v(a_{TO}^*, L) < 0 < a_{TO}^*$. Hence, there is a unique $L^0 > 0$ satisfying $v(a_{TO}^*, L^0) = a_{TO}^*$.

Next, we prove that $L^0 < \frac{2\sigma}{\sqrt{2\pi}}$. Take $L = \frac{2\sigma}{\sqrt{2\pi}}$ and denote $x = \frac{a_{TO}^*}{L}$. Then

$$v(a_{TO}^*, L) = \frac{1}{2}\beta - \rho\beta^2 \left[\frac{\sigma}{\sqrt{2\pi}}(1 - e^{-x}) + \frac{\sqrt{2\pi}\sigma}{2} e^{-x} \right] < \frac{1}{2}\beta - \rho\beta^2 \frac{\sigma}{\sqrt{2\pi}} = a_{TO}^*.$$

Since $v(a_{TO}^*, 0) = a_{TO}^*$, it follows from Lemma C that $v(a_{TO}^*, \hat{L}) > a_{TO}^*$ for some $0 < \hat{L} < L^0$.

The continuity of v then implies that $L^0 \in \left(\hat{L}, \frac{2\sigma}{\sqrt{2\pi}} \right)$.

Finally, we show that L^* induces the highest effort level. For given $L \leq L^0$, let $a^*(L) \geq a_{TO}^*$ be such that $v(a^*(L), L) = a^*(L)$. If $L < L^*$, then for $L + \Delta L < L^*$ it follows from Lemma C that $v(a^*(L), L + \Delta L) > v(a^*(L), L)$. Since $\lim_{a \rightarrow \infty} v(a, L + \Delta L) < \infty$ there exists $a > a^*(L)$ satisfying $v(a, L + \Delta L) = a$. Lemma 2 then implies that $a^*(L + \Delta L) = a > a^*(L)$. If $L > L^*$, then it follows from Lemma C that there exists $L - \Delta L > L^*$ such that $v(a^*(L), L - \Delta L) > v(a^*(L), L)$. By the same argument as above, it holds that $a^*(L - \Delta L) > a^*(L)$. Hence, $a^*(L)$ is maximal for $L = L^*$. $\square$

Proof of Proposition 2:

$$\text{Define } H(a, L) = \frac{\frac{\partial \sigma(a)}{\partial a}(1 - e^{-\frac{a}{L}})}{\sqrt{2\pi}} \left[1 - \rho\beta^2 \frac{2\sigma(a)}{\sqrt{2\pi}} \left(\pi - 1 + e^{-\frac{a}{L}} \right) \right].$$

So that $\hat{v}(a, L) = v(a, L) + H(a, L)$. Since traditional stock options coincide with $L = 0$, it suffices to show that $\tilde{v}(a, L) > \tilde{v}(a, 0)$ for sufficiently small $L > 0$. For in that case we have that $\tilde{v}(a_{TO}^*, L) > \tilde{v}(a_{TO}^*, 0) = a_{TO}^*$ and $\lim_{a \uparrow \infty} \tilde{v}(a, L) < \infty$.⁷³ Hence, there exist $a_{PO}^* > a_{TO}^*$ satisfying $\tilde{v}(a_{PO}^*, L) = a_{PO}^*$.

⁷³For this to hold, we need to assume that either $\lim_{a \uparrow \infty} 1 - \rho\beta \frac{2\sigma(a)}{\sqrt{2\pi}} < 0$ or $\lim_{a \uparrow \infty} \frac{\partial \sigma}{\partial a} < \infty$. This imposes only minor restrictions on the function $\sigma(a)$.

Observe that $\frac{\partial \tilde{v}(a, L)}{\partial L} = \frac{\partial v(a, L)}{\partial L} + \frac{\partial H(a, L)}{\partial L} = \frac{\partial v(a, L)}{\partial L} \left(1 + \frac{\frac{\partial H(a, L)}{\partial L}}{\frac{\partial v(a, L)}{\partial L}} \right)$. Since $\frac{\partial v(a, L)}{\partial L} > 0$, we have that

$\frac{\partial \tilde{v}(a, L)}{\partial L} > 0$ for sufficiently small $L > 0$ if and only if $\frac{\frac{\partial H(a, L)}{\partial L}}{\frac{\partial v(a, L)}{\partial L}} > -1$ for sufficiently small $L > 0$.

Using that

$$\frac{\partial H(a, L)}{\partial L} = -\frac{a}{L^2} e^{-\frac{a}{L}} \frac{\frac{\partial \sigma(a)}{\partial a}}{\sqrt{2\pi}} \left[1 - \rho \beta^2 \frac{\sigma(a)}{\sqrt{2\pi}} \left(\pi - 2 + 2e^{-\frac{a}{L}} \right) \right]$$

and

$$\frac{\partial v(a, L)}{\partial L} = \frac{1}{L^2} e^{-\frac{a}{L}} \left(\alpha_1 - \alpha_2 \frac{a}{L} + \alpha_3 e^{-\frac{a}{L}} - \alpha_4 \frac{a}{L} e^{-\frac{a}{L}} \right).$$

We obtain that $\lim_{L \downarrow 0} \frac{\frac{\partial H(a, L)}{\partial L}}{\frac{\partial v(a, L)}{\partial L}} = 0 > -1$. $\square$

Proof of Lemma 3:

For traditional stock options, the principal's objective equals $a_{TO}^* - \frac{1}{2} a_{TO}^{*2} - \rho \beta^2 \sigma^2 \frac{\pi-1}{2\pi}$.

