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The Volatility and Price Sensitivities of Managerial Stock Option Portfolios and Corporate Hedging

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ABSTRACT

We use estimates of the Black–Scholes sensitivity of managers' stock option portfolios to stock return volatility and the sensitivity of managers' stock and stock option portfolios to stock price to test the relationship between managers' risk preferences and hedging activities. We find that as the sensitivity of managers' stock and stock option portfolios to stock price increases, firms tend to hedge more. However, as the sensitivity of managers' stock option portfolios to stock return volatility increases, firms tend to hedge less.

ONE OF THE AGENCY COSTS associated with the corporate form of ownership comes from the risk aversion of the firm's managers. The typical corporate manager has a significant portion of his or her wealth invested in the corporation, both through portfolio holdings and the value of firm-specific human capital. As a result, managers have an incentive to reduce firm risk more than may be desirable from the perspective of an unaffiliated, diversified shareholder. One way to mitigate managerial risk aversion is to provide the manager with contracts that have a payoff structure that is a convex function of the firm's stock price (Smith and Stulz (1985)). Guay (1999) finds that stock options are an important way in which convexity is added to managers' portfolios.

However, as recognized by Carpenter (2000) and Lambert, Larcker, and Verrecchia (1991), stock options create two opposing effects on managerial incentives. The first effect is sensitivity to stock return volatility. Due to the convex payoff structure of options, the value of a manager's stock option portfolio increases with the volatility of the firm's stock returns. This sensitivity to stock return volatility should, *ceteris paribus*, give the manager an incentive to take more risk. The second effect is sensitivity to stock price. This effect comes from the direct link between the payoff of an option and

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the movements in the underlying stock price. Options tie a manager's wealth to the stock price, thereby decreasing a risk-averse manager's willingness to bear risk. The size of this effect is determined by the relative sensitivity of the stock option portfolio value to changes in the price of the stock as well as other factors such as the manager's outside wealth, stockholdings, and coefficient of risk aversion. *Ceteris paribus*, sensitivity to stock price should give a risk-averse manager an incentive to avoid risk.

In this paper, we examine the relationship between the two sensitivities inherent in managerial stock and stock option portfolios and the use of derivatives by nonfinancial corporations to reduce risk. In our tests, we first use proxies for managers' stock option portfolios constructed in a manner similar to previous studies of derivatives usage (Geczy, Minton, and Schrand (1997) and Gay and Nam (1998)). Using these proxies we find a positive relationship between managers' stock option portfolios and hedging. These results are consistent with the earlier studies, but inconsistent with the theoretical predictions of Smith and Stulz (1985), who base their arguments on the sensitivity of options to stock return volatility. We then use the one-year approximation procedure developed by Core and Guay (1999) to separately estimate the sensitivities of managers' stock option portfolios to stock return volatility and managers' stock and stock option portfolios to stock price. Consistent with the theoretical predictions of Smith and Stulz, we find that hedging activities are positively related to the sensitivity of a manager's stock and stock option portfolio to stock price, and that hedging activities are negatively related to the sensitivity of the manager's stock option portfolio to stock return volatility; however, this latter relationship is not statistically significant. We conclude that these sensitivities provide a more powerful test of managerial incentives than the proxies used in earlier studies.

Several theories have been advanced to explain the prevalence of hedging with derivatives by corporations[1] and a growing number of studies test these theories. Two approaches are used in the literature to empirically test the theories of corporate hedging. One approach is to select a specific industry in which risk exposures can be measured relatively precisely (e.g., Tufano (1996) and Rajgopal and Shevlin (2000)). The other approach is to select a broad sample of firms (e.g., Geczy et al. (1997) and Gay and Nam (1998)).

Within the specific-industry strain of the literature, Rajgopal and Shevlin (2000) test the two incentive effects of managers' portfolios for oil and gas production firms. They find a negative relationship between hedging activities and the sensitivity of the manager's portfolio to stock return volatility. One concern with the specific-industry approach to testing hedging theories is whether the results found can be generalized to other industries. Another

[1] In addition to the managerial incentives theory of Smith and Stulz (1985), several theories are based on the shareholder wealth maximization paradigm in which hedging activities are justified based on market imperfections such as taxes, costs of financial distress, and the underinvestment problem (see Smithson (1996) for a summary of these theories and the empirical evidence).

concern is that these studies focus on one specific type of risk instead of the total risk exposure of the firm. Our study takes the broad sample approach; hence, our study generalizes the findings of Rajgopol and Shevlin by showing that similar results hold in a broad sample of firms with multiple risk exposures.[2]

The remainder of the paper is organized as follows. Section I describes the variables we use as proxies to measure the managerial incentives to manage risk, the control variables we include in our tests, and the predicted relationships between these variables and hedging activities. Section II describes our sample and the methodology used in the tests. Section III reports the results of our analysis. Section IV concludes the paper.

