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Executive Compensation and Hedging Behavior: Evidence from Taiwan

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Abstract: This study examines the relationship between managerial risk-taking incentives and hedging derivatives usage. We have three results. First, executives' risk-taking incentives are negatively related to the hedging derivatives holdings, a result consistent with equity-based compensation that promotes risk taking. Second, the indexed stock options appear to create stronger risk-taking incentives than the traditional stock options. Third, managerial risk-taking incentives are significantly related to executive stock options but not stock holdings.

JEL: G32, M12, M52

Key Words: executive compensation;hedging behavior; risk-taking incentives; agency problems

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1. Introduction

The large number of empirical derivatives research that assumes corporate derivatives are an important component of firms' risk management activities (e.g., Geczy, Minton and Schrand, 1997; Allayannis and Weston, 2001; Graham and Rogers, 2002; Rogers, 2002; Guay and Kothari, 2003; Purnanandam, 2008). These studies assume that derivatives usage is a good proxy for risk management activities (hedging behavior).

For the nonfinancial firms, the main objective of their hedge activities consists of hedging against foreign exchange rate and interest risk. The fluctuations in foreign exchange rate and interest rate values increase firm value volatility. The executives likely consider their risk attitude when deciding corporate hedging policy. The managerial risk aversion leads executive to hedge because his/her compensation is a function of firm value. The financial theory seems to imply that the corporate hedge behavior cannot contribute to the creation of shareholder value.

Berle and Means (1932) indicate that the separation between ownership and control. When the ownership of executives is not one hundred percent, it raises the issue of the agency problem between shareholders and executives. The executives struggle for self-serving and will devote their lifetime to aggrandize wealth, instead of achieving the value maximization goal of shareholders.

The equity-based compensations are often used to align the interests of shareholders and executives by providing executives with incentives to focus on shareholder value. When managerial compensation is often tied to the firm's stock price, executives are more risk-averse than shareholders because of their undiversified wealth. Smith and Stulz (1985) indicate executives hold an excess of the firm's share may become more risk-averse and they argue shareholders can affect managerial risk aversion through the compensation structure.

In contrast, executive stock options provide managerial risk-taking incentives to bear more risk and offer more than proportional benefits for increasing firm value. Guay (1999) shows that stock option grants as compared to stock can encourage executives to take more risky but positive NPV investments. When the executives' wealth is concentrated, they will have difficulty in diversifying firm's risk. Risk-aversion of the managers further increases the likelihood of using derivatives that are used for hedging purpose.

Prior studies indicate that when managers select corporate risk management choice, they also consider his/her stock and options holdings. It seems clear that executive's risk-taking incentives may be an important factor in a firm's hedging policy. Rogers (2002), Rajgopal and Shevlin (2002) and Pennings and Garcia (2004) find evidence that CEO risk-taking incentives may affect the firm's hedging types of derivatives usage and amount.

Furthermore, derivatives usage lies in the risk management decision. That is, managerial risk-taking incentives may be an important factor of corporate hedging policy. In short, firm awards shares to executives drive they hedge more; executive stock options are negatively associated with corporate hedging behavior, as corporate hedging decreases the volatility of share price consequently decrease the value of stock options. Executive stock options and firm shares have different sensitivities of value to changes in stock price and stock return volatility.

Derivatives are risk management tools and are mainly used to hedge risk that firm is routinely exposed to. This study examines factors behind how firms hold financial derivatives such as foreign currency derivative contract (*FX*) and interest rate derivative contract (*IR*). Since the 1980s, several literatures have started to investigate the relation between executives' risk-taking behaviors and the derivatives usage (Stulz, 1984; Smith and Stulz, 1985). Moreover, numerous researches show that the

executives' risk-taking incentives can be altered by equity-based compensation contract (Tufano, 1996; Geczy, Minton and Schrand, 1997; Schrand and Unal, 1998; Core and Guay, 1999; Rogers, 2005). These results reveal that firm awards stock options to executives conduce to their higher risk-taking behaviors, further diminishing the derivatives usage. However, firm awards restricted stock to executives could lead to less risk-taking incentive effects and the direction of effect is uncertain.

On the other hand, shareholders diversify their portfolios through asset allocation in capital market so that they are risk-neutral. On the basis of the discrepancy between risk-averse managers and risk-neutral shareholders, shareholders use of equity-based compensation contract for inducing managers to be less risk averse, risk-neutral, or even risk-seeking. Executives are motivated by strong risk-taking incentives to decrease the hedging derivatives usage, then obtaining the optimal risk management, which corresponds to shareholders' expectation; both firm's risk and stock price are increased (Smith and Stulz, 1985; Tufano, 1996).