Hence, the optimal grant size β_{TO}^* satisfies $\frac{\partial a_{TO}^*}{\partial \beta} - a_{TO}^* \frac{\partial a_{TO}^*}{\partial \beta} - 2\rho \beta_{TO}^* \sigma^2 \frac{\pi-1}{2\pi} = 0$. Since

$\frac{\partial a_{TO}^*}{\partial \beta} - a_{TO}^* \frac{\partial a_{TO}^*}{\partial \beta} < 0$ for $\beta > \frac{\sqrt{2\pi}}{4\rho\sigma}$, it follows that $\beta_{TO}^* \leq \frac{\sqrt{2\pi}}{4\rho\sigma}$. $\square$

Proof of Proposition 3:

Let $V(L) = a_{pO}^*(L) - \psi(a_{pO}^*(L)) - \rho \beta^2 \text{Var}(\tilde{w})$. It suffices to show that $v(L^0) > v(0)$. First,

we show that $\frac{\partial \text{Var}(\tilde{w})}{\partial L} < 0$ for $L \geq 0$. This follows from

$$\begin{aligned} \text{Var}(\tilde{w}) &= p(a)E(\beta \max(\tilde{c} - k, 0)) - p(a)^2 E(\beta \max(\tilde{c} - k, 0))^2 \\ &= p(a)\beta^2 \sigma_k^2 + p(a)(1-p(a))\beta^2 m_k(a)^2. \end{aligned}$$

Hence

$$\frac{\partial \text{Var}(\tilde{w})}{\partial L} = \frac{\partial p(a)}{\partial L} \beta^2 \left[\sigma_k^2 + (1-2p(a))m_k(a)^2 \right] = -\frac{1}{L^2} e^{-\frac{a}{L}} \beta^2 \sigma^2 \left(\frac{1}{2} - \frac{2p(a)}{2\pi} \right) < 0$$

Next, recall that L^0 is such that $v(a_{TO}^*, L^0) = a_{TO}^*$. Then $\frac{\partial \text{Var}(\tilde{w})}{\partial L} < 0$ implies

$$\begin{aligned} V(L^0) &= a_{TO}^* - \psi(a_{TO}^*) - \rho \beta^2 \text{Var}(\tilde{w}(L^0)) \\ &= V(0) + \rho \beta^2 \left[\text{Var}(\tilde{w}(0)) - \text{Var}(\tilde{w}(L^0)) \right] > V(0). \end{aligned}$$

$\square$

Proof of Proposition 4:

Given the Lagrangian multipliers $\lambda_a, \lambda_m \geq 0$, the first-order conditions concerning a and m yield:

$$\frac{1}{2}\beta - e^{-\frac{a_{PO}^* + \mu m^*}{L}} \beta \left(\frac{1}{2} - \frac{\sigma}{L\sqrt{2\pi}} \right) - a_{PO}^* + \lambda_a = 0 \quad (32)$$

$$\mu\beta e^{-\frac{a_{PO}^* + \mu m^*}{L}} \frac{\sigma}{L\sqrt{2\pi}} - m^* + \lambda_m = 0 \quad (33)$$

$$\lambda_m m^* = 0 \quad (34)$$

$$\lambda_a a_{PO}^* = 0 \quad (35)$$

We can distinguish four cases according to the values of the multipliers λ_a and λ_m :

(i) $\lambda_a = 0, \lambda_m = 0$. It follows that $a_{PO}^* > 0$ and $m^* > 0$. Then expression (32) implies that $\beta e^{-\frac{a_{PO}^* + \mu m^*}{L}} = \frac{L\sqrt{2\pi}m^*}{\mu\sigma}$. Substituting this condition into expression (33) yields $m^* = \frac{\mu\sigma(\beta - 2a_{PO}^*)}{L\sqrt{2\pi} - 2\sigma} > 0$. Hence, $a_{PO}^* > \frac{1}{2}\beta = a_{TO}^*$ if and only if $L < \frac{2\sigma}{\sqrt{2\pi}}$.

(ii) $\lambda_a = 0, \lambda_m > 0$. It follows from expression (34) that $m^* = 0$. Then expression (33) implies $\lambda_m = -\mu\beta e^{-\frac{a_{PO}^*}{L}} \frac{\sigma}{L\sqrt{2\pi}} < 0$, which contradicts the assumption of $\lambda_m > 0$.

