Managerial Discretion and the Economic Determinants of the Disclosed volatility Parameter for Valuing ESOs

Eli Bartov
Leonard N. Stern School of Business
New York University
44 W. 4th St, Suite 10-96
New York, NY 10012
ebartov@stern.nyu.edu

Partha S. Mohanram
Columbia Business School
Columbia University
605-A Uris Hall, 3022 Broadway
New York, NY 10027
pm2128@columbia.edu

Doron Nissim
Columbia Business School
Columbia University
604 Uris Hall, 3022 Broadway
New York, NY 10027
dn75@columbia.edu

Abstract

This study investigates the determinants of the expected stock-price volatility assumption that firms use in estimating ESO values and thus option expense. We find that, consistent with the guidance of FAS 123, firms use both historical and implied volatility in deriving the expected volatility parameter. We also find, however, that the importance of each of the two variables in explaining disclosed volatility relates inversely to their values, which results in a reduction in expected volatility and thus option value. This can be interpreted as managers opportunistically use the discretion in estimating expected volatility afforded by FAS 123. Consistent with this, we find that managerial incentives or ability to understate option value play a key role in this behavior. Since discretion in estimating expected volatility is common to both FAS 123 and 123(R), our analysis has important implications for market participants as well as regulators.

Keywords: executive stock options, forward-looking information, SFAS No. 123, implied volatility

JEL Classification: M41, J33, G30, G13

Under Statement of Financial Accounting Standards (SFAS) No. 123, firms are required to disclose the estimated fair value of stock options granted to employees (ESOs) and pro forma earnings as if ESO cost was recognized in the income statement. For many firms, especially firms in industries with high option granting intensity, the effect of ESO cost on earnings is quite significant. A recent Standard & Poor's (S&P) survey indicates that mean earnings of all S&P 500 firms would have been lower by 8.6 percent and 7.4 percent in 2003 and 2004, respectively, if ESO costs had been recognized. Mr. David Blitzer, managing director and chairman of the Index Committee at Standard & Poor's, observed, "A change of 7 percent or 8 percent in estimated earnings for the S&P 500 is significant, especially if investors are not fully aware of what caused the change."[1]

To estimate the fair value of option grants, firms have to select a valuation model and estimate relevant parameters, such as expected stock price volatility and option life. Given the large impact of ESO costs on earnings and the leeway that firms possess in valuing options, prior research has investigated whether managers use this discretion opportunistically to understate option values. For example, Murphy [1996] and Baker [1999] find that in preparing proxy statements' disclosures, firms opportunistically select the option valuation method (fair value versus potential realizable value) to reduce perceived managerial compensation. Further, Yermack [1998] finds that firms "unilaterally apply discounts to the Black-Scholes formula," and both Yermack [1998] and Aboody et al. [2006] show that firms shorten expected lives of options to lower option expense. Somewhat surprisingly, however, related research examining whether firms understate expected volatility, a critical parameter in option valuation whose estimation is subject to considerable discretion under SFAS 123, finds mixed results: Balsam et al. [2003] find no evidence of manipulation of expected volatility, Hodder et al. [2006] find that managerial incentives for opportunistic reporting do not uniformly induce selection of expected volatility that understates reported fair values, and Aboody et al. [2006] find marginally significant evidence of the lowering of expected volatility, as compared with strong evidence of the lowering of expected option life.

In this paper, we complement this related research that considers all parameters in option valuation, by focusing on the volatility assumption alone and examining it in depth. We focus on volatility for the following three reasons. First, the volatility assumption is by far the most important input in option valuation. Brenner and Subrahmanyam [1994], among others, demonstrate this result and further show that for options whose strike price equals the forward stock price, option value is proportional to volatility (i.e., if expected volatility is lowered by 10 percent from 30 percent to 27 percent, option value will also decline by 10 percent). Second, estimating expected volatility involves substantial discretion, as SFAS No. 123 states that the starting point for estimating expected volatility should be historical volatility, but adjustments should be made if "unadjusted historical experience is a relatively poor predictor of future experience" (Para. 276). This contrasts with the risk free rate, where FASB guidance leaves little room for managerial discretion (see Para. 19 of SFAS No. 123), and with the dividend yield, where a substantial portion of firms offering ESOs pay no dividends and thus set the dividend yield to zero.[2] Finally, the somewhat surprising mixed results of related research on whether companies understate expected volatility discussed above may imply that the manipulation of the volatility assumption, if it indeed occurs, may be more sophisticated or more nuanced, requiring a more detailed investigation.

Using a new approach and a relatively large sample (9,185 firm-years) that spans a relatively long period (1996-2004), this study investigates the determinants of disclosed volatility by asking two questions. The first examines the extent to which companies follow the guidance of SFAS No. 123 and use forward-looking information, in addition to historical volatility, in estimating expected volatility. More importantly, the second question examines the cross-sectional variation in the tendency of firms to incorporate such information. In particular, are firms more likely to incorporate forward-looking information when it implies lower expected volatility and hence smaller option value? Further, is such opportunism more likely when managerial incentives to understate volatility are greater (e.g., option grants are relatively large) or when corporate governance and capital market scrutiny are lax?

Examining these questions requires a measure that captures forward-looking expected volatility information. For companies with traded call or put options, one such measure, advocated by the newly promulgated SFAS No. 123(R), is the implied stock price volatility of traded options.[3] In an efficient capital market, this measure should reflect both historical and forward-looking information. Thus, the incremental relationship between disclosed and implied volatilities, after controlling for historical volatility, should indicate the extent to which disclosed volatility contains forward-looking expected volatility information.

The primary innovation in this paper is that we evaluate disclosed volatility using two benchmarks: historical volatility and implied volatility. Since SFAS No. 123(R), the successor of SFAS No. 123, explicitly advocates using implied volatility in addition to historical volatility (see, Appendix A, Para. A32), this approach allows us to assess whether companies estimated expected volatility during the SFAS No. 123 period in a way consistent with the more specific guidance of SFAS No. 123(R).[4] Perhaps more importantly, our analysis also sheds light on whether companies exploit discretion common to the guidance in both SFAS Nos. 123 and 123(R) to lower disclosed volatility and thus the option expense by opportunistically shifting the weights from one factor to another. In contrast, related research assesses disclosed volatility indirectly by examining the difference between reported ESO fair value and a benchmark value produced by the researchers (Hodder et al. [2006]), and by studying the relation between incentives and opportunities to understate assumptions and option values (Aboody et al. [2006]. As this research has not used implied volatility, it is unable to provide insights regarding the efficacy of the guidance in SFAS Nos. 123 and 123(R) for estimating expected volatility.

We find that disclosed volatility is incrementally related to both historical volatility and implied volatility. This appears to indicate that managers are *literally* following the dictum in SFAS No. 123 that they ought to incorporate both historical and forward-looking information in the estimation of expected volatility. Further investigation, however, demonstrates that the weights on the two volatility measures vary inversely to their relative values. For example, when historical volatility is high relative to implied volatility, the weight on historical volatility, 0.230, is substantially lower than that on implied volatility, 0.498. In contrast, when historical volatility is low relative to implied volatility, the weight on historical volatility increases nearly four fold to 0.718, whereas the weight on implied volatility decreases to 0.042. These results are consistent with managers using the discretion afforded by SFAS No. 123 to opportunistically underreport option value.

There are, however, two alternative explanations for these findings. First, managers may place lower weights on higher values of volatility because they are more likely to contain large measurement error. Results from additional tests, however, indicate that the opportunistic-behavior explanation is incremental to this alternative explanation. Second, while in general SFAS No. 123 requires the volatility estimate to be unbiased, Para. 275 of the pronouncement guides that if a range of volatility estimates of equal quality are available, "it is appropriate to use an estimate at the low end of the range ….” It is thus arguable that if implied volatility and historical volatility are of equal quality, firms appropriately pick the lower of the two as the volatility estimate. Inconsistent with this alternative explanation, however, we find that the observed shift in weights between historical and implied volatility is related to the strength of managerial incentives and ability to understate option value.