This paper considers the change of managerial risk-taking incentives arising from firm adopts executive stock options (ESO), for this reason, taking account of risk-taking incentives of executives and the change of compensation structure, to examine the effect of derivatives usage on the nonfinancial firms listed on Taiwan Stock Exchange Corporation (TSEC) and the Gre Tai Securities Market (an over-the-counter market) in Taiwan. We follow Tufano (1996) and Geczy et al. (1997), the logarithm of executive stock value and the number of options holdings are assumed to be exogenous variables. According to Core and Guay (2002), delta and vega of stock and option holdings are taken as exogenous variables of risk-taking incentives. Similar to Rogers (2002), we use the relative risk-taking incentives of executives that are measured by the ratio of vega-to-delta. This ratio provides a

measure of CEO risk-taking incentives per dollar of value-increasing incentives from stock and stock option holdings.

In addition, different types of executive stock options may result in different level of managerial risk-taking incentive effects. We take both indexed stock options and traditional stock options into account to examine the relationship between derivatives usage and executives' risk-taking incentive. To this end, we obtained three results. First, managerial risk-taking incentives of traditional and indexed stock options have a negative and significant effect on the derivatives usage. Second, there is a statistical significant difference between risk-taking incentives of traditional stock options and indexed stock options; the latter provides stronger risk-taking incentives for executives. Third, we examine the relation between executives' risk-taking incentives and equity-based compensation; equity-based compensation is divided into stock options and stock. The results show that executive stock options have a positive and significant effect on managerial risk-taking incentives, while share holdings have a positive, insignificant effect on managerial risk-taking incentives.

The rest of the paper is organized as follows. Chapter 2 presents and discusses the related literatures and hypotheses. Chapter 3 describes the methodology and data. Chapter 4 contains the empirical results. Chapter 5 provides the conclusions and future research.

2. Literature review

2.1 CEO compensation and managerial risk-taking incentives

Smith and Stulz (1985) assume a manager' utility function is concave in expected wealth, which implies a manager is risk-averse; accordingly, shareholders take advantage of the executive compensation structure to offset the influence of risk-aversion incentive. If the manager's expected wealth utility is a concave function

of firm value, the expected income of the manager is maximized if the firm is completely hedged. If the manager's expected wealth utility is a convex function of firm value, the manager will be a risk-lover.

In general, risk-neutral shareholders would like the CEO to take positive net present value (NPV) projects; on the other hand, risk-averse managers are likely to avoid some risky but positive NPV projects. Executive stock options provide risk-averse executives risk-taking incentives that they would invest in risky investment projects to maximize firm value. Prior studies have examined managerial risk-taking incentives and compensation contracts that are summarized as follows.

Chen and Ma (2011) examine the risk-taking effect of stock options on firm performance by taking into consideration managers personal risk aversion. They find that stock options increase managerial risk-taking, but such risk-taking is constrained by managers' personal risk aversion. They further find that managers focus their concerns more on stock risk and return rather than near-term accounting results.

Coles, Daniel and Naveen (2006) find a positive associated between stock options risk-taking incentives and R&D expenditures and leverage as well as a negative associated with the number of lines of business.

Kempf, Ruenzi and Thiele (2009) examine the influence on fund managers' risk taking of incentives due to employment risk and due to compensation, suggesting that managerial risk taking crucially depends on the relative importance of "compensation incentives" and "employment incentives". They show managerial risk taking behavior depends on the interim performance of the funds they manage: compensation incentives lead managers of funds with a poor interim performance to increase their fund's risk relative to managers of funds with a good interim performance. In contrast, employment incentives lead managers of funds with a poor interim performance to decrease their fund's risk relative to managers of funds with a good interim

performance.

Tufano (1996) surveys gold mining firms in North America and shows that managerial risk-taking incentive is the determinant of corporate hedging policy. He assumes that managers' stock and option holdings are exogenous variables, and they find a negative correlation between net derivative holdings and risk-taking incentives. Specifically, executives who own more stock options hedge less, but executives who own more shares of stock manage hedge more, which infers options may give rise to higher managerial risk-taking incentives. Nevertheless, the large numbers of shares held by executives may be more willing to commit his/her firm to higher levels of risk management, which implies stocks may result in lower managerial risk-taking incentives.

