Firm Organizational Environment and The Effect of Options Based Compensation Incentives on Accrual Earnings Management

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Abstract

This paper explores the effect of firm organizational environment on the relationship between the option based incentives of CEO compensation and accrual earnings management. Results show that this relationship varies according to the firm's organizational environment with respect to growth prospects, capital structure, and riskiness. Only delta and the change in delta are significant for high growth and high leverage firms. For low growth and low leverage firms only vega is significant. For low volatility firms delta, change in delta and vega are all significant while none are significant for high volatility firms. Our results have important implications for managers, policy makers, and compensation boards.

Keywords: Earnings management, accruals, CEO compensation, utility function, delta, change in delta, vega.
JEL Classification : F30; F32, G32, G33.

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1 – Introduction

A growing literature examines the effect of equity based compensation incentives, such as delta and vega,[3]on financial misreporting via accrual earnings management. We extend the literature by showing that the effect of these incentives on accrual earnings management is influenced in significant ways by the firm's organizational environment with respect to growth opportunities, capital structure and risk profile.

Accrual earnings management is a well-documented fact of corporate behaviour (e.g. Healey and Wahlen, 1999 and Cohen, Dey, and Lys, 2004).[4] While accrual earnings management can be a useful signalling tool to improve information disclosure about the firm, to improve the ability of earnings to reflect economic value, to dress up financial statements prior to public securities offerings, to avoid violating lending contracts, to reduce regulatory costs or increase regulatory benefits, it can also be a tool to increase corporate managers' compensation and job security at the expense of shareholders (see, e.g. Bergstresser and Philippon, 2006).

Given the multiple potentially conflicting motives for accruals management, the extant empirical literature is unsurprisingly mixed and suggests that the nature of the relationship between option based incentives (delta and vega) and accruals management depends crucially on how accruals management affects the firm's stock price and stock price volatility.[5] For example, Bergstrasser and Philippon (2006) and Cornett, Marcus and Tehranian (2008) argue that accruals management increases the firm's share price and find a positive relation between CEO delta and accrual earnings management while Jiang, Petroni and Wang (2010) find no relation for the

[3]Delta corresponds to the change in managerial wealth with respect to a change in the value of the firm's stock, while vega corresponds to the change in managerial wealth with respect to the change in the volatility of the firm's returns.

[4] See Defond and Jiambalvo (1994), Rees et al. (1996), Teoh et al. (1998a), and Teoh et al. (1998b) for the use of discretionary accruals in tests of earnings management and market efficiency.

[5]The extant studies on the relationship between CEO option based incentives and financial misreporting in general have also been inconclusive. For example, Burns and Kedia (2006) find a positive relation between delta and restatements. Erickson, Hanlon, and Maydew (2006)find no relation between delta and accounting fraud or misrepresentation while Feng, Ge, Luo and Shevlin(2011) a positive relation for the CFO and no relation for the CEO. Armstrong, Jagolinzer and Larcker (2010) find no evidence of a relation between delta and litigation, restatements and accounting fraud or misrepresentation.

CEO and a positive relation for the CFO. In this context, the argument is that a higher delta motivates a corporate manager to increase accruals management in order to benefit from the increase in his equity portfolio as the share price rises (the reward effect), but at the cost of increased exposure to the firm's total risk (the risk effect).[6] Their results are joint evidence that over the sample they study accruals management had the effect of increasing the share price and that the reward effect was stronger than the risk effect.

Chava and Purnanandam (2010) assume that accruals management increases the stock price and decreases stock price volatility. They find a positive relation for delta and a negative relation for vega. The positive relation for delta is evidence that over the sample they study accruals management had the effect of increasing the share price and that the reward effect was stronger than the risk effect. The negative relationship between vega and accruals management is joint evidence that accruals management reduced share price volatility and that corporate managers reduce accrual management in order to avoid the loss to their equity portfolios that would be caused by a reduction in the share price volatility.

Armstrong et al. (2013) argue that accruals management increases both the share price and share price volatility. They find a positive relation for delta and a positive relation for vega. The positive relation for delta is evidence that over the sample they study accruals management had the effect of increasing the share price and that the reward effect was stronger than the risk effect.[7] The negative relationship between vega and accruals management is joint evidence that accruals management increased share price volatility over the sample they study and that corporate managers increase accrual management in order to benefit from the increase in their equity portfolios due to the increased volatility.

There is, however, no definitive theoretical or empirical evidence that accruals management systematically increases the firm's share price. For example, Sloan (1996) and Kothari et al. (2011) find that accruals management actually reduces the firm's share price.[8] In this situation, the

[6] Unlike a well diversified outside shareholder, managers typically hold disproportionately higher fraction of their wealth in the firm. In addition, managers' human capital is closely tied with the firm's performance (see Fama, 1980; Stulz, 1984; Smith and Stulz, 1985). Given these considerations, managers with higher delta are likely to prefer low risk financial policies to minimize the firm's total risk.

[7] When vega and delta appear together in the testing, this effect is subsumed by vega.

[8] There is substantial evidence in the literature that earnings management can reduce firm performance. For example, Huanga, et al. (2009) show that earnings management is inversely

relationship between accruals management and is reversed. A higher delta will discourage accrual management because the value of a manager's equity portfolio decreases as the stock price decreases. On the other hand, it will encourage accrual management because delta amplifies the effect of equity risk on the total riskiness of a manager's equity portfolio.

Ultimately, the relationship between accruals management and option based compensation incentives is an empirical question that depends crucially on the effect that managing the accruals has on the share price. The effect on firm share price could vary from one sample to another depending on the prevailing economic and financial environment. It could also vary from one firm to another within the same sample depending on the firm's organizational environment.[9] For example, the growth opportunity set is a key element in the organizational environment. Firms with greater growth opportunities are subject to greater levels of informational asymmetry and agency costs (Smith and Watts, 1992 and Belghitar and Clark, 2011). Accruals management for high growth firms could be used as a signalling tool to overcome the informational asymmetry. However, firms with higher growth opportunities are also subject to higher bankruptcy costs (Harris and Raviv, 1990; Shleifer and Vishny, 1992). Shin and Stulz (2000) argue that since firm risk and growth opportunities may be positively linked, undiversified managers in high growth firms may have greater incentive to be risk averse than those in low growth firms. Thus, high growth and low growth firms differ in the motivation for accruals management and how it affects firm share priceas well as the degree of managerial risk aversion.