I. Tests and Variables

A. Measures of Managerial Wealth Sensitivities

According to the managerial incentives theory of hedging (Smith and Stulz (1985)), a manager will induce the firm to hedge more as the sensitivity of the manager's wealth to stock price increases, and will induce the firm to hedge less as the sensitivity of the manager's wealth to stock volatility increases. Therefore, the correct variables for our tests should measure the total sensitivities of wealth to stock price and volatility. Our proxies measure these sensitivities with considerably less error than previous studies. This finding is the major contribution of our study.

A.1. Number and Value of Options as Proxies

To determine whether our proxies are indeed better than the proxies used in previous studies, we first test the relationship between hedging activity and managerial incentives using variables constructed in a manner similar to previous studies. Then we rerun the test using our proxies. We use information on the portfolio holdings of the CEO of the company to construct all of the variables. The first proxy from previous studies is LOPTNUM, the logarithm of the number (in thousands) of options exercisable within 60 days of the end of fiscal year 1996. An unlogged version of this variable is used in Tufano (1996) and Gay and Nam (1998). The other proxy is LOPTION, the logarithm of the market value (in $ thousands) of the shares obtainable by exercising options within 60 days of the end of fiscal year 1996. Geczy et al. (1997) use this variable. Smith and Stulz (1985) imply a negative relationship between both of these variables and hedging activities.

LOPTNUM and LOPTION, our initial proxies for the CEOs' option portfolios, are rather crude approximations of the incentives to manage risk due to option holdings for a number of reasons: (a) the measures do not take into

[2] Graham and Rogers (2002) also study a broad sample of firms and include portfolio sensitivities. However, the primary focus of their paper is on issues other than managerial incentives, and they do not include commodity derivatives in their tests.

consideration the strike price or maturity of the options; (b) they ignore unexercisable options; and (c) they do not directly measure the two opposing effects on managerial incentives that come from stock options.

A.2. Price and Volatility Sensitivities as Proxies

To provide more direct estimates of the sensitivities, we use the Core and Guay (1999) procedure to estimate the partial derivatives with respect to stock return volatility and stock price of the Black–Scholes option-pricing model as adjusted for dividends by Merton (1973). From these partial derivatives we construct our proxies. The first proxy is LVOLSEN, the logarithm of the change in the Black–Scholes value (in $ thousands) of the CEO's option portfolio resulting from a one percent change in the annualized standard deviation of the firm's stock return. We calculate LVOLSEN for the option portfolio of the CEO only. Due to limited liability, stock payoffs are also convex and therefore the stock portfolio value is also sensitive to return volatility. However, Guay (1999) demonstrates that this sensitivity is substantially smaller than the option portfolio sensitivity to volatility. Therefore, we do not include an estimate of stock portfolio sensitivity in our proxy for sensitivity to volatility. The second sensitivity variable is LPRICESEN, the change in the Black–Scholes value (in $ thousands) of the CEO's option portfolio resulting from a one percent change in the firm's stock price plus the change in the value of the CEO's stock portfolio from a one percent change in the firm's stock price. Notice that this variable takes into consideration both the option portfolio and the stock portfolio of the CEO. We expect a negative relationship between LVOLSEN and hedging and we expect a positive relationship between LPRICESEN and hedging.

The Core and Guay (1999) procedure allows researchers to apply an option-pricing model, such as Black–Scholes, to accurately estimate sensitivities from the incomplete information that is typically available in proxy statements. In particular, one needs the strike price and maturity of all of the options in the portfolio for estimating sensitivities. Options are disclosed in three different categories in proxy statements: (a) options granted during the current fiscal year, (b) nonexercisable options, and (c) exercisable options. Most corporate proxy statements provide the information necessary for computation of a Black–Scholes value only for options granted in the current fiscal year. Until recently, the only way to estimate the sensitivities of the remaining options was to construct a very labor-intensive data set from a time series of up to 10 or more proxy statements for each firm. However, Core and Guay provide an approximation technique based only on data from one proxy statement, CRSP, COMPUSTAT, and U.S. Treasury yields. Their procedure estimates the average strike price by using a table in the proxy statement that provides the number and current realizable value of exercisable and unexercisable options held by the manager. They estimate the maturity as one year less than the maturity of new options for unexercisable options and four years less for exercisable options. They provide evi-

dence that their procedure produces measures of sensitivities that are very highly correlated with values calculated using the complete time series of proxy statements.