Rogers (2002) studies the cross-sectional data of 569 firms from December 15, 1994 to October 31, 1995, in which CEO risk-taking incentive is assumed to be an endogenous variable, and the vega-to-delta ratio of all stock and option holdings is taken as a proxy variable of CEO risk-taking incentives. He finds a strong negative relation between CEO risk-taking incentives and the amount of derivative holdings, which infers that the primary purpose of derivatives usage is to hedge.

Rajgopal and Shevlin (2002) investigate the influence of ESO risk-taking incentives on actions that CEOs of oil and gas firms take to manage exploration risk, and treat ESO risk-taking incentives and exploration risk as endogenous variables. They find that ESO risk-taking incentives have a positive relation with future exploration risk taking. Overall, their results are consistent with ESOs providing managers with incentives to mitigate risk-related incentive problems.

Low (2009) provides strong empirical evidence regarding the impact of equity-based compensation on managerial risk-taking behavior, find that the decrease in risk is mainly among firms with low sensitivity of CEO wealth to stock return

volatility (low vega) and the risk reductions are associated with decreases in share prices. Taken together, Low (2009) suggests that managerial risk aversion is a serious agency problem and that vega, in contrast to delta, is a more efficient mechanism for mitigating managerial risk aversion.

Armstrong and Vashishtha (2012) examine how stock options give CEOs differential incentives to alter their firms' systematic and idiosyncratic risk and find that vega gives CEO incentives to increase their firms' total risk by increasing systematic risk but not idiosyncratic risk.

2.2 The types of executive stock options

Firm awards stock options to executives for aligning the interest of risk-averse executives with risk-neutral shareholders. There are many non-traditional stock options that are proposed, but have not yet developed, such as a performance-vested stock option, repriceable stock option, purchased stock option, premium stock option, indexed stock option and so on (Johnson and Tian, 2000).

Traditional options, because strike prices are fixed initially, have weaker incentive effects for managers during times of economic boom or depression. In a bull market period, the stock price rises owing to the economic situation, but being irrelevant to executives' effort; executives need not work hard to improve their firms' performance and invest in risky projects. However, they still obtain high compensation because of the increasing value of stock options. On the other hand, in the period of economic recession, even though exhausted from working, managers could fail to make stock options in the money. Johnson and Tian (2000) propose the indexed stock option model which strike price is not fixed but indexed to a stock price index (industry or marketwide) or the competitor's stock price for improving disadvantage of traditional stock options and enhancing managerial incentive effects. Indexed stock options provide CEOs only for idiosyncratic stock price appreciations, and should not be

punished for stock price declines caused by the overall market downturn. They do numerical analysis to compare indexed stock options with traditional options, and their findings confirm that, for increasing stock price or managerial risk-taking incentives, indexed stock options is better than traditional stock options with respect to the risk-taking incentive effect.

Indexed stock options provide that CEOs are rewarded only for idiosyncratic stock price appreciation; a higher systematic risk causes a low option value due to indexing. Duan and Wei (2005) use a GARCH option pricing framework to show that the incentive effects of executive stock options increase with systematic risk and this effect is stronger when the total risk is low. They compare standard stock options, non-indexed stock options and indexed stock options, find that when firms grant standard or non-indexed options, CEOs will have incentives to increase systematic risk even when the total risk remains constant. Indexed stock options will provide CEOs with incentives to reduce systematic risk. They conclude that an optimal mix of indexed and non-indexed options grants will provide CEOs with incentives to take the desired level of systematic risk. A mixture of the two options offers a promising possibility for risk control.

Calvet and Rahman (2006) derive a subjective pricing model for the class of capital-asset pricing model (CAPM)-based index-style stock options and investigating their incentive effects. Indexed stock options can be made flexible to encompass a variety of cases, be they related to the degree of risk aversion of executives, the percentage of stock ownership, or the desired level of executive performance. Contrary to previous works, Calvet and Rahman (2006) indicate executives do not have an incentive to take on investment projects with high idiosyncratic risk once their lack of diversification and degree of risk aversion are factored in the analysis.

According to the above discussions, the hypotheses are proposed as follows.

Hypothesis 1: When executives use the non-trading purpose derivatives for hedging, managerial risk-taking incentive has a negative effect on the use of derviatives.

Hypothesis 2: Indexed stock options provide executives with more risk-taking incentives and induce executives to hedge less than traditional stock options.

Hypothesis 3: Executive stock option holdings increase more managerial risk-taking incentives than executive shareholdings.

3. Method

3.1 Model

We use the following regression models to examine our hypotheses.