These results imply that companies use the discretion afforded by SFAS No. 123 opportunistically to understate volatility and thus lower option expense, particularly when their incentives to report lower option expense are strong. Since the discretion in estimating disclosed volatility is common to both SFAS Nos. 123 and 123(R), this behavior is likely to increase as option expensing starts to directly affect the income statement under SFAS No. 123(R), as opposed to the pro-forma disclosure that most firms provided under SFAS No. 123.

Our analysis has important implications for regulators, investors, and auditors. First, by documenting the widespread usage of implied volatility in the SFAS No. 123 period, we provide support for the new specific guidance in SFAS No. 123(R), which advocates considering implied volatility, in addition to historical volatility, in estimating expected volatility. However, by showing that companies shifted the weights between historical and implied volatility opportunistically, our analysis questions the FASB approach of giving substantial discretion to companies as to how to use these two factors. More generally, our findings have ramifications for standard setters, as they indicate that when managers are given the alternative of choosing between multiple sources of information, they often use their discretion opportunistically. One approach for restraining this behavior could be requiring firms to justify the choice of information sources used (or not used) in exercising the discretion at their disposal. Second, by identifying variables indicating which companies are likely to act opportunistically in estimating expected volatility and by documenting how this opportunistic behavior works (i.e., shifting weights between historical and implied volatilities) our analysis can help investors and auditors to detect such companies and correct distortions in disclosed volatility and option expense.

The remainder of the paper is organized as follows. Section 1 develops the empirical tests. Section 2 delineates the sample selection procedure, defines the variables, and describes the data. Section 3 presents the empirical findings, and Section 4 concludes.

1. Development of the empirical tests

1.1. Primary tests

Our first research question is whether firms follow the guidance in SFAS No. 123 and use both historical and forward-looking information in deriving expected volatility. To address this question, we estimate the following regression:

$$\sigma^D = \alpha_{indu,year} + \beta_1 \sigma^H + \beta_2 \sigma^I + \varepsilon, \tag{1}$$

where the dependent variable, σ^D, is the volatility assumption used by the firm in calculating the value of option grants, disclosed in Form 10-K; $\alpha_{indu,year}$ represents an industry-year fixed effect for pooled regressions, and industry effect for yearly regressions; σ^H is historical stock-price volatility, calculated using monthly returns for the period which ends on the balance sheet date and is equal to the disclosed expected life of the stock options; σ^I is implied volatility, calculated using the prices of traded call and put options as of the end of the fiscal year (more details regarding the measurement of implied volatility are provided in the next section).

Implied volatility, which is derived from option prices, reflects both historical and forward-looking information relevant for the prediction of future stock-price volatility. Consequently, the incremental relationship between disclosed and implied volatilities, after controlling for historical volatility, should indicate the extent to which disclosed volatility contains forward-looking information. In fact, if implied volatility fully reflects the information in historical volatility and firms select the volatility assumption with no bias or error, then disclosed volatility should be unrelated to historical volatility after considering implied volatility. However, implied volatility is not likely to fully reflect the information in historical volatility. Research in finance finds that while implied volatility forecasts future volatility better than historical volatility, both measures contain information incremental to each other (e.g., Mayhew [1995]). This is due to both market inefficiencies in pricing options and errors in option valuation models used to derive implied volatility (e.g., the simplifying assumption of continuous price movements). In the context of ESOs, the advantage of implied volatility over historical volatility may be smaller as the maturity of ESOs is considerably longer than that of traded options, from which implied volatility is derived. Still, implied volatility reflects both historical and forward-looking information relevant for the prediction of future stock-price volatility.

In terms of Equation (1), if firms incorporate both historical and forward-looking information in estimating expected volatility, then H_1: $\beta_1 > 0$ and $\beta_2 > 0$. In contrast, if they use only historical volatility, then H_2: $\beta_1 = 1$ and $\beta_2 = 0$. In addition, the relative magnitudes of β_1 and β_2 indicate the extent to which firms adjust historical volatility to reflect forward-looking information when deriving the expected volatility parameter.

Our second research question asks whether firms use forward-looking information opportunistically to lower expected volatility and thus option value. To address this question, we estimate the following model:

$$\sigma^D = \alpha_{indu,year} + \beta_1\sigma^H + \beta_2\sigma^I + \beta_3 HI\_IMP + \beta_4 HI\_IMP \times \sigma^H + \beta_5 HI\_IMP \times \sigma^I + \varepsilon \,, \qquad (2)$$

where HI_IMP is an indicator variable that equals one when $\sigma^I > \sigma^H$ (i.e., when forward-looking information indicates larger expected volatility than historical information), and the other variables are defined as before. In terms of Equation (2), opportunistic managerial behavior implies that H_3: $\beta_4 > 0$ and $\beta_5 < 0$. A negative β_5 means that the weight on forward-looking information decreases when reliance on forward-looking information leads to higher disclosed volatility and thus larger option expense. An extreme version of opportunism, where managers rely on forward-looking information solely to reduce disclosed volatility, predicts $\beta_2 + \beta_5 = 0$; i.e. if implied volatility is larger than historical volatility, it has no effect on disclosed volatility and thus option expense.

1.2. Tests of alternative explanations

It is arguable that a relatively high volatility value is associated with high measurement error. To distinguish between this measurement-error explanation and the opportunistic-behavior interpretation, we replicate Equation (2) using two alternative dependent variables: realized volatility, σ^R, and the difference between realized and disclosed volatilities, σ^D - σ^R. Specifically, we estimate the following two models:

$$\sigma^R = \alpha'_{indu,year} + \beta'_1\sigma^H + \beta'_2\sigma^I + \beta'_3 HI\_IMP + \beta'_4 HI\_IMP \times \sigma^H + \beta'_5 HI\_IMP \times \sigma^I + \varepsilon \quad (3)$$

$$\sigma^D - \sigma^R = \alpha^*_{indu,year} + \beta^*_1\sigma^H + \beta^*_2\sigma^I + \beta^*_3 HI\_IMP + \beta^*_4 HI\_IMP \times \sigma^H + \beta^*_5 HI\_IMP \times \sigma^I + \varepsilon \quad (4)$$

where the explanatory variables are defined as in Equation (2), and σ^R is realized volatility during the period corresponding to the expected life of the stock options or up to December 2005, whichever is shorter. We calculate realized volatility using monthly stock returns where at least 24 months of returns are available and using daily returns otherwise.

Considering σ^R an unbiased proxy for expected volatility, the parameter estimates from Equation (3) offer a benchmark against which the estimates from Equation (2) may be assessed. Specifically, in the absence of opportunistic behavior, the estimates from equations (2) and (3) should be similar, as the measurement error explanation applies equally to both equations. Conversely, if managerial opportunism plays a role in the determination of σ^D, then β_4 (β_5) from Equation (2) should be greater (smaller) than that from Equation (3), as the predictions of positive β_4 and negative β_5 due to opportunistic behavior apply only to Equation (2). Note that Equation (4) is derived by subtracting Equation (3) from Equation (2). We can thus formulate the tests distinguishing between the two explanations--measurement error and opportunistic behavior--in terms of Equation (4). That is, the opportunistic-behavior explanation predicts that $\beta^*_4 > 0$ and $\beta^*_5 < 0$, whereas absence of opportunism implies that $\beta^*_4 = 0$ and $\beta^*_5 = 0$.