The firm-specific portfolio holdings of managers include stock as well as stock options. Assuming a linear payoff function for common stock, the stock holdings of managers increase the undiversifiable component of the managers' wealth and should therefore increase the managers' tendency to hedge. Our proxy for the managers' stock holdings is LSTOCK, the logarithm of the market value as of the end of fiscal year 1996 of all shares of common stock of the firm beneficially owned by the CEO. Based on the arguments of Smith and Stulz (1985), managers with a higher value of shares owned should be more likely to engage in hedging activities.

B. Control Variables

Many factors affect the hedging activity of firms. Therefore, to improve the explanatory power of our model, we include the variables that previous researchers have shown to influence firm hedging decisions. Furthermore, including the control variables is important because they may be correlated with the stock-based incentive variables.

B.1. Outside Wealth of the Manager

To control for the diversifiable wealth held by the manager, we include *CASH*, the ratio of the sum of salary and bonus to total compensation (the sum of salary, bonus, the value of restricted stock grants, long-term incentive payments, the value of stock option grants, and other compensation) for the CEO in 1996. Since the presence of a diversified outside portfolio should mitigate a manager's risk aversion, we expect a negative relationship between *CASH* and hedging.[3]

B.2. Constraints on Managerial Discretion

For our proxy for managerial entrenchment (the power of managers to make decisions that are suboptimal from the perspective of the unaffiliated shareholders), we collected stock ownership data from the 1997 Disclosure database. We define *OWNPCT* as the percent of total shares owned by outside shareholders who own at least five percent of the firm's common stock.[4] Since large outside shareholders have an incentive to monitor firm activity

[3] Smith and Stulz (1985) point out that incentive plans with a convex payoff structure should give managers an incentive to hedge less. To the extent that the bonus payments included in *CASH* are based on a convex payoff scheme, that component of *CASH* could provide an additional incentive to managers to hedge less.

[4] We also ran our tests using the percentage of stock held by institutions instead of *OWNPCT*. The results were qualitatively the same.

and the model of Smith and Stulz (1985) predicts that managers will hedge more than is optimal from the perspective of unaffiliated shareholders, we expect a negative relationship between *OWNPCT* and hedging activities.

B.3. Shareholder Wealth Maximization Theories of Hedging

Three theories of hedging have been advanced that are based on the shareholder wealth maximization paradigm: (a) the reduction in expected taxes theory, (b) the reduction in the costs of financial distress theory, and (c) the mitigation of the underinvestment problem theory.[5] Empirical tests of these theories have produced mixed results, but two theories—reduction in the costs of financial distress and mitigation of the underinvestment problem theories—have received substantial support.[6]

We include as control variables proxies for these shareholder wealth maximization theories. These variables are similar to ones used in previous studies. For the reduction in expected taxes theory, we use *TAX*, which represents the tax loss carryforwards available to the firm divided by the total assets of the firm as of the end of fiscal year 1995. We expect a positive relationship between *TAX* and hedging activities.

We include two proxies for the reduction in the costs of financial distress theory. The first proxy is *DEBT*, the firm's long-term debt ratio as of the end of fiscal year 1995. We expect a positive relationship between *DEBT* and hedging activities. The second proxy is *INTCOV*, the interest coverage ratio as of the end of fiscal year 1995. We expect a negative relationship between *INTCOV* and hedging activities.

We also include two proxies for the mitigation of the underinvestment problem theory. The first proxy is *INVEST*, the ratio of research and development expenses for fiscal year 1996 to total assets as of the end of fiscal year 1996. We expect a positive relationship between *INVEST* and hedging activities. The second proxy is *MKTBK*, the ratio of the market value of the firm's assets to the book value of assets as of the end of fiscal 1996. We expect a positive relationship between *MKTBK* and hedging activities.