3.1.1 Hedging behavior model

Hedging behavior = f (*Vega/Delta, BTM, R&D, CAPEX, Acid, Debt, ROA, ISP, Size*) (1)

Géczy, Minton and Schrand (1997) find that firms with the greatest economies of scale in implementing and maintaining a risk management program are more likely to use currency derivatives. Net notional values for FX and IR derivatives have recently been used in Graham and Rogers (2002) and Rogers (2002)[1]. We follow Graham and Rogers (2002) and Rogers (2002) using the sum of net currency and interest rate positions scaled by total assets as the dependent variable in our regression analyses[2] and use only derivatives held for non-trading purposes. Most nonfinancial firms disclosed that derivatives are held for risk management purposes.

[1] Rogers (2002) indicates net notional values may provide a less noisy proxy than total notional values because derivative usage takes into account the effect of holding both "long" and "short" positions in similar derivative contracts.

[2] For example, suppose a firm has a notational value of NT$5 million long interest rate, NT$2 million short interest rate, NT$ 6 million long US dollars, and NT$5 million short Euros. The firm's net position in IR (FX) derivatives is NT$3 (NT$11) million. Following Graham and Rogers (2002), we use absolute values because hedging to maximize firm value may require going long in one derivatives category but short in another. The sum of the net absolute IR and FX derivative holdings is NT$14 million in this example. Following Graham and Rogers (2002) we ignore commodity derivatives, because of the possibility of physical delivery (such as with commodity futures contracts).

Following Rogers (2002), we use a managerial option $\frac{Vega}{Delta}$ to measure managerial risk-taking incentives per dollar of value-increasing incentives form stock and stock option holdings[3]. Smith and Stulz (1985) and Froot, Scharfstein and Stein (1993) indicate that when a firm has more growth opportunities, the benefits of hedging increase; because hedging derivatives usage can reduce the volatility of cash flow and underinvestment costs, investment projects would be carried out with certainty, namely, growth opportunity has a great impact on corporate hedging policy. We use the book to market ratio (*BTM*), R&D expenses (*R&D*), and capital expenditure (*CAPEX*) as proxy variables for growth opportunity.

Moreover, when firms face financial crisis, financial distress costs increase, and managers will increase hedging derivatives usage to mitigate the loss. Financial distress costs are the determinant of corporate policy. Nance et al. (1993) represent that when firms are of high liquidity and equipped with a greater financial buffer, the probability of financial distress could be lower, and consequently firms tend to hedge less. We follow Rogers (2002) using an acid-test ratio (*Acid*), debt ratio (*Debt*), and return on assets (*ROA*) as proxy variables for financial distress costs.

DeMarzo and Duffie (1991) emphasize that information asymmetry exists between managers and shareholders; while managers have an advantage of possessing more information associated with the firm's risk exposures, shareholders consent to hedge more for exposure position. We use the ownership of institutional investors (*ISP*) and firm's market capitalization (*Size)* as proxy variables for information asymmetry.

3.1.2 Managerial risk-taking incentives model

[3] See the parameter estimation details in the Appendix.

Managerial risk-taking incentives = *f* (*ESO holdings/outstanding shares,*

Stock holdings/ outstanding shares, SD, BTM, R&D, SR) (2)

The dependent variable is executives' risk-taking incentives, managerial option $\frac{Vega}{Delta} = \frac{\partial S}{\partial \sigma}$. Core and Guay (1999) find that firms use annual grants of stock options and restricted stock to CEOs to manage the optimal level of equity incentives. In addition, as to the level of executives' risk-taking incentives, we follow Rogers (2002) employ a ratio of vega-to-delta as a proxy variable[4]. This ratio provides a measure of managerial risk-taking incentives per dollar of value-increasing incentives form stock and stock option holdings. Vega is the partial derivatives with respect to stock return volatility that represents the executive's risk-taking incentives that increases the volatility by one percentage point. Delta is the partial derivative with respect to underlying stock price which measures the stock option value change as the change in the price of the underlying stock.

Knopf et al. (2002) find as the sensitivity of the total portfolio to stock price increases, the firm tends to hedge more; but as the sensitivity of the stock option portfolio to stock return volatility increases, the firm tends to hedge less. The different type of executive compensation drives different managerial risk-taking incentives.