(iii) $\lambda_a > 0, \lambda_m = 0$. It follows from expression (36) that $a_{PO}^* = 0$. Expression (32) then yields:

$$\lambda_a = \beta e^{-\frac{\mu m^*}{L}} \left(\frac{1}{2} - \frac{\sigma}{L\sqrt{2\pi}} \right) - \frac{1}{2}\beta$$

If $\frac{1}{2} - \frac{\sigma}{L\sqrt{2\pi}} < 0$, then $\lambda_a < 0$, which contradicts the assumption that $\lambda_a > 0$. If $\frac{1}{2} - \frac{\sigma}{L\sqrt{2\pi}} \geq 0$, then $e^{-\frac{\mu m^*}{L}} \leq 1$ yields $\lambda_a \leq \beta \left(\frac{1}{2} - \frac{\sigma}{L\sqrt{2\pi}} \right) - \frac{1}{2}\beta = -\frac{\sigma\beta}{L\sqrt{2\pi}} < 0$, which contradicts the assumption $\lambda_a > 0$.

(iv) $\lambda_a > 0, \lambda_m > 0$. It follows that $m^* = 0$ and $a_{PO}^* = 0$, yielding the contradictions $\lambda_a = -\frac{\beta\sigma}{L\sqrt{2\pi}} < 0$ and $\lambda_m = -\frac{\mu\beta\sigma}{L\sqrt{2\pi}} < 0$.

In sum, the optimal solution is characterized by case (i), which implies that

$$a_{PO}^* > \frac{1}{2}\beta = a_{TO}^* \text{ if and only if } L < \frac{2\sigma}{\sqrt{2\pi}} \text{ and } m^* = \frac{\mu\sigma(\beta - 2a_{PO}^*)}{L\sqrt{2\pi} - 2\sigma}.$$

Define

$$f(a, \mu) = \frac{1}{2}\beta - \frac{1}{2}\beta e^{-(a+\mu m^*)} \left(1 - \frac{2\sigma}{\sqrt{2\pi}}\right),$$

so that $a_{PO}^*(\mu)$ satisfies $f(a_{PO}^*(\mu), \mu) = a_{PO}^*(\mu)$. Substituting $m^* = \frac{\mu\sigma(2a_{PO}^*(\mu)-\beta)}{2\sigma-L\sqrt{2\pi}}$ yields

$$f(a, \mu) = \frac{1}{2}\beta - \frac{1}{2}\beta e^{-(a+\mu^2 \frac{\sigma(2a-\beta)}{2\sigma-L\sqrt{2\pi}})} \left(1 - \frac{2\sigma}{\sqrt{2\pi}}\right)$$

Let $\mu_1 < \mu_2$. Since $\frac{\partial f(a, \mu)}{\partial \mu} < 0$ for all $a > 0$, it holds that

$$a_{PO}^*(\mu_2) = f(a_{PO}^*(\mu_2), \mu_2) < f(a_{PO}^*(\mu_2), \mu_1).$$

From $\lim_{a \rightarrow \infty} f(a, \mu) < \infty$ it follows that there exists $a > a_{PO}^*(\mu_2)$ such that $f(a, \mu_1) = a$.

Hence, $a_{PO}^*(\mu_1) > a_{PO}^*(\mu_2)$.

In particular, since $m^* < \infty$, it follows from $m^* = \frac{\mu\sigma(2a_{PO}^*(\mu)-\beta)}{2\sigma-L\sqrt{2\pi}}$ that $\lim_{\mu \rightarrow \infty} 2a_{PO}^*(\mu) - \beta = 0$,

or equivalently, $\lim_{\mu \rightarrow \infty} a_{PO}^*(\mu) = \frac{1}{2}\beta = a_{TO}^*$. $\square$

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The vesting of traditional stock options (TSOs) only depends on the passage of time and managerial compensation might merely reflect price increases in a rising market. As a reform on traditional stock option plans, performance targets have been introduced as a condition for option vesting. The use of performance-vested stock options (PVSOs) has been advocated as in line with "best corporate governance practice" and have been implemented rapidly, especially in high-profile companies. Little is known, however, about their implications on managerial behavior.

This dissertation investigates the effects of PVSOs in motivating managers to promote shareholder value. Undesired consequences associated with PVSOs are also examined. Chapter 2 studies the effectiveness of PVSOs in aligning interests between managers and shareholders. Chapter 3 explores managers' propensity to engage in earnings management when PVSOs are used in compensation. In an agency setting, Chapter 4 compares the incentive effects of PVSOs with TSOs in inducing managerial effort. Chapters 2 and 3 illustrate two sides of one coin: option vesting targets incentivize managers to work in the shareholders' best interest but at the same time, these targets also provide managers with incentive to manage earnings. Incorporating the effects of earnings management into the analysis, Chapter 4 shows positive net effects of PVSOs in motivating managers. More specifically, with appropriately defined performance targets, PVSOs will still induce higher economic effort from managers than TSOs.

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