B.4. Alternatives to Hedging

To control for alternatives to hedging with derivative contracts, we include two variables: (a) *DIV*, the firm's dividend yield for fiscal year 1995, and (b) *PREF*, the ratio of preferred stock to total assets as of the end of fiscal 1995. We expect a positive relationship between *DIV* and hedging activities, while we expect a negative relationship between *PREF* and hedging activities.

[5] See Mayers and Smith (1982), Zimmerman (1983), Smith and Stulz (1985), Smith, Smithson, and Wilford (1990), and Froot, Scharfstein, and Stein (1993).

[6] See Wall and Pringle (1989), Nance, Smith, and Smithson (1993), Dolde (1995), Berkman and Bradbury (1996), Li (1996), Mian (1996), Tufano (1996), Geczy et al. (1997), Gay and Nam (1998), Howton and Perfect (1998), and Allayannis and Ofek (2001).

B.5. Firm Size

Several of the previous empirical studies of derivative usage have found a strong positive relationship between the size of the firm and hedging activity.[7] To control for size effects, we include *SIZE*, the natural logarithm of the sum of the book value of the firm's debt and preferred stock plus the market value of the common equity for fiscal year-end 1995.

C. Dependent Variable

To measure the hedging activity of firms in our sample, we use *DERIV*, the total notional amount of interest rate, currency, and commodity derivatives reported by the firm as of fiscal year-end 1996 divided by the total assets of the firm at fiscal year-end 1996. For all interest rate and currency derivatives, and some commodity derivatives, our data source directly reports the notional amount. However, for some commodity derivatives, our data source only reports the number of contracts outstanding. We estimate the notional amount of commodity derivatives by multiplying the reported number of contracts by the price of the commodity at the end of fiscal year 1996. Assuming hedging is costly and firms perform a cost-benefit analysis for hedging activities, when the costs exceed the benefits, the firm will be observed to have a zero hedging position. Hence, we use a left-censored Tobit model for our tests.

One concern with our measure of hedging activity is whether we are truly capturing firms that use derivatives to hedge risk exposures, as opposed to firms that use derivatives to trade or speculate on price movements. Our sample is based on reported derivatives positions at the end of fiscal year 1996. The Financial Accounting Standards Board's standard SFAS 119 became effective for fiscal years ending after December 15, 1994. Thus SFAS 119 applies to all firms in our sample. Among other things, this standard requires firms to report whether any of their derivatives are used for trading purposes. None of the firms in our sample report the use of derivatives for trading purposes.

II. Description of the Sample

The starting point for our sample was the firms in the 1996 S&P 500. Of the S&P 500 firms, we eliminated 64 financial institutions. Our analysis focuses on nonfinancial corporations because of their less frequent use of derivatives for trading purposes or in the course of performing dealer activities. For information on the managerial compensation, stock holdings, and option portfolio details, we used the ExecuComp database published by Standard and Poors COMPUSTAT. We supplemented the ExecuComp data by hand-collecting data from proxy statements. To be included in our sample, a

[7] See Nance et al. (1993), Mian (1996), and Geczy et al. (1997).

firm had to have complete compensation, stock holdings, and option portfolio details for 1996. We deleted 27 firms that did not have this complete information.

Most of the previous empirical studies of the hedging decision use the stock and option holdings of all officers and directors of the firm as proxies for the managerial incentives to manage risk (e.g., Tufano (1996), Geczy et al. (1997), and Gay and Nam (1998)). For our study, we focus on the incentives of the CEO of the company. Although our baseline results are generally consistent with other studies that use the combined holdings of all officers and directors, we believe there are two advantages to concentrating on the CEO. First, using all officers and directors mixes the incentives of agents with different motivations. Second, while it is almost certainly true that more officers than just the CEO of the firm are involved in the hedging decision, the CEO retains ultimate authority over such an important decision as the hedging activities of the firm.

For derivatives information, we use the Swaps Monitor database supplemented with hand-collection from annual reports for fiscal year 1996. This database published by Swaps Monitor Publication, Inc., provides information on the notional amount of interest rate and currency derivatives, including swaps, forwards, options, and futures held by firms as of 1996 fiscal year-end. Some firms do not report sufficient information to determine the notional amount of their derivatives position. We excluded 69 firms from our sample for this reason.