Aggarwal and Samwick (1999) indicate that the higher firm risk, the lower pay-performance sensitivity. Accordingly, less risk-averse managers are inclined to select high-risk firms. In other words, in high-risk firms, executives have stronger risk-taking incentives. Consequently, for the measure of firm risk, we use firm's standard deviation of monthly stock return over the previous 12 months as a proxy

[4] Rogers (2002) proposes the advantages of taking the ratio of vega-to-delta into consideration at the same time are regression model can simultaneously consider incentive effects created by stock and option grants and both vega and delta are influenced by firm size, vega divided by delta, which can reduce the effect of different firm size. Executives are risk-averse; Black-Scholes (1973) pricing model is constructed on the basis of a risk-neutral world, which will lead to deviations, taking vega divides by delta which can reduce errors and incorrect estimate.

variable of the firm's ex ante risk.

Firms provide executives with equity-based compensation for increasing managerial risk-taking incentives; nevertheless, risk-taking incentives do not fully depend on equity-based compensation, because several other factors will cause executives to be less risk-averse. Smith and Watts (1992) point out that when executives hold more stock and stock options, the firm has greater growth opportunity, which suggests managers tend to invest in beneficial projects. We employ the book to market ratio (*BTM*) and R&D expenses (*R&D*) as proxy variables. Rogers (2002) assumes a six-month stock return (*SR*) is utilized in the model of current incentives. Table 1 summarizes the definitions for each of the above-mentioned variables.

[Insert Table 1 here]

3.2 Data and descriptive statistics

We collect the nonfinancial firms' stock options data and the yearly notional amount of derivatives for non-trading purpose from the *Market Observation Post System (MOPS*) while firm characteristics and stock price data are collected from the *Taiwan Economic Journal Database (TEJDB).* Our study covers the period between 2001 and 2011 for the nonfinancial firms listed on the Taiwan Stock Exchange (TSE) and the Gre Tai Securities Market (an over-the-counter market). The start date is the first year that listed firms granted stock options to executives in Taiwan. The final sample consists of 1,552 individual stock options award after deleting 32 samples due to those firms with incomplete financial information.

4. Empirical results

Table 2 summarizes the descriptive statistics of all variables. The mean of the net

notional values of hedging derivative holdings (*FX* + *IR*) is NT$ 412,583 thousand. The mean of $\frac{FX+IR}{Total\ asset}$ is 6 percent of total assets. The mean of managerial option $\frac{Vega}{Delta}$ (traditional stock options) and managerial option $\frac{Vega}{Delta}$ (indexed stock options) is 4.16 and 6.83, respectively. This suggests the indexed stock options provide stronger risk-taking incentives to executives. The mean of the number of unexercised stock options by executives (ESO holdings) and number of stock holdings shares (Stock holdings) in firm level is 10.386 million and 271.006 million, respectively. The mean of stock options holdings scaled by total shares outstanding ($\frac{ESO\ \ holdings}{outstanding\ \ shares}$) and stock holdings scaled by total shares outstanding ($\frac{Stock\ \ holdings}{outstanding\ \ shares}$) is 2.96% and 21.16%, respectively.

[Insert Table 2 here]

In addition, we test the difference between the managerial risk-taking incentives (managerial option $\frac{Vega}{Delta}$) of traditional and indexed stock options in Table 3. As Table 3 shows, there is a statistical significant difference between risk-taking incentives in traditional and indexed stock options. In brief, indexed stock options provide stronger risk-taking incentives for executives.

[Insert Table 3 here]

4.1 Hedging behavior

In this section, we examine the relation between the firm's hedging behavior and executives' risk-taking incentives. Table 4 reports the results of the hedging behavior model. Two versions are presented. The dependent variable is the vega-to-delta ratios to proxy for managerial risk-taking incentives. We analyze the indexed and traditional

stock options[5] in the aspect of managerial risk-taking incentive effects. In Model 1, the risk-taking incentives (managerial option $\frac{Vega}{Delta}$) of traditional stock options (coeff. = -0.205, *p*-value < 10%) is negative and has a significant effect on net notional values of hedging derivatives usage scaled by total assets. This negative relation is consistent with equity-based compensation triggering executives risk-taking and theoretical predictions of Smith and Stulz (1985) one way to mitigate managerial risk aversion is to provide executive payoff structure contracts that is a convex function of the firm's stock price. And this finding is consistent with the result of Knopf et al. (2002) as the sensitivity of manager's stock option portfolios to stock return volatility increase, firms tend to hedge less. The return on assets (*ROA*) (coeff. = -2.083, *p*-value <5%) is negative and significant effect on the net notional values of hedging derivatives usage scaled by total assets, which imply executives reduce the level of hedging behavior while the firm has good profitability.