A second possible alternative explanation for the predictions of H_3 may be that managers follow Para. 275 of SFAS No. 123, which directs that if multiple volatility estimates of equal quality are available, the lowest estimate should be used. To assess this alternative explanation, we study the relation between managerial incentives and ability to understate expected volatility and the opportunistic use of forward-looking volatility information. If managers incorporate forward-looking information opportunistically, they are likely to do so especially when their incentives and ability to understate the option expense are strong. More specifically, in terms of Equation (2), hypothesis H_4 predicts that β_4 (β_5) will be increasing (decreasing) in a firm's incentives and/or ability to understate the option expense. Conversely, if the estimate for expected volatility reflects the effect of Para. 275, β_4 and β_5 should be unrelated to incentives or ability to manipulate the option expense.[5]

To investigate H_4, we re-estimate Equation (2) for subsamples partitioned based on various proxies for incentives and ability to understate the option expense, as well as on the interaction between the two effects. If the weights on historical and implied volatilities reflect opportunistic behavior rather than the requirement of Para. 275, then $\beta_4^{\mathrm{High}} > \beta_4^{Low}$ and $\beta_5^{\mathrm{High}} < \beta_5^{Low}$, where $\beta_{\mathrm{i}}^{\mathrm{High}}$ represents parameter estimates from subsamples of high incentives/ability to understate disclosed volatility and $\beta_{\mathrm{i}}^{\mathrm{Low}}$ represents estimates from low-incentives/ability subsamples.

2. Data

2.1. Data sources and sample selection

Our sample covers the nine years from 1996 to 2004. Our sample period commences in 1996 because this is the first year companies were required to provide a (footnote) description of their employee option plans in annual reports and Form 10-K. Our sample period ends in 2004 because this is the last year with available data. The sample is generated, as described in Table 1, by intersecting five data sources: the New Constructs database, the source for disclosed volatilities and annual option grants; the Optionmetrics database, the source of implied volatility; the CRSP database, the source for stock returns used to compute historical and realized volatilities; the Compustat database, the source for firm characteristics; and the IBES database, the source of the number of analyst following a firm.[6] This procedure yielded a sample size of 9,189 firm-years (2,215 distinct firms). However, four firm-years are obvious multivariate outliers: they each have χ^2 value (a measure of the standardized distance from the other observations, see Watson, 1990) that is at least 25 percent larger than that of any other observation, while none of the other observations has a χ^2 that is more than 10 percent larger than the next highest χ^2.[7] We thus removed these four firm-years, and our final sample consists of 9,185 firm-years (2,215 distinct firms).

We next describe how we obtain the volatility measures and other variables used in our analysis. Companies disclose information about option grants to all employees in the annual report and Form 10-K. These disclosures are prepared according to SFAS No. 123, with value estimates typically based on the Black-Scholes (1973) methodology.[8] We retrieve the stock price volatility assumption and annual option grants data from the New Constructs database, a machine readable database that gleans stock option compensation data from Form 10-K footnote disclosures, with an emphasis on Russell 3,000 companies and recent years (2000 onwards).

Both historical and realized volatility are calculated using monthly stock returns over a period equal to the expected option life, as disclosed in Form 10-K. The period for historical (realized) volatility ends (starts) on the balance sheet date. For example, if the fiscal year end is December 2000 and expected option life is three years, historical volatility is measured over the three-year period January 1998 to December 2000, while realized volatility is estimated over the three-year period January 2001 to December 2003. If the estimation period for realized volatility is less than 24 months, we use daily instead of monthly returns (a minimum of 50 daily returns is required).

We calculate our measure of implied volatility by using data from the Optionmetrics database and applying the following procedure. First, for each firm-year and each strike price, we obtain the implied volatilities of call and put options with the longest maturity as of the end of the fiscal year. We consider both calls and puts to mitigate any measurement error in implied volatility induced by the Black-Scholes method. We focus on options with the longest maturities because employee stock options have very long expected maturities (3.31 years on average for our sample firms).[9] For both calls and puts, we then identify the options with the strike price closest to the prevailing stock price on both sides, because prior research has demonstrated that near-the-money options perform better in predicting future volatility than deep in- or out-of-the-money options (see, e.g., Mayhew, 1995; Hull, 2000). If an exact match is found, we use that option to measure the implied volatility of the corresponding type (call or put). If not, we extrapolate from the implied volatilities of the two options, assigning weights that are inversely proportional to the distance between the stock price and the exercise price.[10] Finally, we calculate the average of the call and put implied volatilities.

In addition to the four volatility variables (disclosed, historical, implied and realized), we compute proxies for incentives and ability to understate disclosed volatility in order to test alternative interpretations of our results. We use three proxies for incentives: annual option grants, option holdings, and capital market issuance. We obtain option data from the New Constructs database. Following Richardson and Sloan (2003), we measure capital market issuance as the sum of external financing raised from equity, short term debt and long term debt (change in Compustat #60 – #172 + change in #9 + change in #34 + change in #130), scaled by total assets. We also compute three proxies for managerial ability to manipulate disclosed volatility: analyst following, institutional ownership, and board independence. Analyst following is measured as the number of analysts issuing one-year ahead EPS forecasts at the fiscal year end (from IBES). Institutional ownership is measured as the percentage of shares outstanding owned by institutional shareholders at fiscal year end (from Thomson financial). Board independence is measured as the proportion of board directors that were deemed as independent and without any interlocking relationships with any other board members (from the Investor Responsibility Research Center (IRRC) database).

2.2. Descriptive statistics

Table 2 outlines characteristics of our sample firms (Panel A), as well as the time (Panel B) and industry (Panel C) distributions of the sample. As evident from the statistics displayed in Panel A, a number of important firm characteristics vary substantially across our sample firms. For example, the spread in market value of equity--5th percentile of \$173 million; \$1,452 million mean; 95th percentile of \$25,985 million--indicates that our sample consists of small, medium, and large firms, and the spread in return on assets between the 5th percentile (-23.5 percent) and 95th percentile (16.7 percent) suggests that the sample firms are also quite diverse in profitability. Panel B shows that the number of observations is increasing over our sample period in a nearly monotonic fashion; it ranges from 366 observations in 1996 (4 percent of the sample) to 1,677 observations in 2004 (18.3 percent of the sample). This trend reflects the dramatic growth in employee stock option plans over our sample period (see, e.g., Desai, 2002; and Graham, Lang and Shackelford, 2004), as well as the focus of the New Constructs database on more recent years (2000 onwards). Panel C demonstrates that although industry membership is not evenly distributed, the sample does contain a broad cross section of firms from all major industries. The two industries with the highest representation in the sample are Business Services (11.0 percent of sample firms) and Chemicals (9.8 percent of sample firms).

Table 3 presents descriptive statistics and correlations for the four volatility measures. Panel A reports statistics for disclosed volatility as well as three other assumptions underlying the Black-Scholes option pricing model. The important point to note is that while disclosed volatility varies substantially both across firms and over time, the variation in the other three assumptions, dividends yields, expected life, and the risk free rate, is relatively small. For example, the spread between the 25th percentile and the 75th percentile is zero years in expected life and only 1.1 percent in dividend yield, whereas the inter-quartile range of disclosed volatility is 34.6 percent. The relatively large spread in disclosed volatility (also observed in historical and implied volatilities) is consistent with our assertion that companies may manage the disclosed volatility more easily than the other parameters, as its high variability enables companies to mask the management of this estimate, thereby escaping detection. It is also evident that the over time variability in disclosed volatility across firms as measured by $|(\sigma_t^D - \sigma_{t-1}^D)/\sigma_{t-1}^D|$ is substantial. This may explain the variation in the extent to which companies use the volatility estimate to manipulate the option expense.

Panel B of Table 3 analyzes the correlations among the primary variables used in our empirical analyses. We first calculate the pair-wise cross-sectional correlations each year and then average the correlation coefficients across the nine years in our sample. As shown, the pair-wise correlations between all four volatility measures, σ^D, σ^H, σ^I, and σ^R are high, all being significant at the 5% level or better. The high correlation between σ^I and σ^H is expected because historical volatility is a primary source of information for predicting future volatility (e.g., Alford and Boatsman, 1995). The high correlation between σ^R and both σ^I and σ^H suggests that σ^R is a reasonable proxy for expected volatility.