Another key element in the firm's organizational environment that can affect the effectiveness of managerial compensation incentives is the firm's capital structure. Under the bondholder wealth expropriation hypothesis developed by Black and Scholes (1973), *unanticipated* increases in the riskiness of the firm's assets transfer wealth from bondholders to shareholders. Based on this, and other things being equal, shareholders have an incentive to increase the riskiness of the firm's assets and bondholders have an incentive to reduce it.Within certain boundaries (see, for example, Jensen and Meckling, 1976) shareholders also have an incentive to increase leverage, which also increases the riskiness of equity (as opposed to the

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related to firm value. In a similar vein, Aboody et al. (2005) and Francis et al.(2005) show that accrual earning management leads to higher costs of capital. DeFond and Park (1997) show that firms use accrual management to understate the volatility of earnings.

[9]Hutchinson and Gul (2004) have shown that this is the case with other corporate governance mechanisms.

riskiness of the firm's total assets). To protect themselves against these sources of "wealth expropriation" bondholders often impose covenants that restrict corporate borrowing and risk-taking. Thus, different levels of leverage create different risk dynamics for managerial compensation incentives. For example, because of restrictive covenants at higher levels of leverage,vegamight be a less effective incentive than delta to affect accruals management.

Finally, the level of firm volatility could also affect the impact of managerial compensation incentives on earnings management. The argument here is that the incentive to increase risk can hold only if the level of risk aversion is compatible with risk higher than the ongoing level of risk. If it is higher, the tendency will be to reduce volatility. Thus, if firm volatility is high enough, it is conceivablethat no incentive scheme would lower the level of risk aversion enough to make the manager increase the volatility. Conversely, if firm volatility is low enough,option based incentives would have more scope for increasing volatility.

Another innovation of this paper is that we build our research design around the concepts of convexity, magnification and translation[10] in Ross (2004) operationalized by Belghitar and Clark (2014) with respect to the Black/Scholes option pricer. Belghitar and Clark (2014) show that the relationship between option based compensation incentives and risk aversion depends on whether the managerial utility function shows decreasing, increasing or constant absolute risk aversion (DARA, IARA, CARA respectively).[11] More specifically, they identify two parameters, delta and the change in delta, that appear directly in the Arrow-Pratt measure of CEO risk aversion.[12] The change in delta corresponds to the "risk effect" in Armstrong et al. (2013). It increases CEO risk aversion through its effect on convexity and magnification. The effect of delta itself corresponds to the "reward effect" in Armstrong et al. (2013) and depends on whether the CEO has DARA, IARA or CARA. Belghitar and Clark (2014) also show that although vega does not appear directly in the measure of risk aversion, it could impact risk

[10]The convexity effect is how the individual option based incentives affect managerial risk aversion at a given level of wealth. The magnification effect reflects how different levels of exposure to the firm's share price affect managerial risk aversion. The translation effect is how different levels of wealth affect managerial risk aversion.

[11] See Appendix for details.

[12]Abdel-Khalik (2007) establish an empirical link between CEO risk aversion and earnings management.

aversion through its effect on CEO wealth. As with delta, the effect of vega depends on whether the CEO has DARA, IARA or CARA.

In the main contribution to the literature, we show that although the relationship between the option based incentives and accrual earnings management is strong and significant, it varies according to the firm's growth prospects, its capital structure and overall firm riskiness. Only delta and the change in delta are significant determinants of abnormal accruals in high growth firms, while only vega is significant in low growth firms. The relationship between firm based compensation and abnormal accruals disappears in high leverage firms where the CEO/shareholder agency conflict is neutralized by the shareholder/bondholder agency conflict. It also disappears in high risk firms where the agency conflict between CEO and shareholders is not apparent. Our results provide an explanation for some of the apparent contradictions in the outstanding literature and have important implications for corporate compensation policies and accounting regulations.

The rest of this study is structured as follows. Section 2 provides a description of the sample utilized in the current study and develops the links between delta, the change in delta and vega and accrual earnings management. Section 3 presents the empirical results. Section 4 concludes.

2 – Data and methodology

The initial sample consists of all UK firms that are listed on the 350 FTSE as of January 2000. Data on managerial compensation sensitivities and data regarding the number of directors and the number of independent non-executive directors on the board are obtained from BoardEx. Company balance sheet information used for estimating abnormal accruals and other control variables used for the analysis are collected from Thomson Reuters Worldscope. After excluding financial firms and firms without the requisite information on managerial compensation sensitivities, the final sample consists of an unbalanced sample of 270 firms for the period 2000 through 2004. [13]

[13] We settled on this time period because of data availability and because it was homogenous in so far as it was pre-crisis period and relatively free of potential distortions due to major tax reforms. The year 2000 is the first year that Boardex reports estimations of CEO vega and delta. It is also the first year after the end of the effects of UK tax reform of July 1997 on equity prices as reported by Bell and

2.1 - Measurement of Earnings Management

In this study we use abnormal accruals as our proxy for accrual earnings management. To this end, we follow closely Dechow et al. (1995), Bergstresser and Philippon (2006) and Caramanis and Lennox (2008) to define total accruals as:

$$TAC_{it} = \frac{\Delta CurA_{it}}{Asset_{i\,t-1}} - \frac{\Delta CurL_{it}}{Asset_{i\,t-1}} - \frac{\Delta Cash_{it}}{Asset_{i\,t-1}} + \frac{\Delta Sdebt_{it}}{Asset_{i\,t-1}} - \frac{Dep_{it}}{Asset_{i\,t-1}} \qquad (2.1)$$

Where TAC_{it} is total accruals for firm *i* at time *t*; Δ is the first difference operator for a one year change; $\Delta CurA_{it}$ is change in current assets for firm *i* at time *t*; $\Delta CurL_{it}$ is the change in current liabilities of firm *i* at time *t*; $\Delta Cash_{it}$ is the change in cash and short-term investments for firm *i* at time *t*; $\Delta Sdebt_{it}$ is the change in short-term debt and current portion of long-term debt for firm *i* at time *t*; Dep_{it} is the depreciation and amortisation expense for firm *i* at time *t*; and $Asset_{it-1}$ is the lagged assets of firm *i* at time *t-1*.

To obtain abnormal accruals, we use the performance matched model advocated by Kothari et al. (2005) and estimate equation (2.2) cross-sectionally for each year using all firm-year available observations in the same industry code:[14]

Jenkinson (2002). Boardex modified its database for the post-2004 period due to the passage of FAS 123R on December 12, 2004. Up to 2005 Boardex reports compensation data using the old format (pre-FAS 123R). For fiscal years 2005 and later, Boardex reports compensation using the new format (post-FAS 123R). In the post-FAS 123R period, firms calculate and expense equity-based compensation at fair value using their own valuation models. Thus, for the post-2004 data, Boardex does not calculate the Black-Scholes value of current year stock option grants, nor do they provide estimates of CEO vega and delta. Instead, Boardex reports the firm‘s own calculated fair values of equity-based compensation, which is not comparable across firms within the same year if firms are using different valuation methods. Additionally, for the same firm, *CEO* vega and deltaare not comparable pre- and post-FAS 123R.