In Model 2, the managerial risk-taking incentives (managerial option $\frac{Vega}{Delta}$) of indexed stock options (coeff. = -0.239, *p*-value < 5%) is negative and has a significant effect on net notional values of hedging derivatives usage scaled by total assets. In both models, the firm size is negatively associated with net notional values of hedging derivatives usage scaled by total assets.

[Insert Table 4 here]

4.2 Managerial risk-taking incentives

Grating stock options to executives not only motivates executives to maximize stock price, but also increase executives' risk-taking incentives, which may encourage executives to increase firm's specific risks. The managerial compensation structure

[5] See the parameter estimation details in the Appendix.

(stock and stock option holdings) is considered a determinant of the corporate hedging behavior. Tufano (1996) examines gold mining firms and finds that managerial risk aversion which related to components of stock and stock option holdings is a key determinant of risk management policy. But he does not use the broader-based samples to confirm this relation.

In this section, we examine the relation between executives' risk-taking incentives and executives' equity-based compensation holdings. The results are shown in Table 5. Four versions are presented. In model 1, ex ante risk (*SD*) has a positive and significant effect (coeff. = 0.329, *p*-value < 1%) on executive's risk-taking incentives. Managerial risk-taking incentives are a positive function of ex ante risk level. Model 2 shows the key factor executives' stock options to outstanding shares ($\frac{ESO\ \ holdings}{outstanding\ \ shares}$) has a positive and significant effect (coeff. = 0.351, *p*-value < 1%) on executive's risk-taking incentives, suggesting executives hold more stock options; they would be less risk-averse.

We find the results from Model 3 of Table 5, executives' stock holdings to outstanding shares ($\frac{Stock\ \ holdings}{outstanding\ \ shares}$) has a positive but insignificant effect on managerial risk-taking incentives. The results from Model 4 of Table 5 suggest that managerial stock option holdings are positively related to risk-taking incentives, but share holdings are not, that suggest managerial risk-taking incentives come from stock options holdings.

The evidence on managerial ownership affects risk-taking incentive is inconclusive due to the mixed incentives provided by stock compensation. The result is different with Grant, Markarian and Parbonetti (2009) indicating that the CEO's higher share ownership is related to having lower levels of risk incentive.

In the four models, book to market ratio (*BTM*), which proxies for future growth

opportunities has a positive and significant impact on executives' risk-taking incentives; this result suggests higher-growth firms is related to higher managerial risk-taking incentives. Moreover, *R&D* and market return (*SR*) show a negative and significant relation with managerial risk-taking incentives. The result is similar to Grant et al. (2009)'s finding indicate that the higher investment risk, the lower risk-taking incentives given to the executives. The result of market return (*SR*) is consistent with Rogers (2002) lower returns are associated with higher vega-to-delta ratio.

[Insert Table 5 here]

5. Conclusions

In this study we have investigated the relation between managerial risk-taking incentives and derivatives usage. The results show managerial risk-taking incentives of traditional and indexed stock options are negative and has a significant effect on the derivatives usage. This negative relation is consistent with equity-based compensation triggering executives risk-taking. Further we find there is a statistical significant difference between managerial risk-taking incentives of traditional stock options and indexed stock options. Our analysis shows that indexed stock options provide stronger risk-taking incentives for executives.

In addition, we divide equity-based compensation into stock and stock options to examine the relation between managerial risk-taking incentives and managerial equity-based compensation holdings. The results show that executive stock options have a positive and significant effect on managerial risk-taking incentives, suggesting executives hold more stock options, they would be less risk-averse. The managerial share holdings have a positive but insignificant effect on managerial risk-taking incentives.

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Appendix

We use the traditional stock options pricing model proposed by Merton (1973) and the indexed stock options pricing model by Johnson and Tian (2000). The traditional stock option pricing model proposed by Merton (1973) is:

$$C_t^M = S_t e^{-q_s(T-t)} N(d_{1,t}) - K e^{-r(T-t)} N(d_{2,t})$$

$$d_{1,t} = \frac{\ln \frac{S_t}{K} + (r - q_S + \frac{1}{2}\sigma^2)(T-t)}{\sigma\sqrt{T-t}},\ d_{2,t} = d_{1,t} - \sigma\sqrt{T-t}$$

$$vega = \frac{\partial C_t^M}{\partial \sigma} = S_t e^{-q_S(T-t)} n\left(d_{1,t}\right)\sqrt{T-t}\ ,\ \ delta = \frac{\partial C_t^M}{\partial S_t} = e^{-q_S(T-t)} N\left(d_{1,t}\right)$$