3. Empirical results

3.1. Do firms incorporate forward-looking information in estimating expected volatility?

Table 4 presents the estimation results of Equation (1) for pooled data, for each of the nine sample years separately, and using the Fama and MacBeth (1973) technique.[11] Considering the results from the pooled regressions and the Fama-MacBeth technique first, we note that the coefficients on historical volatility (β_1) and on implied volatility (β_2) are both positive and highly significant. These findings are consistent with H_1 and the guidance in SFAS No. 123, suggesting that firms rely on both historical and forward-looking information in determining the expected volatility parameter used in the calculation of the option expense. The findings are inconsistent with hypothesis H_2 that only historical information is used in deriving σ^D.

Considering next the nine yearly regression results reveals an interesting pattern: in the early sample period, 1996-1999, $\beta_1 - \beta_2 > 0$, whereas in the later sample period, 2000-2004, $\beta_1 - \beta_2 < 0$ (the only exception is 2004 for which the difference is insignificant). What may underlie this pattern? The graphs in Figure 1, which depicts the evolution of our four volatility measures over the sample period, show that in the early (later) sample period mean historical volatility was lower (higher) than mean implied volatility (the only exception is 2004). As a result, the time-series correlation between mean $(\beta_1 - \beta_2)$ and mean $(\sigma^H - \sigma^I)$ is negative and highly significant (Pearson correlation coefficient is -0.73; Spearman rank order correlation is -0.75). This may be considered prima-facie evidence that managers shift the weights between historical volatility and implied volatilities over time to understate disclosed volatility, consistent with hypothesis H_3. Finally, we note that the stability of the finding that β_1 and β_2 are both significantly positive for all years and estimation procedures (pooled and Fama-MacBeth) increases our confidence in the reliability of the findings. In particular, multicollinearity due to high correlations among the volatility measures, and potential correlations among the regression residuals, do not appear to materially affect the findings.

3.2. Do firms use forward-looking information opportunistically?

In this section we formally test hypothesis H_3 by estimating Equation (2) using pooled regressions, yearly regressions, and the Fama-MacBeth technique. Recall that Equation (2) is derived from Equation (1) by allowing the intercept and the slope coefficients to vary, depending on whether implied volatility is above (HI_IMP = 1) or below (HI_IMP = 0) historical volatility. Thus, when implied volatility is smaller than historical volatility, the coefficient on historical volatility is equal to β_1 and the coefficient on implied volatility is equal to β_2. However, when implied volatility is larger than historical volatility, the coefficient on historical volatility is equal to $\beta_1 + \beta_4$ and the coefficient on implied volatility is equal to $\beta_2 + \beta_5$.

The results, displayed in Table 5, reveal that when implied volatility is lower (higher) than historical volatility, firms rely heavily on implied (historical) volatility. For example, the pooled regression results show that when implied volatility is smaller than historical volatility, β_2, the coefficient on implied volatility (0.498), is more than twice as large as β_1, the coefficient on historical volatility (0.230). In contrast, when implied volatility is larger than historical volatility the coefficient on implied volatility ($\beta_2 + \beta_5$) declines by more than 90 percent, from 0.498 to 0.042. Correspondingly, the coefficient on historical volatility ($\beta_1 + \beta_4$) increases dramatically from 0.230 to 0.718. That is, when implied volatility, our proxy for forward-looking information, indicates high future volatility, firms largely ignore this information and instead rely nearly exclusively on historical volatility in estimating volatility. Accordingly, β_4, which measures the differential weights on historical volatility when implied volatility is high, is positive (0.488) and highly significant (t-statistic = 14.85), and β_5, which measures the differential weights on implied volatility, is negative (-0.455) and highly significant (t-statistic = -14.82).

Examination of the results from the nine annual regressions and the Fama-MacBeth technique indicates that the inferences from the pooled regression are robust. For example, the relative change in the coefficient on implied volatility when it is higher than historical volatility

(β_5 / β_2) is substantially negative in all nine years, ranging from -71 percent in 1996 to -90% in 2000. Correspondingly, we see substantial increases in the relative coefficient on historical volatility when it is low. Further, the two coefficients that measure the differential weights on historical volatility (β_4) and on implied volatility (β_5) are statistically significant with the expected sign in each of the nine sample years and in the Fama-Macbeth procedure. Moreover, there is no apparent time trend in any of the coefficients, suggesting that our results are unlikely to be period specific.

One way to interpret the findings in Table 5 is that managers generally use both historical volatility and implied volatility to estimate expected volatility. The importance of each of the two variables in explaining estimated volatility, however, varies over time and across firms as if managers opportunistically lower expected volatility and thus option value and expense. However, as discussed above, these results could be driven not by manipulation, but by measurement error that varies with the relative values of σ^I and σ^H. That is, even if managers are not opportunistically managing the volatility estimate, they will assign less weight to σ^I and more weight to σ^H when $\sigma^I > \sigma^H$, and conversely when $\sigma^I < \sigma^H$. This alternative explanation is investigated next.

3.3. Opportunistic-behavior explanation vs. measurement error explanation

Thus far we have focused on the relation between implied and historical volatilities in testing whether firms manage the disclosed volatility parameter. We next use realized future volatility as a proxy for expected volatility and conduct supplementary tests which examine whether measurement error in implied and/or historical volatility provide an alternative explanation for our findings.

It is arguable that the results reported in Table 5, indicating that disclosed volatility reflects forward-looking information primarily when $\sigma^I < \sigma^H$, are due to the relative magnitudes of measurement error in implied and historical volatilities rather than to management of disclosed volatility. More specifically, it is possible that a relatively high volatility value is associated with a relatively high magnitude of measurement error, which makes the volatility number relatively less informative. If so, when $\sigma^I < \sigma^H$ ($\sigma^I > \sigma^H$) firms appropriately rely less on σ^H (σ^I) and more on σ^I (σ^H) in deriving σ^D, as this will lead to a more accurate expected volatility estimate.

To assess the validity of this alternative interpretation for our findings, we re-estimate Equation (2) using two alternative dependent variables: realized volatility, σ^R, and the difference between realized and disclosed volatilities, $\sigma^D - \sigma^R$. The results in both Panel A (for the entire sample) and Panel B (subsample with at least 24 months to compute realized volatility) of Table 6 show that while the measurement error explanation is valid, our interpretation that managers shift the weights between historical and implied volatilities to understate disclosed volatility continues to hold. Specifically, when σ^R is the dependent variable, β_4 is significantly positive and β_5 is significantly negative, which is consistent with the measurement error explanation. However, a comparison of these coefficients across Equation (2) and (3) clearly indicates that the estimates of Equation (2) are substantially larger (in absolute value) than their counterparts in Equation (3). For example, using the Fama-MacBeth procedure and the entire sample (Panel A), in Equation (2) $\beta_4 = 0.516$ and $\beta_5 = -0.527$, while in Equation (3) $\beta_4 = 0.227$ and $\beta_5 = -0.235$. To test the significance of the differences in coefficients, we estimate Equation (4), where the dependent variable is $\sigma^D - \sigma^R$. Consistent with the opportunistic-behavior explanation, β_4 (0.289) is significantly positive and β_5 (-0.292) is significantly negative. Overall, the results in Table 6 lead us to conclude that differential measurement errors in σ^I and σ^H can only partially explain the results in Table 5, and that the opportunistic-behavior explanation is incremental to the measurement error story.

3.4. Managerial incentives and ability to understate the option expense

Another alternative explanation for the findings in Table 5 is that implied volatility and historical volatility are two alternative estimates for expected volatility of equal quality, and following Para. 275 of SFAS No. 123 firms appropriately pick the lower of the two as their estimate for expected volatility. In an effort to assess the validity of this explanation for the prediction of H_3, we examine whether the correlations documented in Table 5 relate to the costs and benefits of understating the option expense by testing H_4.