[14] As a robustness check and comparison with other studies, we also estimate equation 2.2 without the constant term. To justify the constant, Kothari et al. (2005) p. 173 writes: “While prior research typically does not include a constant in the above model, we include a constant in the estimation for several reasons. First, it provides an additional control for heteroskedasticity not alleviated by using assets as the deflator. Second, it mitigates problems stemming from an omitted size (scale) variable.Finally, we find that discretionary accrual measures based on models without a constant term are less symmetric, making power of the test comparisons less

$$TAC_{it} = \beta_0 + \beta_1 \left(\frac{1}{Asset_{i\,t-1}}\right) + \beta_2 \Delta Rev_{it} + \beta_3 PPE_{it} + \beta_4 ROA_{it} + \varepsilon_{it} \qquad (2.2)$$

where TAC_{it} is total accrual for firm i at time *t*; Δ is the first difference operator for a one year change; β_0 is the slope intercept; $\beta_i$is the i-th slope coefficient for i∈ {1,2,3}; $Asset_{it-1}$ is the lagged assets of firm i at time *t-1*; ΔRev_{it} is the change in revenue for firm i at time t, scaled by the lagged value of assets; PPE_{it} is the plant, property and equipment for firm i at time t scaled by the lagged value of assets; ROA_{it} is return on assets for firm i at time t; ε_{it} is the stochastic error term. Subsequent to the estimation of equation 2.2, the absolute value of the regressions residual term is utilised as a proxy for the magnitude and propensity for abnormal accruals and by extension accrual earnings management.

Since accruals management depends crucially on how accruals management affects the firm's stock price and stock price volatility, in results not reported here but available on request we look at the relationship between lagged abnormal accruals and market returns to equity as well as the volatility of market returns to equity. The correlation coefficient for both is negative and significant. OLS regressions of market returns to equity and the volatility of market returns to equity on lagged abnormal returns with and without control variables confirm the significant negative relationship. This situates our overall sample in the zone where the overall effect of accruals on stock market returns and return volatility is negative.

2.2 - Managerial Compensation Incentives

Following Belghitar and Clark (2014), we use as CEO option based risk incentives the delta, the change in delta and the vega of CEO firm based wealth.[15] Firm based wealth includes the value of all stock ownership,

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clear-cut. Thus, model estimations including a constant term allow us to better address the power of the test issues that are central to our analysis".

[15]The delta of a share is equal to 1 and its vega is equal to 0. The delta and vegaof total firm based wealth is the weighted average of the deltas and vegas of the individual shareholdings and options: $\Delta = \sum_i z_i \Delta_i$ and $vega = \sum_i z_i\, vega_i$ where i refers to the individual

unexpired stock options and long term incentive plans (LTIPs) accumulated and held by the CEO to date. CEO delta (*CEO_Delta*) measures the pound gain in the CEO's firm based wealth following a stock price increase of 1%. The change in CEO delta (*CEO_DeltaChg*) is captured by computing the first difference of delta [*CEO_Delta time T* - *CEO_Delta time T-1*]. CEO vega is defined as the pound gain in the CEO's firm based wealth as stock return volatility increases by 1%.[16]

Delta acts on risk aversion through the translation effect derived in Ross (2004). Its effect depends on whether the manager's utility function has decreasing, increasing or constant absolute risk aversion.[17] The effect on risk aversion is negative with DARA.[18] It is positive with IARA[19] and it is equal to zero with CARA.[20] This implies that if the CEO is using accrual earnings management to aggressively manipulate earnings for his own personal benefit at the expense of shareholders, the effect of delta on abnormal accruals will depend on the CEO utility function. Thus, we have no prior on the sign of delta.

Changes in delta affect risk aversion through their effect on convexity and magnification. An increase in delta will reduce the effects of convexity

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shareholdings and options and Z_i is the proportion of asset *i* in total firm based wealth. For example, consider a manager with 50% of his firm based wealth in shares and 50% in an option with a delta of 0.5. The delta of his portfolio will be equal to $0.5 \times 1 + 0.5 \times 0.5 = 0.75$.

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[16]All compensation sensitivities are scaled by thousands of pounds similar to previous studies (Guay, 1999; Coles, et al, 2006).

[17]Ross calls this moving the evaluation to a different part of the domain of the original utility function where the utility function can have greater or lesser risk aversion.

[18] Let *A* represent absolute risk aversion, *w* represent wealth and *u* the CEO utility function, where primes signify first and second derivatives:

DARA implies $\frac{dA}{dw} = \left[- \frac{u''(w)}{u'(w)} \right]' < 0$

[19]IARA implies $\frac{dA}{dw} = \left[- \frac{u''(w)}{u'(w)} \right]' > 0$

[20]CARA implies $\frac{dA}{dw} = \left[- \frac{u''(w)}{u'(w)} \right]' = 0$

and magnification and increase managerial risk aversion. This implies that if the CEO is using accrual management to manipulate reported earnings for his own personal benefit at the expense of shareholders, an increase in CEO delta will increase abnormal accruals. Thus, we expect a positive relationship between change in delta and abnormal accruals.

Vega does not appear directly as a determinant of CEO risk aversion in Ross (2004). It could, however, affect risk aversion indirectly through the effect of volatility on CEO wealth. It is well known in the option pricing literature that the first derivative of the option price with respect to the volatility of the firm's returns/earnings to equity is positive. An increase in volatility increases the CEOs firm based wealth.[21] The higher the vega, the larger is the increase in wealth. An increase in wealth affects risk aversion depending on whether the manager has decreasing, increasing or constant absolute risk aversion. As with delta, the effect is negative with DARA, positive with IARA and equal to zero with CARA. Thus, higher levels of vega should increase the incentive of CEOs with DARA to reduce abnormal accruals. Higher levels of vega should increase the incentive of CEOs with IARA to increase abnormal accruals. Higher levels of vega should have no effect on abnormal accruals for CEOs with CARA.Sincevega and delta affect risk aversion in a similar manner, they should both have the same sign with respect to abnormal accruals.