We also obtained data from four other sources: (a) the COMPUSTAT database for financial information on the firm, supplemented by hand collection from annual reports; (b) the CRSP database for stock prices; (c) the 1997 Disclosure database for the percent of total shares owned by outside shareholders who own at least five percent of the firm's common stock; and (d) various editions of the *Wall Street Journal* for U.S. Treasury yields. A total of 80 firms were excluded from the sample due to missing data. Our final sample consists of 260 firms: 146 derivative users and 114 nonusers.

III. Results

A. *Descriptive Statistics*

Table I provides descriptive statistics for the sample. The managerial portfolio variables are presented in unlogged form in Table I, although for our tests we use the logged version for these variables.[8] The values for the portfolio size and sensitivities in our study are similar to, but somewhat larger than those reported in Guay (1999). We attribute the difference to the tim-

[8] Taking the log of the variables is consistent with a concave utility function. A concave utility function reasonably implies that the utility of stock-based wealth increases at a decreasing rate as the sensitivities to price and volatility increase. Furthermore, logging the variables corrects for skewness in the data. We also ran our tests using an unlogged version of the variable. The results were similar to the reported results.

Table I

Summary of Financial and CEO Portfolio Characteristics for the Sample

This table provides summary statistics of measures of financial and CEO portfolio characteristics of the sample. The sample includes 260 nonfinancial firms. Derivatives usage is taken from the Swaps Monitor database for fiscal year-end 1996. All data are measured as of fiscal year-ends. In the table, *TAX* is the ratio of the book value of net operating loss carryforwards to total assets as of fiscal year-end 1995; *DEBT* is the ratio of a firm's long term debt to total assets as of fiscal year-end 1995; *INTCOV* is the interest coverage ratio as of fiscal year-end 1995; *INVEST* is the ratio of research and development expenditures to total assets as of fiscal year-end 1996; *MKTBK* is the ratio of the market value of the firm's assets to the book value of assets as of fiscal year-end 1996; *DIV* is the dividend yield for fiscal year 1995; *PREF* is the ratio of preferred stock to total assets as of fiscal year-end 1995; *SIZE* is the log of the sum of the book value of debt and preferred stock plus the market value of common equity as of fiscal year-end 1995; *OWNPCT* is the percent of total common shares controlled by outside shareholders who own at least five percent of the firm's common stock at fiscal year-end 1996; *CASH* is the ratio of the sum of salary and bonus to total compensation for the CEO in 1996; *STOCK* is the total market value of common shares (excluding shares that can be obtained within 60 days through the exercise of options) beneficially owned by the CEO as of the end of fiscal year 1996; *OPTION* is the market value of the shares obtainable by the CEO by exercising options within 60 days as of the end of 1996; *OPTNUM* is the number of outstanding stock options exercisable within 60 days held by the CEO as of the end of fiscal 1996; *VOLSEN* is the change in the dividend-adjusted Black–Scholes value of the CEO's option portfolio for a one percent change in the annualized standard deviation of the firm's stock returns. *PRICESEN* is the change in the dividend-adjusted Black–Scholes value of the CEO's stock options plus the change of CEOs' common stockholdings for a one percent change in the value of the firm's stock price. *OPTNUM* is in thousands. *STOCK* and *OPTION* are the values in million dollars. *VOLSEN* and *PRICESEN* are the values in thousand dollars. Statistics reported include mean, standard deviation, first quartile, median, and third quartile.

Variables	Mean	Std. Dev.	First Quartile	Median	Third Quartile
TAX	0.007	0.037	0.000	0.000	0.000
DEBT	0.223	0.155	0.108	0.217	0.306
INTCOV	9.184	16.344	1.000	3.820	10.182
INVEST	0.061	0.042	0.021	0.056	0.102
MKTBK	2.131	5.457	1.125	1.714	2.798
DIV	0.031	0.026	0.012	0.029	0.043
PREF	0.010	0.025	0.000	0.000	0.002
SIZE	8.418	1.264	7.616	8.421	9.218
OWNPCT	21.427	20.382	6.120	15.430	32.350
CASH	0.468	0.233	0.297	0.451	0.615
STOCK ($MM)	157.737	825.779	2.933	7.018	27.810
OPTION ($MM)	26.402	60.121	2.285	10.138	27.023
OPTNUM (000)	591.106	966.778	71.670	276.421	665.067
VOLSEN ($000)	274.723	741.289	36.600	104.060	249.890
PRICESEN ($000)	538.341	632.519	63.245	210.209	601.298

ing of the two samples. Guay's sample is as of the end of 1993, while ours is as of the end of 1996. During the three-year period between the two samples, there was a general rise in the stock market. In addition, there has been an ongoing trend toward increasing option compensation in U.S. corporations.