The benefits from manipulation include lower option expense and lower perceived top management compensation and wealth. Firms with high levels of option-based compensation are likely to have strong incentives to understate expected volatility. However, the downwards manipulation of volatility is unlikely to be costless as managers and the financial statements they produce are subject to the scrutiny of audit committees, auditors and external capital market participants. The costs of manipulating financial disclosures include a negative effect on management's reputation, a decrease in management's ability to convey information to the market, an increase in audit costs and, in extreme cases, potential SEC enforcement actions or shareholder litigation. These costs are not likely to be identical for all firms. In general, firms facing low levels of monitoring are likely to have relatively low costs and hence high ability to manipulate expected volatility, while firms with high levels of monitoring are likely to have high costs and low ability to understate expected volatility.

Recall that in terms of Equation (2), H_4 predicts that β_4 (β_5) will be increasing (decreasing) in a firm's incentives/ability to understate the option expense. Conversely, if the estimated coefficients merely reflect the effect of Para. 275, β_4 and β_5 should be unrelated to incentives/ability. To investigate H_4, we re-estimate Equation (2) after partitioning the sample into two groups based on each variable's median, where the partitioning variables measure the strength of managers' incentives or ability to understate the option expense. If values of disclosed volatility reflect incentives/ability, then according to H_4, $\beta_4^{\text{High}} > \beta_4^{Low}$ and $\beta_5^{\text{High}} < \beta_5^{Low}$, where $\beta_{\text{i}}^{\text{High}}$ is the parameter estimate from the subsample of firms with high incentives/ability to understate disclosed volatility, and $\beta_{\text{i}}^{\text{Low}}$ is from the low incentives/ability subsample.

Table 7 displays the test results of H_4 using proxies for incentives (Panel A) and ability (Panel B) to understate disclosed volatility, as well as the interaction of the two effects (Panel C). Panel A reports the results using three alternative partitioning variables capturing incentives. The first variable, Option Grants, is the total number of options granted by the firm to all employees in the year of analysis scaled by shares outstanding. Option grants greater (less) than the contemporaneous median for firms in the same 2 digit SIC code are considered large (small). The second partitioning variable, Option Holdings, is the cumulative number of outstanding ESOs (i.e., held by employees) scaled by shares outstanding. Option holdings greater (less) than the contemporaneous median for firms in the same 2 digit SIC code are considered high (low). The third partition is based on Capital Market Issuance, defined as the sum of external financing raised from equity, short term debt and long term debt, scaled by total assets (Richardson and Sloan 2003). This variable serves as a proxy for incentives since prior research has shown that firms inflate income prior to tapping into the capital market (see, e.g., Dechow, Sloan and Sweeney, 1996).

Consistent with the prediction of H_4, the results indicate that the tendency to understate disclosed volatility by shifting the weights between historical and implied volatilities is most pronounced when incentives are high. Consider, for example, the results for our first proxy--the size of annual option grants to all employees. When option grants are relatively small, $\beta_4 = 0.404$ and $\beta_5 = -0.364$, whereas when they are relatively large, $\beta_4 = 0.539$ and $\beta_5 = -0.531$; the differences, $\beta_4^{\text{Large}} - \beta_4^{Small} = 0.135$ and $\beta_5^{\text{Large}} - \beta_5^{Small} = -0.168$, have both the expected signs and are statistically significant at conventional levels.

Panel B reports the results where the partitioning variables are based on the ability to manipulate disclosed volatility, given the potential costs of manipulation. We consider three alternative variables: Analyst Following, Institutional Ownership, and Board Independence. The first two variables serve as proxies for the extent of monitoring by outsiders that company executives may be subject to. Prior research indicates that firms with a higher level of analyst following or institutional ownership are potentially subject to a higher level of capital market scrutiny. Del Guercio and Hawkins (1999) show that activist pension funds are more successful in monitoring and promoting change at target firms. Monitoring by outsiders may also indirectly affect the activities of insiders such as auditors and audit committees since the latter may pay increased attention to sensitive accounting choices when they know that those choices are likely to be scrutinized by financial market participants. Indeed, Klein (2002) documents a negative relation between board independence and abnormal accruals, and also finds that reductions in board independence are associated with increases in abnormal accruals. Our third variable, which captures the extent of board independence, serves as a more direct proxy for the level of monitoring that company executives may be subject to by insiders. The ability to manipulate disclosed volatility is likely to be relatively high with weaker monitoring mechanism, i.e. lower analyst following, lower institutional ownership or less independent boards.

Consistent with the predictions of H_4, greater weight shifting occurs when the ability to manipulate is high because of weaker monitoring. Consider, for example, the results for institutional ownership. When the ability to manipulate is low because of high institutional ownership, β_4 = 0.412 and β_5 = -0.300, whereas when the ability is high because of low institutional ownership, β_4 = 0.555 and β_5 = -0.558; the differences 0.135 and -0.259 for β_4 and β_5 respectively have both the expected signs and are statistically significant at conventional levels. Similar results are seen for partitions based on analyst following or board independence, although the differences are only marginally significant for the board independence partition.

Finally, the results in Panel C are based on the interaction of Option Grants, a measure of incentives, and Institutional Ownership, a measure of the ability to understate disclosed volatility. The sample is partitioned into three groups: a group of Low Benefit and High Cost, which contains firms with below median Option Grants and above median Institutional Ownership, a second group of High Benefit and Low Cost, which contains firms with above median Option Grants and below median Institutional Ownership, and a third group which contains all other sample firms. The results from estimating Equation (2) using the three groups are consistent with those for the individual proxies. Specifically β_4 increases monotonically from 0.333 for low incentives/ability group (Group 1) to 0.545 for high incentives/ability group (Group 3), and β_5 decreases monotonically from -0.136 for low incentives/ability group to -0.546 for high incentives/ability group. As before, the differences between the coefficients of the two extreme groups, $\beta_4^{\text{High}} - \beta_4^{Low}$ = 0.212 and $\beta_5^{\text{High}} - \beta_5^{Low}$ = -0.410, have the predicted signs and are statistically significant at conventional levels.[12]

Overall, the picture that emerges from our findings is that firms use both historical volatility and implied volatility in estimating expected volatility, and that the importance of each of these variables in explaining disclosed volatility varies across firms and over time. The crucial determinants underlying the importance of each volatility measure are its relative magnitude and managerial incentives and ability to exploit the discretion inherent in SFAS No. 123 to opportunistically understate expected volatility.[13]

4. Summary and Conclusion

To estimate the value of ESOs, firms are required to first derive an estimate for expected stock-price volatility. This input parameter has three characteristics. First, it is highly discretionary as firms are allowed to use forward-looking information in addition to historical information in setting an estimate. Second, it varies considerably across firms and over time. Third, it has a large effect on the estimated value of ESOs and thus on option expense. Together, these three characteristics imply that if firms wish to manipulate option expense, the expected volatility parameter would be a prime target. Yet, previous studies examining the parameters used in option valuation find mixed results regarding the manipulation of disclosed volatility, though they do find that firms manipulate other parameters such as expected option life. This indicates that the manipulation of volatility, if indeed it is taking place, may be more sophisticated or more nuanced than assumed by prior studies, requiring more detailed investigation.

Using a new approach, we address two questions: (1) Do firms follow the guidance in SFAS No. 123 and use both historical and forward-looking information in estimating expected volatility? (2) What are the determinants underlying the cross-sectional variation in firms' tendency to incorporate historical volatility and forward-looking information into their expected volatility assumption? We find that managers use both historical and forward-looking information in determining expected volatility, consistent with the literal guidance in SFAS No. 123. We also find, however, that the reliance on each of the two variables varies inversely with their relative values. One way to interpret this finding is that managers opportunistically use the discretion in estimating expected volatility afforded by SFAS No. 123 to understate disclosed volatility. In support of this interpretation, we find that managerial incentives and ability to understate option expense play a key role in explaining this opportunism.