2.3 - Control Variables

The control variables employed in this study are all consistent with prior studies on accrual earnings management. Following Klein (2002)andPeasnell et al. (2005), we control for board size and the percentage of independent non-executive directors on the board where the natural logarithm of total directors on the board, and the number of independent non-executives to total directors on the board are used as respective proxies. We include CEO cash compensation, measured as the sum of all cash based compensation received by the CEO during the year. We use the audit fees as a proxy for audit effort.Wealsocontrol for the following firm characteristics:

[21] Other things being equal, the vega of a share is equal to zero. Like delta, the vega of managerial total wealth is a weighted average of the vegas of the individual shareholdings and options: $vega = \sum_i z_i \, vega_i$.

leverage and firm size. Leverage is defined as the ratio of long-term debt to total assets. The natural logarithm of total sales is utilized as a proxy for firm size. Finally, the ratio of research and development plus selling, general and administrative expenses to total assets is used for firm uniqueness similar to Titman and Wessells (1988). Descriptive statistics for the main variables are presented in Table 1.

Table 1: Descriptive Statistics

Variable	Mean	Median	SD
AB_ACC	0.164	0.059	0.337
AB_ACC2	0.146	0.062	0.303
CEO_Delta	82.042	22.000	198.192
CEO_Vega	17.171	1.253	99.674
CEO_DeltaChg	-3.512	3.000	182.362
BSIZE	2.085	2.079	0.304
CEO_Cash	516.390	395.6	444.014
NEXEC	0.436	0.429	0.158
AUDIT	6.378	6.217	1.455
R&D	0.283	0.206	0.298
LEV	0.165	0.130	0.164
RISK	0.380	0.321	0.222
SIZE	12.696	12.922	2.155

AB_ACC is the absolute value of residuals obtained from equation 2.3. *AB_ACC2* is the absolute value of residuals obtained from equation 2.2 excluding the constant term. CEO_Delta is the pound change in CEO wealth for a 1% change in stock price. CEO_Vega is the pound change in the CEO's wealth for a 0.01 change in stock return standard deviation. CEO_DeltaChg is the first change in CEO_Delta. CEO_Cash is measured as the sum of all cash based compensation received by the CEO during the year in thousands.Bsize is the natural logarithm of total directors on the board. *NEXEC* is the ratio of total independent non-executive directors on the board to total directors on the board. AUDIT is the natural logarithm of audit fees. R&D is the ratio of research and development plus selling, administrative and general expenses to total assets. LEV is the ratio of long-term debt to total assets. RISK is the annualised standard deviation of year t daily stock return. SIZE is the natural logarithm of total sales

3 – Empirical results

To examine the impact of CEO compensation incentives on earnings management we employ pooled, multivariate regression analysis controlling for both industry-effects and time-effects. One salient issue is the potential endogeneitybetween earnings management and its hypothesized determinants. The independent variables are lagged by one year in order to reduce the potential endogeneity bias. In regression 1, the dependent variable, absolute abnormal accruals (noted *AB_ACC*), is estimated using equation (2.1), while in regression 2the dependent variable (noted *AB_ACC2*) is estimated using equation (2.2) without a constant. The regression results are reported in Table 2.

Table 2: Determinants of Earnings management

	(1)	(2)
CEO_Delta	-0.00020**	-0.00022**
	(-2.82)	(-2.98)
CEO_Vega	-0.00008**	-0.00009**
	(-2.63)	(-2.85)
CEO_DeltaChg	0.00009*	0.00010*
	(1.84)	(1.81)
CEO_Cash	-0.18955**	-0.20977*
	(-1.97)	(-1.87)
BSIZE	0.07802	0.06814
	(0.71)	(0.57)
NEXEC	-0.11860	-0.15238
	(-0.95)	(-1.07)
AUDIT	-0.00912	0.01183
	(-0.62)	(0.73)
RD	-0.04761	-0.06113
	(-0.92)	(-1.12)
LEV	0.30741**	0.42498**
	(2.43)	(2.88)
RISK	-0.07522	-0.12833
	(-0.66)	(-1.02)
SIZE	-0.00155	-0.00798
	(-0.22)	(-1.01)
Constant	0.57038**	0.62635**
	(4.13)	(4.02)
Ind. dummies	Yes	Yes
Year dummies	Yes	Yes
F	3.99**	3.72**
R^2	3.81%	4.88%

The dependent variables are AB_ACC and AB_ACC2 in models (1) and (2) are measured as the absolute value of residuals obtained from equation 2.2 with and without the constant term respectively. CEO_Delta is the pound change in CEO wealth for a 1% change in stock price. CEO_Vega is the pound change in the CEO's wealth for a 0.01 change in stock return standard deviation. CEO_DeltaChg is the first change in CEO_Delta.CEO_Cash is measured as the natural logarithm of the sum of all cash based compensation received by the CEO during the year.BSIZE is the natural logarithm of total directors on the board. *NEXEC* is the ratio of total independent non-executive directors on the board to total directors on the board. AUDIT is the natural logarithm of audit fees. R&D is the ratio of research and development plus selling, administrative and general expenses to total assets. LEV is the ratio of long-term debt to total assets. RISK is the annualised standard deviation of year t daily stock return. SIZE is the natural logarithm of total sales. The coefficients' standard errors are adjusted for the effects of non-independence by clustering on each firm (Petersen 2009). The number of observations in the regression is 698. t statistics in parentheses. ** and * indicate statistical significance at the 5% and 10% level respectively

Our results provide evidence that managerial compensation incentives play an important role in influencing earnings management decisions. All three incentive measures, CEO delta, the change in CEO delta (*CEO_DeltaChg*) and CEO vega, are significant and have the signs suggested in section 2. CEO delta and vega have the same negative sign, which is evidence that the CEOs in our sample have DARA.[22] The change in CEO delta is positive, meaning that larger changes in delta increase earnings management. CEO Cash is negative and significant. Overall our findings suggest that managerial compensation incentives exert significant influence on the decision to employ accruals to manage earnings.

With respect to firm characteristics, leverage is positive and significant in both regressions. This is consistent with the findings of Klien (2002),Bergstresser and Philippon (2006), and Caramanis and Lennox (2008). None of the other firm specific variables are significant at any conventional level. The fact that none of the governance variables, such as board size, independent board members and auditing cost is significant is evidence of the wide latitude that CEOs have in the decision to allocate and reprise certain types of accruals.

[22]This substantiates Abdel-Khalik's (2007) assumption of DARA.