The indexed stock option pricing model proposed by Johnson and Tian (2000). We use the parameters to simulate managerial risk-taking incentives from indexed stock options

$$C_t = e^{-q_S(T-t)}[S_t N(d_{1,t}) - \lambda H_t N(d_{2,t})]$$

$$d_{1,t} = \frac{\ln\frac{S_t}{\lambda H_t} + \frac{1}{2}\sigma_a^2(T-t)}{\sigma_a\sqrt{T-t}}\ ,\ \ d_{2,t} = d_{1,t} - \sigma_a\sqrt{T-t}\ ,\ \ \sigma_a = \sigma_S\sqrt{1-\rho^2}$$

$$vega = \frac{\partial C_t}{\partial \sigma_S}$$

$$= \lambda H_t e^{-q_S(T-t)}\left(\sqrt{(1-\rho^2)(T-t)}\, n\left(d_{2,t}\right) - \left[\frac{\rho}{\sigma_I}\ln\left(\frac{I_t}{I_0}\right) + t\left(\frac{\rho\sigma_I}{2} - \rho^2\sigma_S - (r-q_I)\frac{\rho}{\sigma_I}\right)\right] N\left(d_{2,t}\right)\right)$$

$$delta = \frac{\partial C_t}{\partial S_t} = e^{-q_S(T-t)} N\left(d_{1,t}\right)$$

where *St* is the closing price of the adjusted stock price at time t. *K* denotes strike price ($K = S_0$ in the traditional stock options model; $K = H_t$ in the indexed stock options model.); we define H_t as strike price with indexed model. $H_t = S_0\left(\frac{I_t}{I_0}\right)^{\beta} e^{\eta t}$, where $\eta = (r - q_S) - \beta(r - q_I) + \frac{1}{2}\rho\sigma_S\sigma_I(1-\beta)$; I_0 is the market index at grant date; I_t is market closing index at time t; *r* is the risk-free rate. *T* is the year of maturity; λ is

the granting stock options out of money level; q_s is dividend yield on stock; σ_S is the volatility of stock price; σ_I is the volatility of market index; ρ is the correlation coefficient of the firm's stock price and market index.

Table 1 Variable definitions

Variables		Definition
Managerial ESO holding	*ESO holdings/ outstanding shares*	The ratio of ESO holdings by executives to outstanding shares
Managerial stock holdings	*Stock holdings/ outstanding shares*	The ratio of stock holdings by executives to outstanding shares
Managerial option risk-taking incentive	Managerial option $\frac{Vega}{Delta}$	The ratio of vega-to-delta is calculated by vega / delta. Vega is the change in the stock option's value per 1% increase in the firm's annualized stock return volatility. Delta is the change in stock and stock option's value per 1% increase in the firm's stock price.
Hedging behavior	$\frac{FX + IR}{Total\ asset}$	The net notional values of hedging derivatives usage / total assets. *FX* is the net notional values of foreign currency derivatives usage. *IR* is the net notional values of interest rate derivatives usage.
Book to market ratio	*BTM*	Book value of equity / market value of equity
R&D	*R&D*	R&D expense / total assets
Capital expenditure	*CAPEX*	Capital expenditures scaled by book value of assets
Acid ratio	*Acid*	(Cash + accounts receivable + short-term investments) / current liabilities
Debt ratio	*Debt*	Total debt / total asset
Return on asset	*ROA*	Operating income / total assets
Firm size	*Size*	Natural logarithm of market capitalization
Institutional ownership	*ISP*	The ownership by institutional investors
Stock return	*SR*	The average six-month stock return
Ex ante risk	*SD*	The standard deviation of monthly stock return over the previous 12 months.