These results have important ramifications for standard setters deciding about the extent of discretion to provide managers in estimating parameters for option valuation. The results indicate that when managers are given the alternative of choosing between multiple sources of information, they could potentially use that discretion opportunistically.

It is important to note that while our tests are based on data from the SFAS No. 123 period, our results have implications also for its new enacted successor, SFAS No. 123(R), which specifically advocates considering implied volatility in estimating expected volatility in addition to historical volatility. Indeed, companies under the new standard disclose that they follow the new guidance and consider implied volatility, in addition to historical volatility, in estimating expected volatility. For example, UnitedHealth Group disclosed on its Form 10-Q for the first quarter of 2006, "Expected volatilities are based on a blend of implied volatilities from traded options on our common stock and the historical volatility of our common stock." Our findings suggest that following this procedure by itself does not guarantee the integrity of disclosed volatility. Auditors, investors, and other users of financial statements evaluating the appropriateness of a company's volatility assumption should consider whether the weights given to each factor, historical and implied volatilities, are appropriate.

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NOTES

[1] See CFO.com, Today in Finance for April 01, 2004, The Cost of Expensing Stock Options, at http://www.cfo.com/article.cfm/3012993?f=TodayInFinance040104

[2] Estimating option lives does involve discretion, but the effect of this assumption on option fair value as well as the cross-sectional and time-series variation in expected option lives are relatively small. Moreover, there is no obvious benchmark against which this variable can be assessed.

[3] SFAS No. 123(R), which was promulgated in December, 2004, mandates income statement recognition for employee stock option expense for fiscal years starting after June 15, 2005. However, in April 2005, the Securities Exchange Commission amended Rule S-X to delay the effective date for compliance with SFAS No. 123(R) to fiscal year starting after June 15, 2005. Based on the amended rule, most companies are required to adopt SFAS No. 123(R) on January 1, 2006.

[4] SFAS No. 123 guides that in estimating expected volatility companies should consider historical volatility and forward-looking information. SFAS No. 123(R) is more specific in that it guides that in addition to historical volatility, implied volatility from traded options can be considered.

[5] A necessary condition for the magnitude of volatility understatement to vary with incentives is that managers incur costs that offset the benefits of reporting understated option expense. We discuss these costs in Section IV below.

[6] The use of the IBES database did not lead to any loss in sample size. There were 700 observations out of 9,185 with no analyst following data on IBES, which we coded as having zero analyst following. Removing these observations does not affect the results reported in Table 7 below for either the analyst following partition or the composite measure.

[7] Following Watson [1990], we detect multivariate outlier observations using the statistic $\chi_i^2 = (m_i - \overline{m})' S^{-1} (m_i - \overline{m})$, where i denotes the ith observation; bar denotes average over all sample firms; m is the 4×1 vector of volatilities (historical, implied, disclosed and realized); and S is the 4×4 sample covariance matrix of m.

[8] It is well recognized that ESOs violate important assumptions underlying the Black-Scholes model (e.g., Black-Scholes assume a diffusion process and values European calls, whereas in reality stock prices may jump and nearly all ESOs are American calls). Moreover, academic research offers models which might be more appropriate for valuing ESOs (see, e.g., Hemmer et al. [1994], and Carpenter [1998]). Yet, most firms use the Black-Scholes model

to value their ESOs, perhaps due to the robustness of the Black-Scholes values and the complexity of alternative models.

[9] Indeed, our success in matching on time-to-maturity is only partial. The mean time-to-maturity of our traded options is 329.2 calendar days.

[10] For example, if stock price is $42 and the two nearest call options have strike prices of $40 and $45 and implied volatilities of 0.34 and 0.36, respectively, we estimate the implied volatility of call options as: $\frac{(1/2)*0.34+(1/3)*0.36}{(1/2)+(1/3)}=0.348$. If all strike prices are on one side of the prevailing stock price, we use the implied volatility of the option with the nearest strike price.

[11] For the Fama-Macbeth regressions, the t-statistics are corrected for auto-correlation using the methodology outlined by Bernard (1995).

12 When we use other measures for incentives and ability to manipulate, we consistently find that β_4 (β_5) increases (decreases) monotonically from the low incentives/ability group to the high incentives/ability group.

13 We also conduct three types of sensitivity tests to ensure that our results are robust. First, to verify that our methodology of extrapolating at-the-money implied volatilities does not induce significant measurement error, we rerun our tests excluding observations where the nearest strike price is more than five percent different from the prevailing stock price. Second, to control for skewness in the distribution of our volatility measures, as well as to account for potential non-linearities in the relationship between our dependent and independent variables, we rerun our analyses using: (1) rank regressions, and (2) log transformed variables. Results from all three types of sensitivity tests (not tabulated for parsimony) are similar to our basic results.

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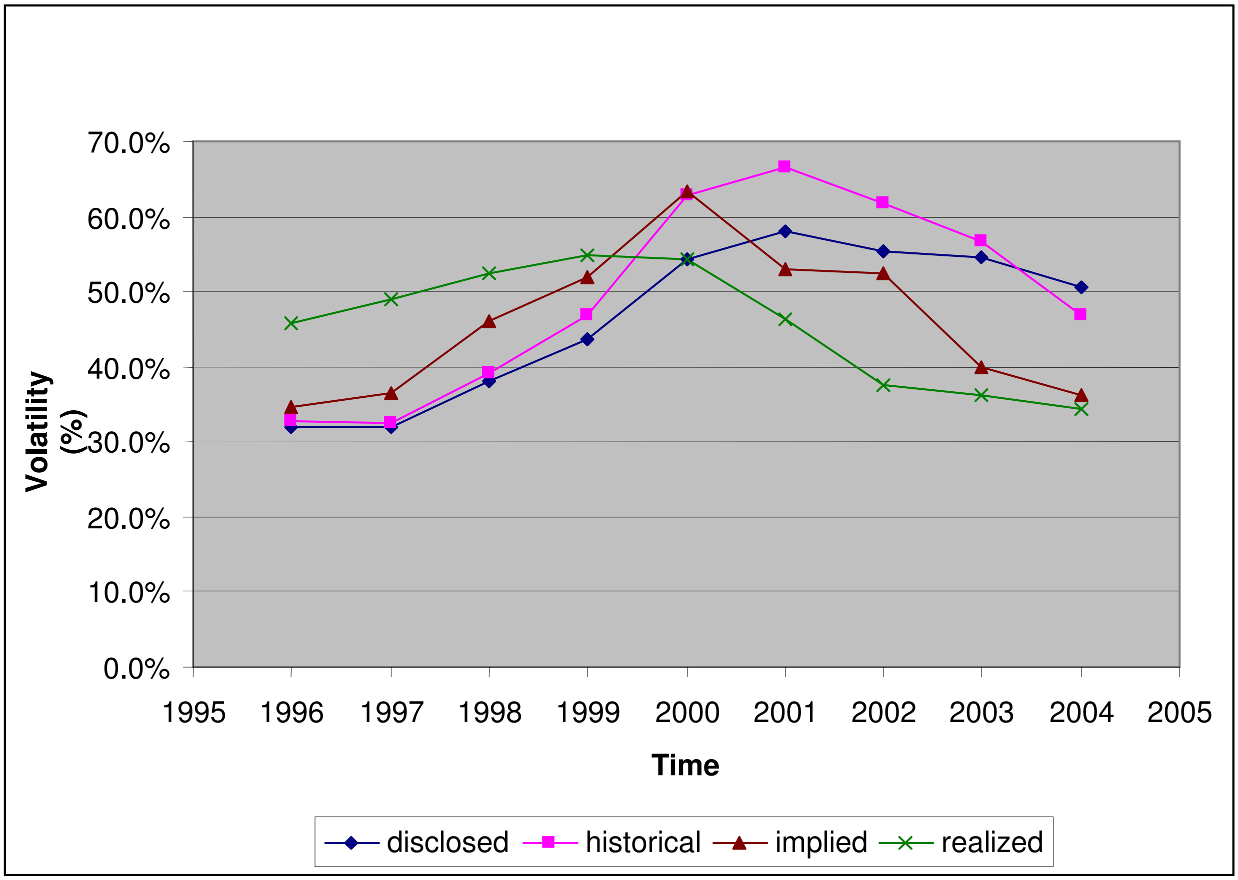

Fig. 1 Mean values of volatility measures over time. Disclosed volatility is the volatility used by the firm in calculating the value of option grants, disclosed in Form 10-K. Historical and realized volatility are calculated using monthly stock returns over a period equal to the expected option life, as disclosed in Form 10-K. The period for historical (realized) volatility ends (starts) on the balance sheet date. If the estimation period for realized volatility is less than 24 months, daily instead of monthly returns are used (a minimum of 50 daily returns is required). Implied volatility is calculated using the prices of traded call and put options at the end of the fiscal year.