3.1 - The Growth Opportunity Set, Earnings Management and Managerial Compensation Sensitivities

As argued in the introduction, the effectiveness of managerial compensation incentives may depend on the organisational environment in which a firm operates as is the case with other corporate governance mechanisms (Hutchinson and Gul, 2004). The growth opportunity set is a key element in the organizational environment. It is generally accepted that firms with greater growth opportunities are subject to greater levels of informational asymmetry and agency costs (Smith and Watts, 1992; Belghitar, Clark and Kassimatis, 2011). Firms with higher growth opportunities are also subject to higher bankruptcy costs (Harris and Raviv, 1990; Shleifer and Vishny, 1992). Shin and Stulz (2000) argue that since firm risk and growth opportunities may be positively linked,undiversified managers in high growth firms may have greater incentive to be risk averse than those in low growth firms. Therefore, we examine the impact of managerial compensation incentives in influencing earnings management in firms with large and small growth opportunity sets.

To investigate the impact of managerial compensation sensitivity in influencing earnings management in different growth environments we utilise the ratio of market value of equity to book value of equityas a proxy for growth opportunities.[23] We split our sample into three categories. Firms with growth opportunity less than the 40th percentile are classified as small growth opportunity firms and firms with growth opportunity greater than the 60thare categorised as large growth firms. The results are presented in Table 3. Models (3) and (4) refer to regressions for high and low growth firms where the dependent variable is *AB_ACC*. Models (5) and (6) refer to high growth and low growth regressions where the dependent variable is *AB_ACC2*.

In both regressions for high growth firms (models (3) and (5)) both *CEO_Delta* and *CEO_DeltaChg*are significant and have the predicted signs. Delta is negative, which is evidence for DARA, and *CEO_DeltaChg*ispositive, which is evidence that the sensitivity to the convexity and magnification effects decreases as delta increases. Vega, however, is not significantwiththe implication that managers in high growth firms are wary of firm risk, even when it can increase their wealth. This is evidence for the Shin and Stulz (2000) argument that undiversified managers in high growth firms may have greater incentive to be risk averse than those in low growth firms.

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[23]As a robustness test we also use Tobin's Q to proxy for growth opportunities and get weaker but qualitatively similar results.

In both regressions for low growth firms (models (4) and (6)) vega is negative and significant, which is evidence of DARA formanagers in low growth firms.Delta is also negative but not significant. Remember that delta reflects the sensitivity of managerial wealth to changes in the firm share price. Low growth firms have low prospects for gains in the share price. Thus, the strong effect of vega and the insignificant effect of delta might reflect the fact that CEOs of low growth firms see wealth enhancement through increases in volatility as more likely than through increases in the firm's share price. The fact that *CEO_DeltaChg* is not significant reinforces this argument. The convexity and magnification effects that depend on the value of the firm share price may not matter much if the share price is not likely to change much.

Table 3: Earnings management and investment opportunity growth

	High growth (3)	Low growth (4)	T-diff	High growth (5)	Low growth (6)	T-diff
CEO_Delta	-0.00022**	-0.00025	2.14**	-0.00038**	-0.00024	2.02**
	(-2.92)	(-1.39)		(-3.71)	(-1.29)	
CEO_Vega	0.00053	-0.00006**	2.05**	0.00072	-0.00007*	1.92*
	(1.13)	(-2.03)		(1.18)	(-1.90)	
CEO_DeltaChg	0.00011*	0.00017	1.85*	0.00020**	0.00016	2.19**
	(1.93)	(1.09)		(3.17)	(1.03)	
CEO_Cash	-0.02455	0.04925	1.55	-0.05657	0.01606	1.43
	(-0.67)	(0.62)		(-1.21)	(0.20)	
BSIZE	0.11244	-0.38055		0.46068	-0.18944	
	(0.34)	(-0.62)		(1.18)	(-0.29)	
NEXEC	-0.18842	0.00183		-0.19318	-0.07687	
	(-1.02)	(0.01)		(-0.86)	(-0.29)	
AUDIT	-0.02304	-0.02878		-0.01885	0.00876	
	(-1.16)	(-0.94)		(-0.76)	(0.25)	
RD	-0.02863	-0.21183		-0.06294	-0.17918	
	(-0.63)	(-1.40)		(-1.21)	(-1.20)	
LEV	0.28301	0.33453*		0.07448	0.59111**	
	(1.54)	(1.94)		(0.36)	(2.79)	
RISK	-0.12398	0.11451		-0.13821*	0.03713	
	(-1.59)	(0.52)		(-1.74)	(0.15)	
SIZE	0.00848	-0.02298		0.01546	-0.04738	
	(1.07)	(-0.83)		(1.63)	(-1.52)	
Constant	0.30719	1.02225		-0.17633	0.99979	
	(0.77)	(1.35)		(-0.41)	(1.24)	
Ind. dummies	Yes	Yes		Yes	Yes	
Year dummies	Yes	Yes		Yes	Yes	
F-test	1.93**	2.1**		2.13**	1.88**	
R^2	6.27%	5.47%		6.21%	8.33%	

The dependent variables in models (3) and (4) are AB_ACC and AB_ACC2 in models (5) and

(6) are measured as the absolute value of residuals obtained from equation 2.2 with and without the constant term respectively. CEO_Delta is the pound change in CEO wealth for a 1% change in stock price. CEO_Vega is the pound change in the CEO's wealth for a 0.01 change in stock return standard deviation. CEO_DeltaChg is the first change in CEO_Delta. CEO_Cash is measured as the natural logarithm of the sum of all cash based compensation received by the CEO during the year. BSIZE is the natural logarithm of total directors on the board. *NEXEC* is the ratio of total independent non-executive directors on the board to total directors on the board. AUDIT is the natural logarithm of audit fees. R&D is the ratio of research and development plus selling, administrative and general expenses to total assets. LEV is the ratio of long-term debt to total assets. RISK is the annualised standard deviation of year t daily stock return. SIZE is the natural logarithm of total sales. The coefficients' standard errors are adjusted for the effects of non-independence by clustering on each firm (Petersen 2009). T-Diff is the t-test of difference between regression coefficients. The number of observations in the regressions for testing the difference in the coefficients is 698. t statistics in parentheses. ** and * indicate statistical significance at the 5% and 10% level respective.

3.2 - Leverage, Earnings Management and Managerial Compensation Sensitivities

Another key element in the firm's organizational environment that lends itself to assessing the effectiveness of managerial compensation incentives is the firm's capital structure. As argued in the introduction, covenants associated with the bondholder wealth expropriation hypothesis can restrict corporate borrowing and risk-taking. Thus, different levels of leverage create different risk dynamics for managerial compensation incentives. Therefore, we examine the impact of managerial compensation incentives in influencing earnings management in firms with large and small leverage ratios.