Since we derived all the option portfolio variables from the same basic data, a natural question is the degree to which the variables are correlated. The Pearson correlation coefficient between *LOPTNUM* and *LOPTION* is 0.560 and is significant at the one percent level. These two variables are also relatively highly correlated with our sensitivity measures, *LVOLSEN* and *LPRICESEN* (the Pearson correlation coefficients range from 0.277 to 0.427 and all are significant at the one percent level). Finally, our sensitivity variables, *LVOLSEN* and *LPRICESEN*, have a Pearson correlation coefficient of 0.361, which is significant at the one percent level. In spite of this degree of correlation between the two sensitivity measures, we include both variables in the same multivariate specification because we believe that they capture two different incentive effects.[9]

B. Managers' Portfolio Sensitivities and Hedging

In Table II, we report the results of our three Tobit models specifications of the determinants of hedging activity. In our first two specifications, we construct managerial sensitivities variables, *LOPTUM* and *LOPTION*, in a manner similar to previous studies (Tufano (1996), Geczy et al. (1997), and Gay and Nam (1998)). In Specification I, the proxy used for the CEO's option portfolio is *LOPTNUM*, the logarithm of the number of options exercisable within 60 days held by the CEO. In Specification II, the proxy for the CEO's option portfolio is *LOPTION*, the logarithm of the value of shares that could be obtained by exercising options within 60 days. Our results in the first two specifications are similar to the previous studies, but inconsistent with theory. Specification III includes *LVOLSEN*, our measure of the sensitivity of the CEO's option portfolio to stock return volatility and *LPRICESEN*, our measure of the sensitivity of the CEO's total portfolio (stock and options holdings) to stock price. Using these more precise measures of managerial sensitivities, our results are more consistent with theory.

The coefficient on *LOPTNUM* in Specification I and the coefficient on *LOPTION* in Specification II are both positive and significant. The results using these two proxies seem to indicate that there is a positive relationship between managerial stock option holdings and hedging activities. These findings are consistent with Geczy et al. (1997) and Gay and Nam (1998), but the results seem to contradict the theoretical prediction in Smith and Stulz (1985). The proxies for managerial option portfolios in Specifications I and II, however, do not capture the two opposing effects on managerial incentives that come from option portfolios—sensitivity to stock return volatility and sensitivity to stock price.

In Specification III, we use separate estimates of the two sensitivities to provide a more powerful test of the relationship between managerial incentives and hedging activities. The coefficient on *LPRICESEN* is positive and

[9] We also ran our tests with *LVOLSEN* and *LPRICESEN* in separate specifications. The results were similar to the reported results.

Table II

The Relation Between Firm's Derivatives Usage and the Sensitivity of CEOs' Option Portfolios to Price and Volatility

This table presents results from three specifications of a Tobit model that relates the corporate use of derivatives to a set of financial variables and sensitivities of CEOs' option portfolios to price and volatility. In the Tobit model, the dependent variable is equal to zero for nonusers of derivatives and equal to the notional value of outstanding interest rate, foreign currency, and/or commodity derivatives scaled by a firm's total assets at the end of fiscal year 1996 for users. The sample consists of 146 users and 114 nonusers. All data are measured as of fiscal year-ends. In the table, *LOPTNUM* is the logarithm of the number of outstanding stock options exercisable within 60 days held by the CEO as of the end of fiscal year 1996; *LOPTION* is the logarithm of the market value of the shares obtainable by the CEO by exercising options within 60 days as of the end of 1996; *LVOLSEN* is the logarithm of the change in the dividend-adjusted Black–Scholes value of the CEO's option portfolio for a one percent change in the annualized standard deviation of the firm's stock returns; *LPRICESEN* is the logarithm of the change in the dividend-adjusted Black–Scholes value of the CEO's stock options plus the change of CEOs' common stockholdings for a one percent change in the value of the firm's stock price; *LSTOCK* is the logarithm of the total market value of common shares (excluding shares that can be obtained within 60 days through the exercise of options) beneficially owned by the CEO as of the end of fiscal year 1996; *TAX* is the ratio of the book value of net operating loss carryforwards to total assets as of fiscal year-end 1995; *DEBT* is the ratio of a firm's long-term debt to total assets as of fiscal year-end 1995; *INTCOV* is interest coverage ratio as of fiscal year-end 1995; *INVEST* is the ratio of research and development expenditures to total asset as of fiscal year-end 1996; *MKTBK* is the ratio of the market value of the firm's assets to the book value of assets as of fiscal year-end 1996; *DIV* is the dividend yield for fiscal year 1995; *PREF* is the ratio of preferred stock to total assets as of fiscal year-end 1995; *SIZE* is the log of the sum of the book value of debt and preferred stock plus the market value of common equity as of fiscal year-end 1995; *OWNPCT* is the percent of total common shares controlled by outside shareholders who own at least five percent of the firm's common stock at fiscal year-end 1996; *CASH* is the ratio of the sum of salary and bonus to total compensation for the CEO in 1996. Standard errors are in parentheses.