Table 2 Summary statistics

Variable	Max.	Min.	Mean	Median	Std. Dev.
FX + IR (thousand)	11,128,263	10.23	412,583	36,419	1,265,329
$\frac{FX+IR}{Total\ assets}$	0.72	0.01	0.06	0.08	0.13
Managerial option $\frac{Vega}{Delta}$ (traditional stock options)	20.31	2.86	4.16	3.89	3.27
Managerial option $\frac{Vega}{Delta}$ (indexed stock options)	26.97	0.01	6.83	5.71	4.78
ESO holdings (thousand shares)	312,687	76	10,386	2,217	29,693
Stock holdings (thousand shares)	4,623,923	3,879	271,006	35,112	609,617
$\frac{ESO\ \ holdings}{outstanding\ \ shares}$ (%)	8.69	0.01	2.96	0.87	1.69
$\frac{Stock\ \ holdings}{outstanding\ \ shares}$ (%)	53.03	3.77	21.16	17.01	10.29
BTM	0.26	0.02	0.09	0.08	0.04
R&D	0.06	0.00	0.01	0.004	0.01
CAPEX	67.35	0.00	14.67	11.02	13.96
Acid	11.06	0.00	1.89	1.33	1.42
Debt	0.71	0.08	0.46	0.49	0.17
ROA	0.62	-0.31	0.14	0.11	0.16
ISP	0.55	0.00	0.10	0.05	0.12
Size (million)	1,306,578	287	28.969	3.728	141,032
SD	0.39	0.05	0.17	0.14	0.06
SR	25.18	-25.61	1.03	1.12	7.12

The sample is collected from the nonfinancial firms listed on Taiwan Stock Exchange and the Gre Tai Securities Market (an over-the-counter market) which consists of 1,552 firm-year observations between 2001 to 2011. All variables are defined in Table1.

Table 3 Difference between managerial risk-taking incentive on traditional and indexed stock option model

Variable	Mean	Std. Dev.	*t*-value	*p*-value
Managerial option $\frac{Vega}{Delta}$ (traditional stock options model)	4.16	3.27	-4.39	0.001***
Managerial option $\frac{Vega}{Delta}$ (indexed stock options model)	6.83	4.78		

The sample is collected from the nonfinancial firms listed on Taiwan Stock Exchange and the Gre Tai Securities Market (an over-the-counter market) which consists of 1,552 firm-year observations between 2001 to 2011. Managerial option $\frac{Vega}{Delta}$ is the ratio of vega-to-delta is calculated by vega / delta. *** Significant at 1% level.

Table 4 Regression of hedging behavior model

Variable	Model 1 Traditional stock options	Model 2 Indexed Stock options
Managerial option $\frac{Vega}{Delta}$	-0.205*	-0.239**
	(0.061)	(0.011)
BTM	0.081	0.085
	(0.431)	(0.402)
R&D	-0.163**	-0.206**
	(0.031)	(0.019)
CAPEX	0.103	0.093
	(0.193)	(0.227)
Acid	0.093	0.098
	(0.361)	(0.335)
Debt	0.131	0.129
	(0.219)	(0.221)
ROA	-2.083**	-2.031**
	(0.039)	(0.043)
ISP	0.131	0.128
	(0.131)	(0.134)
Size	-0.279**	-0.289**
	(0.011)	(0.015)
Adjusted R^2	0.15	0.19

The sample is collected from the nonfinancial firms listed on Taiwan Stock Exchange and the Gre Tai Securities Market (an over-the-counter market) which consists of 1,552 firm-year observations between 2001 to 2011. The dependent variable is the net notional values of hedging derivatives usage / total assets (*(FX+IR)/Total assets*). *FX* is the net notional values of foreign currency derivatives usage. *IR* is the net notional values of interest rate derivatives usage. All variables are defined in Table1. *p*-values are in parentheses. ***, ** and * denote significance at 0.01, 0.05 and 0.1 levels, respectively.

Table 5 Regression of managerial risk-taking incentives model

Variable	Model 1	Model 2	Model 3	Model 4
$\frac{ESO\ holdings}{outstanding\ shares}$		0.351***		0.173***
		(0.006)		(0.007)
$\frac{Stock\ holdings}{outstanding\ shares}$			0.109	0.123
			(0.231)	(0.381)
SD	0.329***	0.331***	0.412***	0.358***
	(0.001)	(0.001)	(0.001)	(0.001)
BTM	0.357***	0.373***	0.433***	0.481***
	(0.001)	(0.001)	(0.001)	(0.001)
R&D	-0.111**	-0.125**	-0.127*	-0.136**
	(0.041)	(0.039)	(0.071)	(0.046)
SR	-0.139**	-0.149**	-0.155**	-0.136**
	(0.042)	(0.029)	(0.019)	(0.026)
Adjusted R^2	0.28	0.32	0.35	0.37

The sample is collected from the nonfinancial firms listed on Taiwan Stock Exchange and the Gre Tai Securities Market (an over-the-counter market) which consists of 1,552 firm-year observations between 2001 to 2011. The dependent variable is Managerial option Vega/Delta of the traditional stock options model. All variables are defined in Table 1. *p*-values are in parentheses. ***, ** and * denote significance at 0.01, 0.05 and 0.1 levels, respectively.