To investigate the impact of managerial compensation incentives in influencing earnings management at different leverage ratios, we proceed as above and split our sample into 3 categories. Firms with leverage ratios less than the 40^{th} percentile are classified as low leverage firms and firms with leverage ratios greater than the 60^{th} are categorized as high leverage firms. The results of the tests using the same methodology as above are presented in Table 4. Models (7) and (8) refer to regressions for high and low leverage firms where the dependent variable is *AB_ACC*. Models (9) and (10) refer to high and low leverage firms where the dependent variable is *AB_ACC2*.

The results are similar to those in table 3. In both regressions for high leverage firms (models (7) and (9)) *CEO_Delta* and *CEO_DeltaChg*are significant and have the predicted signs. Delta is negative, which is evidence for DARA, and *CEO_DeltaChg* is positive, which is evidence of sensitivity to the convexity and magnification effects. Vega, however, is not significant. As in the case of managers in high growthfirms, this implies that managers in high leverage firmswhere volatility is already high due to the leverageare wary of more firm risk, even when it can increase their wealth. This is evidence that undiversified managers in high leverage firms may have greater incentive to be risk averse than those in low leverage firms.

In both regressions for low leverage firms (models (8) and (10)) vega is negative and significant, which is evidence of DARA for managers in low leverage firms. Delta is also negative but not significant. Since, *ceteris paribus*, lower leverage implies more latitude with respect to bondholder restrictions and lower volatility of market returns, the strong effect of vega and the insignificant effect of delta might reflect the fact that there is more scope for CEO wealth creation from increased return volatility than from increased share price. The fact that *CEO_DeltaChg* is not significant is evidence that in a low leverage/low volatility environment, increases in exposure to the firm's share price are not a major determinant of CEO risk aversion and earnings management.

Table 4: Earnings management and leverage

	High leverage (7)	Low leverage (8)	T-Diff	High leverage (9)	Low leverage (10)	T-Diff
CEO_Delta	-0.00032**	-0.00008	1.98*	-0.0003**	-0.00009	2.15**
	(-3.4)	(-0.68)		(-2.1)	(-0.90)	
CEO_Vega	-0.00003	-0.00012**	1.15	-0.00003	-0.00016**	1.79*
	(-0.60)	(-2.60)		(-0.49)	(-3.25)	
CEO_DeltaChg	0.00012*	0.00001	2.27**	0.00009	0.00004	2.32**
	(1.80)	(0.08)		(2.58)**	(0.43)	
CEO_Cash	0.01150	0.00344	1.21	0.01529	0.01200	1.03
	(0.12)	(0.09)		(0.16)	(0.28)	
BSIZE	-0.28310	-0.04918		-0.44561	-0.17193	
	(-0.35)	(-0.14)		(-0.50)	(-0.44)	
NEXEC	-0.29376	0.07940		-0.26249	0.00569	
	(-0.96)	(0.61)		(-0.79)	(0.04)	
AUDIT	0.01912	-0.04391**		0.01971	-0.01807	
	(0.68)	(-2.09)		(0.63)	(-0.78)	
RD	-0.10201	-0.00265		-0.19815	0.01427	
	(-0.47)	(-0.06)		(-0.88)	(0.35)	
LEV	0.00838	0.15695		0.10857	0.43740	
	(0.04)	(0.50)		(0.40)	(1.26)	
RISK	0.01410	-0.12073*		-0.05079	-0.13558*	
	(0.05)	(-1.72)		(-0.15)	(-1.83)	
SIZE	-0.04270	0.01488**		-0.03657	0.00908	
	(-1.38)	(2.15)		(-1.12)	(1.31)	
Constant	1.38483	0.32488		1.65086	0.43568	

	(1.29)	(0.72)	(1.41)	(0.87)
Ind. dummies	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes
F-test	1.77*	2.81**	1.94**	2.75**
R^2	5.40%	5.96	5.48%	5.82%

The dependent variables in models (3) and (4) are AB_ACC and AB_ACC2 in models (5) and (6) are measured as the absolute value of residuals obtained from equation 2.2 with and without the constant term respectively. CEO_Delta is the pound change in CEO wealth for a 1% change in stock price. CEO_Vega is the pound change in the CEO's wealth for a 0.01 change in stock return standard deviation. CEO_DeltaChg is the first change in CEO_Delta. CEO_Cash is measured as the natural logarithm of the sum of all cash based compensation received by the CEO during the year. BSIZE is the natural logarithm of total directors on the board. *NEXEC* is the ratio of total independent non-executive directors on the board to total directors on the board. AUDIT is the natural logarithm of audit fees. R&D is the ratio of research and development plus selling, administrative and general expenses to total assets. LEV is the ratio of long-term debt to total assets. RISK is the annualised standard deviation of year t daily stock return. SIZE is the natural logarithm of total sales. The coefficients' standard errors are adjusted for the effects of non-independence by clustering on each firm (Petersen 2009). T-Diff is the t-test of difference between regression coefficients. The number of observations in the regressions for testing the difference in the coefficients is 698. t statistics in parentheses ** and * indicate statistical significance at the 5% and 10% level respectively.

3.3 - Risk, Earnings Management and Managerial Compensation Sensitivities

As a final test to our empirical analysis, we examine the impact of managerial compensation incentives in influencing earnings management at different levels of firm risk, measured as the annualized standard deviation of the daily stock returns. The argument here is that if firm volatility is high enough, it is conceivable that no incentive scheme would lower the level of risk aversion enough to make the manager increase the volatility. Conversely, if firm volatility is low enough, option based incentives would have more scope for increasing volatility.

As in the previous two sub-sections, we split our sample into 3 categories. Firms with risk levels less than the 40th percentile are classified as low risk firms and firms with risk levels greater than the 60th are categorized as high Risk firms. The results of the tests are presented in Table 5. Models (11) and (12) refer to regressions for high and low risk firms where the dependent variable is *AB_ACC*. Models (13) and (14) refer to high and low risk firms where the dependent variable is *AB_ACC2*.

Interestingly, option based compensation incentives have no significant effect on high risk firms. They affect only low risk firms (models

(12) and (14))wherethe change in CEO delta is positive and significant, andCEO delta and CEO vega are both negative and significant. This suggests a very limited scope for incentivizing CEO behavior with option based compensation packages.