Table 1 Sample selection procedure

	Firm-Years	*Distinct Firms*
Data on option grants obtained from New Constructs database	16,987	3,025
LESS implied volatility unavailable on Optionmetrics database	6,503	593
Both option grant and implied volatility information available	10,484	2,432
LESS Unavailable CRSP returns to calculate historical/realized volatility	798	215
Option grant, implied volatility and CRSP returns available	9,286	2,227
LESS Unavailable COMPUSTAT information for incentive variables	97	12
Option, volatility, CRSP and COMPUSTAT information all available	9,189	2,215
LESS Deletion of outliers	4	0
FINAL SAMPLE	9,185	2,215

Table 2 Sample descriptive statistics

Panel A: Descriptive statistics for sample firm-years (beginning of year)

	N	*Mean*	*Std. Dev.*	*P5*	*Q1*	*Median*	*Q3*	*P95*
Sales ($millions)	9,170	4,221	11,880	34	286	993	3,388	18,570
Assets	9,170	10,113	43,104	86	374	1,353	5,126	34,621
Book value of equity	9,170	1,848	4,605	41	189	526	1,565	7,464
Market value of equity	9,161	6,902	23,663	173	561	1,452	4,551	25,985
Book-to-market	9,161	0.440	0.331	0.064	0.211	0.373	0.584	1.059
Return on assets	9,170	1.9%	13.9%	-23.5%	0.7%	3.8%	8.2%	16.7%
Sales growth	9,128	22.9%	-48.4%	-24.1%	0.7%	11.3%	28.7%	102.8%

Panel B: Time Distribution

Year	*Firm-Years*	*%*
1996	366	4.0%
1997	371	4.0%
1998	451	4.9%
1999	929	10.1%
2000	1,084	11.8%
2001	1,292	14.1%
2002	1,465	15.9%
2003	1,550	16.9%
2004	1,677	18.3%
TOTAL	9,185	100%

Table 2 continued

Panel C: Industry distribution

SIC Code	*Description*	*Firm-Years*	*%*
73	Business services	1010	11.0%
28	Chemicals and allied products	898	9.8%
36	Electronic & other electric equipment	794	8.6%
35	Industrial machinery and equipment	578	6.3%
38	Instruments and related products	549	6.0%
60	Depository institutions	443	4.8%
49	Electric, gas, and sanitary services	349	3.8%
13	Oil and gas extraction	297	3.2%
63	Insurance carriers	295	3.2%
48	Communication	274	3.0%
67	Holding and other investment offices	223	2.4%
37	Transportation equipment	209	2.3%
20	Food and kindred products	176	1.9%
59	Miscellaneous retail	167	1.8%
50	Wholesale trade-durable goods	158	1.7%
87	Engineering and management services	151	1.6%
56	Apparel and accessory stores	142	1.5%
80	Health services	141	1.5%
62	Security and commodity brokers	130	1.4%
58	Eating and drinking places	129	1.4%
27	Printing and publishing	125	1.4%
33	Primary metal industries	123	1.3%
53	General merchandise stores	110	1.2%
26	Paper and allied products	107	1.2%
79	Amusement and recreation services	96	1.0%
61	Non-Depository institutions	91	1.0%
	ALL OTHER INDUSTRIES	1420	15.5%
	TOTAL	9185	100.0%

For Panel A, the following data items are used from the annual Compustat file: Sales (#12), Assets (#6), Book Value of Equity (#60), Market Value of Equity (shares outstanding (#25) * stock price (#24)), ROA (Income before extraordinary items (#18) divided by Assets (#6)), Sales Growth (Sales (#12)/lagged Sales (#12)-1). ROA, book-to-market and sales growth are winsorized at 1% and 99%. Data from prior year is used for this table.

Table 3 Descriptive statistics and correlations for volatility measures

Panel A: Descriptive statistics for option valuation parameters

	Mean	*Std. Deviation*	*5th percentile*	*25th percentile*	*Median*	*75th percentile*	*95th percentile*
σ^D	50.7%	25.9%	20.4%	31.0%	44.9%	65.0%	97.7%
$\lvert\sigma_t^D - \sigma_{t-1}^D\rvert$	8.3%	11.8%	0.4%	2.2%	5.1%	10.2%	26.0%
$\lvert(\sigma_t^D - \sigma_{t-1}^D)/\sigma_{t-1}^D\rvert$	14.7%	15.7%	0.9%	4.9%	10.6%	20.2%	40.6%
Dividend Yield	0.8%	1.6%	0.0%	0.0%	0.0%	1.1%	4.0%
Expected Life	3.3	0.9	2.0	3.0	3.0	3.0	5.0
Risk Free Rate	4.3%	1.3%	2.5%	3.3%	4.3%	5.3%	6.4%

Panel B: Time-series means of cross-sectional correlation coefficients amongst volatility measures

	σ^D	σ^H	σ^I	$\sigma^I - \sigma^H$	σ^R	$\sigma^R - \sigma^D$
σ^D	1.000	0.861	0.809	-0.314	0.730	-0.345
σ^H	0.780	1.000	0.847	-0.483	0.767	-0.150
σ^I	0.756	0.764	1.000	-0.028	0.772	-0.090
$\sigma^I - \sigma^H$	-0.301	-0.620	0.001	1.000	-0.202	0.213
σ^R	0.663	0.671	0.707	-0.207	1.000	0.279
$\sigma^R - \sigma^D$	-0.356	-0.090	-0.039	0.143	0.414	1.000

σ^D is the volatility used by the firm in calculating the value of option grants, disclosed in Form 10-K. σ_t^D is the disclosed volatility for the current year, while σ_{t-1}^D is the disclosed volatility for the immediate lagged year. σ^H is historical stock-price volatility, calculated using monthly returns over a period equal to the expected option life which ends on the balance sheet date. σ^I is implied volatility, calculated using the prices of traded call and put options at the end of the fiscal year. σ^R is realized volatility, calculated using monthly stock returns over a period equal to the expected options life which starts on the balance sheet date. If the estimation period for realized volatility is less than 24 months, daily instead of monthly returns are used (a minimum of 50 daily returns is required). N=9,185 for all variables, except changes in volatility (N=6,306). Pearson (Spearman) Correlations are below (above) the Main Diagonal. Mean correlations above 0.7 are significant at the 1% level. Mean correlations above 0.59 are significant at the 5% level. Mean correlations above 0.53 are significant at the 10% level.