Variable	Predicted Sign	Specification I	Specification II	Specification III
Intercept	NA	−0.2101	−0.4060	−0.4011
		(0.6601)	(0.6742)	(0.7182)
LOPTNUM	−	0.0761		
		(0.0290)***		
LOPTION	−		0.0811	
			(0.0299)***	
LVOLSEN	−			−0.0829
				(0.0606)
LPRICESEN	+			0.1596
				(0.0691)**
LSTOCK	+	−0.0052	−0.0115	
		(0.0331)	(0.0335)	
TAX	+	−1.0545	−0.7280	−0.8927
		(1.7291)	(1.7295)	(1.7874)
DEBT	+	1.3856	1.4629	1.6262
		(0.4136)***	(0.4111)***	(0.4292)***
INTCOV	−	−0.0075	−0.0070	−0.0075
		(0.0055)	(0.0054)	(0.0062)
INVEST	+	2.5080	2.4111	3.1586
		(1.1237)**	(1.1243)**	(1.1480)***
MKTBK	+	0.0249	0.0242	0.0261
		(0.0101)**	(0.0101)**	(0.0102)**
DIV	+	1.5102	1.6306	2.8860
		(2.6023)	(2.5999)	(2.6590)
PREF	+	−0.0658	0.2592	−1.1400
		(2.3632)	(2.3785)	(2.4754)
SIZE	+/−	−0.0815	−0.0928	−0.0891
		(0.0569)	(0.0571)	(0.0597)
OWNPCT	−	−0.0042	−0.0040	−0.0039
		(0.0031)	(0.0031)	(0.0033)
CASH	−	−0.1084	−0.1046	−0.1991
		(0.2881)	(0.2858)	(0.3162)

, * Statistically significant at the five percent and one percent levels, respectively.

significant. This result shows that there is a positive relationship between the price sensitivity of the CEO's stock and stock option portfolio holdings and hedging activity. The coefficient on *LVOLSEN*, our measure of the sensitivity of the CEO's option portfolio to stock return volatility, is negative but not statistically significant at conventional levels (p-value 0.17). This result provides weak evidence that as the sensitivity of the CEO's option portfolio to stock return volatility increases, the firm tends to conduct less hedging activity. Overall, these results are consistent with the theoretical model of Smith and Stulz (1985).

The results for the control variables in all three specifications are generally consistent with previous studies. The coefficients on *LSTOCK* and *CASH* are negative, but not significant in any of the specifications. The coefficients on *DEBT* are positive and significant, while the coefficients on *INTCOV* are negative, but not significant. These results support the financial distress theory of hedging. The coefficients on *INVEST* and *MKTBK* are positive and significant. These results support the underinvestment problem theory of hedging. The coefficients on *TAX* and *SIZE* are negative, but not significant. The coefficients on *DIV* and *PREF*, our proxies for hedging alternatives, are not significant. The coefficients on *OWNPCT* are negative, but not significant.

A comparison of the results in Specification III to those in Specifications I and II makes it clear that it is important to measure both of the incentive effects inherent in stock option portfolios. The results of Specifications I and II seem to contradict the theoretical model of Smith and Stulz (1985). However, the results of Specification III provide evidence of behavior that is consistent with the Smith and Stulz model. By separately measuring sensitivity to stock return volatility and sensitivity to price, we are able to disentangle the two incentive effects and provide a more powerful test of the relationship between managers' risk preferences and hedging activities.