Table 5 Earnings management and firm risk

	High risk (11)	Low risk (12)	T-Diff	High risk (13)	Low risk (14)	T-Diff
CEO_Delta	0.00003	-0.00038**	2.02**	-0.00014	-0.00044**	1.77*
	(0.13)	(-2.88)		(-0.71)	(-3.05)	
CEO_Vega	-0.00001	-0.00012**	1.16	-0.00002	-0.00012*	1.22
	(-0.26)	(-2.10)		(-0.76)	(-1.88)	
CEO_DeltaChg	-0.00005	0.00013**	1.67*	0.00003	0.00015**	1.86**
	(-0.36)	(2.41)		(0.23)	(2.17)	
CEO_Cash	-0.01386	0.00266	1.12	-0.04273**	0.02847	0.92
	(-0.77)	(0.03)		(-2.00)	(0.32)	
BSIZE	0.02079	-0.08462		0.24884	-0.28825	
	(0.12)	(-0.13)		(1.29)	(-0.41)	
NEXEC	-0.15113	-0.11058		-0.34335**	-0.12448	
	(-1.10)	(-0.47)		(-2.05)	(-0.48)	
AUDIT	-0.00702	-0.00824		0.00207	0.03125	
	(-0.38)	(-0.31)		(0.12)	(1.05)	
RD	0.03071	0.01976		-0.00459	0.06277	
	(0.55)	(0.16)		(-0.09)	(0.48)	
LEV	0.22469	0.37688*		0.22345	0.53262**	
	(1.20)	(1.72)		(1.08)	(2.17)	
RISK	0.21616	-0.22071		0.21903	-0.46273	
	(1.41)	(-0.68)		(1.30)	(-1.29)	
SIZE	0.00524	-0.01035		0.00324	-0.02435	
	(0.73)	(-0.62)		(0.54)	(-1.34)	
Constant	0.05300	0.67462		-0.10042	0.89018	
	(0.24)	(0.89)		(-0.43)	(1.08)	
Ind. dummies	Yes	Yes		Yes	Yes	
Year dummies	Yes	Yes		Yes	Yes	
F	1.79**	3.05**		1.65*	3.70**	
R^2	6.98%	3.93%		8.40%	4.97%	

The dependent variables in models (3) and (4) are AB_ACC and AB_ACC2 in models (5) and (6) are measured as the absolute value of residuals obtained from equation 2.2 with and without the constant term respectively. CEO_Delta is the pound change in CEO wealth for a 1% change in stock price. CEO_Vega is the pound change in the CEO's wealth for a 0.01 change in stock return standard deviation. CEO_DeltaChg is the first change in CEO_Delta. CEO_Cash is measured as the natural logarithm of the sum of all cash based compensation received by the CEO during the year. BSIZE is the natural logarithm of total directors on the board. *NEXEC* is the ratio of total independent non-executive directors on the board to total directors on the board. AUDIT is the natural logarithm of audit fees. R&D is the ratio of research and development plus selling, administrative and general expenses to total assets. LEV is the ratio of long-term debt to total assets. RISK is the annualised standard deviation of year t daily stock return. SIZE is the natural logarithm of total sales. The coefficients' standard errors are adjusted for the effects of non-independence by clustering on each firm (Petersen 2009). T-Diff is the t-test of difference between regression coefficients. The number of observations in the regressions for testing the difference in the coefficients is 698. t statistics in parentheses. ** and * indicate statistical significance at the 5% and 10% level respectively.

4 – Summary and conclusion

Our findings suggest that option based compensation incentives do have an effect on CEO risk aversion and accrual earnings management, but that the effect varies with the organizational environment of the firm. In the overall sample,delta, vega and the change in deltaare significant determinants of earnings management. Higher levels of delta and vegareduceearnings management, which is evidence that CEOs have decreasing absolute risk aversion, and higher levels of the change in delta increase it.

The picture is more nuanced when different organizational environments are considered. For high growth firms,*CEO_Delta* and *CEO_DeltaChg*are significant and have the predicted signs. Vega, however, is not significant. For low growth firms,vega is significant but *CEO_Delta* and *CEO_DeltaChg*are not. Similarly, for high leverage firms, *CEO_Delta* and *CEO_DeltaChg*are significant and have the predicted signs, whilevega is not significant. For low leverage firms, vega is significant but *CEO_Delta* and *CEO_DeltaChg* are not. Thus, it looks like the CEOs are reacting to the option based incentives with respect to the opportunities and constraints specific to each environment. It is particularly interesting that vega is only significant in the lower risk environments associated with low growth/low leverage where delta and the change in delta are not significant. This could be a problem because contrary to delta and the change in delta, which are related to the firm's share price, vega is related only to risk. Increased risk for its own sake is not necessarily in the shareholders interest unless it is associated with higher NPV projects that add value to the firm.

When we look at the effect of option based incentives in an environment of firm based risk, option based compensation incentives have no significant effect on high risk firms. They affect only low risk firms (models (12) and (14)) where the change in CEO delta is positive and significant CEO delta and CEO vega are both negative and significant. This suggests a very limited scope for high risk firms to incentivize CEO behaviour with option based compensation packages.

The implication for compensation boards is that structuring option based compensation packages is much more complicated than previous literature suggests.[24]A successful structure that reduces accrual management depends on the firm's organizational environment as well as the CEO's attitude towards risk.For high growth and high leverage firms, the change in delta increases abnormal accruals and suggests that the option should be priced far in the money or far out of the money where the changes in delta are smallest. Far in the money options will be more effective in reducing abnormal accruals for CEOs with DARA (higher delta reduces abnormal accruals for DARA utility functions), while far out of the money options will be more effective for those with IARA (higher delta increases abnormal accruals for IARA utility functions). Since vega is significant but neither delta nor the change in delta are significant for low growth and low leverage firms, the option can be structured to make vega as large as possible as far out of the money as possible in order to get the maximum vega effect at the lowest option cost. For high risk firms, option incentives do not seem to be an effective tool for reducing accrual management. On the other hand, for low risk firms all three incentives are significant. Thus, we want the option to be far in or out of the money in order to have a low change in delta. The structure of delta and vega depends on whether the CEO has DARA, IARA or CARA.

Appendix

Following Ross (2004), each manager has a utility function $u(w)$ satisfying the following conditions:

$$u'(w) \geq 0, u''(w) \leq 0, \forall w \qquad \text{(A1)}$$

where primes denote first and second derivatives with respect to wealth, noted as *w*. The degree of absolute risk aversion (Pratt, 1964) is defined as

$$A = -\frac{u''(w)}{u'(w)} \qquad \text{(A2)}$$

[24] *The structure can be modified by varying the strike price and time to maturity.*

where A measures how much the manager dislikes the uncertainty he faces.

Consider a manager whose firm based wealth, noted by $f(x)$, consists of a call option on one share of the firm's stock with a market price noted as *x* that follows geometric Brownian motion:[25]

$$dx = \alpha x dt + \sigma x dz \tag{A3}$$

where α is the drift parameter, σ is the standard deviation of dx/x and dz is a standard Wiener process with zero mean and variance of *dt*.

Let $u(f(x))$ represent the derived utility function, where $f(x) = xN(d_1) - e^{-r(T-t)} XN(d_2)$, the Black/Scholes (BS) European option pricer. $N(d_1)$ is the normal cumulative evaluated at d_1 and d_1 is equal to $d_1 = \frac{\ln(x_t / X) + (r + \sigma^2/2)(T-t)}{\sigma\sqrt{T-t}}$, $N(d_2) = 1 - N(d_1)$, r is the risk free interest rate, X is the strike price, and (*T*-*t*) is the time to maturity.

The derived coefficient of absolute risk aversion is given as:

$$A(f) = -\frac{u''(f)}{u'(f)} \tag{A4}$$

Outright stock ownership has a delta of one. Thus, if total firm based wealth is held as outright stock ownership, it is easy to verify that equation (A4) reduces to equation (A2), the original Pratt measure.[26]

Ross (2004) has shown that the relationship between option based incentives and corporate decision-making can be broken down into three

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[25] For expository convenience to identify the pertinent variables and their effect on risk aversion, we consider only option based firm wealth. It is straightforward to incorporate portfolios of individual options and outright shareholdings in the analysis because the pertinent variables for the portfolios are linear combinations of the variables of the individual options and shareholdings.

[26] The delta of total firm based wealth is the weighted average of the deltas of the individual shareholdings and options: $\Delta = \sum_i z_i \Delta_i$, where *i* refers to the individual shareholdings and options and z_i is the proportion of asset *i* in total firm based wealth. For example, consider a manager with 50% of his firm based wealth in shares and 50% in an option with a delta of 0.5. The delta of his portfolio will be equal to $0.5 \times 1 + 0.5 \times 0.5 = 0.75$.

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distinct effects: convexity, magnification and translation. The convexity effect is defined as

$$\text{Convexity effect} = -\frac{f''(x)}{f'(x)} \tag{A5}$$

In the Black/Scholes option pricer $f'(x)$ corresponds to delta and $f''(x)$ corresponds to gamma where $0 < f'(x) < 1$ and $0 < f''(x)$. Since both are positive, the convexity effect on managerial risk aversion is negative.[27]

To see how delta affects the convexity effect, let delta change while holding gamma constant:[28]

$$\frac{d\left[-\frac{f''(x)}{f'(x)}\right]}{d\left[f'(x)\right]} = \frac{f''(x)}{f'(x)^2} > 0 \tag{A6}$$

This derivative is positive because both $f''(x)$ and $f'(x)$ are positive. Thus, an increase in delta will reduce the effects of convexity and increase managerial risk aversion.

The magnification effect is defined as:

$$\text{Magnification effect} = A(f)\left[f'(x) - 1\right] \tag{A7}$$

and since $f'(x)$ is positive and less than 1, the magnification effect on risk aversion is also negative. The effect of a change in delta on magnification is given by holding $f(x)$ constant and letting delta change:[29]

$$\frac{d\left[A(f)\left[f'(x) - 1\right]\right]}{d\left[f'(x)\right]} = A(f) > 0 \tag{A8}$$

This derivative is positive because $A(f)$ is positive due to the risk aversion postulated in equation (A1).

[27] The Black-Scholes formula for the delta and gamma of a European call option are respectively $\Delta = f'(x) = N(d_1)$ and $\Gamma = f''(x) = \frac{1}{\sigma x\sqrt{2\pi(T-t)}} e^{-\frac{(d_1)^2}{2}}$.

[28] For example, in the context of a simple call option this can be achieved by making appropriate changes in the strike price and the option's time to maturity. In the more general context of a portfolio of options and shares the same effect can be achieved by adding an option or portfolio of options or options and shares with a different delta but the same gamma.

[29] Again, this can be achieved by making appropriate changes in the strike price and the option's time to maturity.

The translation effect in Ross (2004) is given as:

Translation effect = $A(f)$ - $A(x)$ (A9)

This effect on risk aversion depends on whether the manager's utility function has decreasing, increasing or constant absolute risk aversion. Since $f < x$, the effect is positive with DARA.[30] It is negative with IARA[31] and it is equal to zero with CARA.[32] The translation effect depends on the level of managerial firm based wealth and will change as the value of the firm's shares changes. Taking the derivative of (A9) with respect to *x* gives:

$$\frac{d\left[A(f)-A(x)\right]}{dx}=\left[-\frac{u'''(f)}{u'(f)}+\frac{u''(f)^2}{u'(f)^2}\right]f'(x)-\left[-\frac{u'''(x)}{u'(x)}+\frac{u''(x)^2}{u'(x)^2}\right] \quad \text{(A10)}$$

Both parentheses on the right hand side of equation (A9) have the same sign with DARA and IARA. For DARA they are negative and for IARA they are positive. Thus, since $f'(x)$ is positive, higher levels of delta increase the absolute value of the first term on the right hand side of the equation and, consequently, decrease the translation effect for utility functions with DARA and IARA. It has no effect for utility functions with CARA.

Althoughvega does not appear directly as a determinant of managerial risk aversion in the three effects outlined above, it could, however, affect risk aversion indirectly through the effect of sigma on managerial wealth. It is well known in the option pricing literature that $\text{vega}=\frac{df}{d\sigma}>0$.[33] An increase in

[30]DARA implies $\frac{dA}{dw}=\left[-\frac{u''(w)}{u'(w)}\right]'<0$

[31]IARA implies $\frac{dA}{dw}=\left[-\frac{u''(w)}{u'(w)}\right]'>0$

[32]CARA implies $\frac{dA}{dw}=\left[-\frac{u''(w)}{u'(w)}\right]'=0$

[33] The Black-Scholes formula for the vega of a European call option is $\frac{\partial f}{\partial\sigma}=x\sqrt{T-t}\,\frac{1}{\sqrt{2\pi}}e^{-\frac{(d_1)^2}{2}}$.

sigma increases the manager's firm based wealth.[34] The higher the vega, the larger is the increase in wealth. An increase in wealth affects risk aversion depending on whether the manager has decreasing, increasing or constant absolute risk aversion. As with delta, the effect is negative with DARA, positive with IARA and equal to zero with CARA.

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[34]Other things being equal, the vega of a share is equal to zero. Like delta, the vega of managerial total wealth is a weighted average of the vegas of the individual shareholdings and options: $vega = \sum_i z_i \, vega_i$.

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