IV. Summary and Conclusions

In this paper, we use separate estimates of the Black–Scholes sensitivity of managers' stock option portfolios to stock return volatility and the Black–Scholes sensitivity of managers' stock and stock option portfolios to stock price to provide a more powerful test of the relationship between managers' risk preferences and hedging activities. We find that, 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.

Our results help to resolve an apparent inconsistency between the theoretical literature and the empirical literature. Smith and Stulz (1985) predict a negative relationship between managerial options and hedging. However, Geczy et al. (1997) and Gay and Nam (1998), find a positive relationship between options and hedging. We believe that the key to explaining this apparent inconsistency lies in the two opposing effects on managerial incentives to manage risk that come from stock options—sensitivity to stock re-

turn volatility and sensitivity to stock price. By empirically disentangling these two effects, we find results that are consistent with the theory of Smith and Stulz (1985).

REFERENCES

Allayannis, George, and Eli Ofek, 2001, Exchange rate exposure, hedging and the use of foreign currency derivatives, *Journal of International Money and Finance* 20, 273–296.

Berkman, Henk, and Michael E. Bradbury, 1996, Empirical evidence on the corporate use of derivatives, *Financial Management* 25, 5–13.

Carpenter, Jennifer N., 2000, Does option compensation increase managerial risk appetite? *Journal of Finance* 55, 2311–2331.

Core, John, and Wayne Guay, 1999, Estimating the value of stock option portfolios and their sensitivities to price and volatility. Working paper, University of Pennsylvania.

Dolde, Walter, 1995, Hedging, leverage, and primitive risk, *Journal of Financial Engineering* 4, 187–216.

Froot, Kenneth A., David S. Scharfstein, and Jeremy C. Stein, 1993, Risk management: Coordinating corporate investment and financing policies, *Journal of Finance* 48, 1629–1658.

Gay, Gerald D., and Jouahn Nam, 1998, The underinvestment problem and corporate derivatives use, *Financial Management* 27, 53–69.

Geczy, Christopher, Bernadette A. Minton, and Catherine Schrand, 1997, Why firms use currency derivatives, *Journal of Finance* 52, 1323–1352.

Graham, John R., and Daniel A. Rogers, 2002, Do firms hedge in response to tax incentives? *Journal of Finance* 57, 815–840.

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

Howton, Shawn D., and Steven B. Perfect, 1998, Currency and interest-rate derivatives use in U.S. firms, *Financial Management* 27, 111–121.

Lambert, Richard A., David F. Larcker, and Robert E. Verrecchia, 1991, Portfolio considerations in valuing executive compensation, *Journal of Accounting Research* 29, 129–149.

Li, Haitao, 1996, Corporate use of interest rate swaps: Empirical evidence. Working paper, Yale University.

Mayers, David, and Clifford W. Smith, Jr., 1982, On the corporate demand for insurance, *Journal of Business* 55, 281–296.

Merton, Robert C., 1973, Theory of rational option pricing, *Bell Journal of Economics and Management Science* 4, 141–183.

Mian, Shehzad L., 1996, Evidence on corporate hedging policy, *Journal of Financial and Quantitative Analysis* 31, 419–439.

Nance, Deana R., Clifford W. Smith, Jr., and Charles W. Smithson, 1993, On the determinants of corporate hedging, *Journal of Finance* 48, 267–284.

Rajgopal, Shivaram, and Terry Shevlin, 2000, Stock option compensation and risk taking: The case of oil and gas producers. Working paper, University of Washington.

Smith, Clifford W., Charles Smithson, and D. Sykes Wilford, 1990, *Managing Financial Risk* (Harper and Row, New York, NY).

Smith, Clifford, and René Stulz, 1985, The determinants of firm's hedging policies, *Journal of Financial and Quantitative Analysis* 48, 391–405.

Smithson, Charles, 1996, Theory versus practice: Does financial risk management increase shareholder value? *Risk* 9, 128–131.

Tufano, Peter, 1996, Who manages risk? An empirical examination of risk management practices in the gold-mining industry, *Journal of Finance* 51, 1097–1137.

Wall, Larry D., and John J. Pringle, 1989, Alternative explanations of interest rate swaps: An empirical analysis, *Financial Management* 18, 59–73.

Zimmerman, Jerold L., 1983, Taxes and firm size, *Journal of Accounting and Economics* 5, 119–149.