Table 4 Regressions examining the extent to which firms incorporate forward-looking information in estimating expected volatility

$$\sigma^D = \alpha_{indu,year} + \beta_1\sigma^H + \beta_2\sigma^I + \varepsilon$$

Sample	β_1	β_2	*Adj. R^2*	*N*	$\beta_1 - \beta_2$
Pooled	0.313	0.478	66.7%	9,185	-0.165
	(39.96)	(38.05)			(-11.13)
1996	0.670	0.217	76.8%	366	0.454
	(14.3)	(4.83)			(6.99)
1997	0.587	0.319	77.5%	371	0.268
	(12.48)	(6.65)			(3.99)
1998	0.602	0.238	74.4%	451	0.364
	(15.66)	(5.91)			(6.53)
1999	0.546	0.303	66.9%	929	0.243
	(17.22)	(8.84)			(5.21)
2000	0.225	0.411	64.5%	1084	-0.185
	(13.04)	(15.53)			(-5.86)
2001	0.180	0.718	59.0%	1292	-0.538
	(8.89)	(17.86)			(-11.95)
2002	0.320	0.441	66.8%	1465	-0.121
	(17.24)	(14.98)			(-3.47)
2003	0.379	0.503	68.9%	1550	-0.124
	(18.49)	(13.31)			(-2.88)
2004	0.465	0.421	64.2%	1677	0.044
	(20.71)	(11.55)			(1.04)
Summary	0.442	0.397	68.8%	1,021	0.045
(Fama-Macbeth)	(3.63)	(5.28)			(0.22)

σ^D is the volatility used by the firm in calculating the value of option grants, disclosed in Form 10-K. σ^H is historical stock-price volatility, calculated using monthly returns over a period equal to the expected life of the stock options which ends on the balance sheet date. σ^I is implied volatility, calculated using the prices of traded call and put options at the end of the fiscal year. The regressions include fixed effect for industry-year (industry) in the pooled (year-by-year and Fama-MacBeth) regressions, where industry is determined at the 3 digit SIC code level. t-statistics for Fama-Macbeth regressions include correction for auto-correlation using the methodology in Bernard (1995).

Table 5 Regressions examining whether firms' propensity to incorporate forward-looking information in estimating expected volatility is related to the relative magnitudes of historical and implied volatilities

$$\sigma^D = \alpha_{indu,year} + \beta_1\sigma^H + \beta_2\sigma^I + \beta_3 HI\_IMP + \beta_4 HI\_IMP \times \sigma^H + \beta_5 HI\_IMP \times \sigma^I + \varepsilon$$

SAMPLE	β_1	β_2	β_3	β_4	β_5	*Adj. R^2*	*N*	$\beta_1+\beta_4$	$\beta_2+\beta_5$
Pooled	0.230	0.498	-0.066	0.488	-0.455	68.3%	9,185	0.718	0.042
	(23.64)	(27.89)	(-8.59)	(14.85)	(-14.82)			(20.95)	(1.20)
1996	0.341	0.511	-0.013	0.398	-0.364	71.9%	366	0.739	0.148
	(2.39)	(3.02)	(-0.51)	(2.32)	(-2.04)			(3.31)	(0.60)
1997	0.064	0.847	-0.049	0.742	-0.655	74.2%	371	0.805	0.192
	(0.67)	(7.45)	(-1.61)	(5.21)	(-4.57)			(4.70)	(1.05)
1998	0.190	0.758	-0.007	0.509	-0.581	74.6%	451	0.699	0.177
	(1.80)	(5.15)	(-0.20)	(3.75)	(-3.66)			(4.07)	(0.82)
1999	0.248	0.583	-0.043	0.508	-0.433	76.3%	929	0.757	0.150
	(3.96)	(6.78)	(-1.77)	(5.71)	(-4.37)			(6.95)	(1.14)
2000	0.035	0.735	-0.019	0.638	-0.662	68.7%	1,084	0.674	0.073
	(1.45)	(14.09)	(-0.73)	(10.10)	(-9.73)			(9.95)	(0.85)
2001	0.118	0.830	0.040	0.428	-0.572	64.5%	1,292	0.546	0.258
	(5.34)	(16.22)	(1.13)	(2.27)	(-3.36)			(2.87)	(1.45)
2002	0.199	0.618	-0.006	0.455	-0.500	67.6%	1,465	0.654	0.118
	(7.96)	(13.36)	(-0.24)	(4.26)	(-5.11)			(5.96)	(1.09)
2003	0.315	0.585	-0.024	0.482	-0.521	69.8%	1,550	0.798	0.064
	(13.06)	(12.53)	(-0.90)	(2.18)	(-2.55)			(3.58)	(0.31)
2004	0.372	0.547	-0.001	0.485	-0.458	64.8%	1,677	0.857	0.089
	(12.06)	(9.34)	(-0.06)	(3.74)	(-4.18)			(6.44)	(0.72)
Summary	0.209	0.668	-0.014	0.516	-0.527	70.3%	1,021	0.725	0.141
(Fama-Macbeth)	(4.86)	(17.55)	(-1.68)	(20.71)	(-24.72)			(16.03)	(7.39)

σ^D is the volatility used by the firm in calculating the value of option grants, disclosed in Form 10-K. σ^H is historical stock-price volatility, calculated using monthly returns over a period equal to the expected life of the stock options which ends on the balance sheet date. σ^I is implied volatility, calculated using the prices of traded call and put options at the end of the fiscal year. HI_IMP is a dummy variable that equals 1 if $\sigma^I > \sigma^H$ and 0 otherwise. The regressions include fixed effect for industry-year (industry) in the pooled (year-by-year and Fama-MacBeth) regressions, where industry is determined at the 3 digit SIC code level. t-statistics for Fama-Macbeth regressions include correction for auto-correlation using the methodology in Bernard (1995).

Table 6 Regressions examining the importance of measurement error in σ^H and σ^I

$$\sigma^D = \alpha_{indu} + \beta_1\sigma^H + \beta_2\sigma^I + \beta_3 HI\_IMP + \beta_4 HI\_IMP \times \sigma^H + \beta_5 HI\_IMP \times \sigma^I + \varepsilon, \quad (2)$$

$$\sigma^R = \alpha'_{indu} + \beta'_1\sigma^H + \beta'_2\sigma^I + \beta'_3 HI\_IMP + \beta'_4 HI\_IMP \times \sigma^H + \beta'_5 HI\_IMP \times \sigma^I + \varepsilon \quad (3)$$

$$\sigma^D - \sigma^R = \alpha^*_{indu} + \beta^*_1\sigma^H + \beta^*_2\sigma^I + \beta^*_3 HI\_IMP + \beta^*_4 HI\_IMP \times \sigma^H + \beta^*_5 HI\_IMP \times \sigma^I + \varepsilon \quad (4)$$

Panel A: Entire sample

Dep. Var.	β_1	β_2	β_3	β_4	β_5	*Adj. R^2*	*N*	$\beta_1+\beta_4$	$\beta_2+\beta_5$
<u>Pooled Regression</u>									
σ^D	0.230	0.498	-0.066	0.488	-0.455	68.3%	9,185	0.718	0.042
	(23.64)	(27.89)	(-8.59)	(14.85)	(-14.82)			(20.95)	(1.2)
σ^R	0.010	0.722	0.069	0.272	-0.241	53.7%	9,185	0.282	0.481
	(0.93)	(36.33)	(8.14)	(7.43)	(-7.04)			(7.39)	(12.17)
σ^D - σ^R	0.220	-0.224	-0.135	**0.216**	**-0.215**	21.7%	9,185	0.436	-0.439
	(15.11)	(-8.39)	(-11.8)	**(4.39)**	**(-4.67)**			(8.50)	(-8.25)
<u>Summary of Annual Regressions (Fama-Macbeth)</u>									
σ^D	0.209	0.668	-0.014	0.516	-0.527	70.5%	9,185	0.725	0.141
	(4.86)	(17.55)	(-1.68)	(20.71)	(-24.72)			(16.03)	(7.39)
σ^R	0.272	0.556	-0.004	0.227	-0.235	55.2%	9,185	0.499	0.321
	(1.83)	(4.42)	(-0.18)	(2.98)	(-2.16)			(4.35)	(12.63)
σ^D - σ^R	-0.063	0.112	-0.01	**0.289**	**-0.292**	17.8%	9,185	0.226	-0.180
	(-0.38)	(0.77)	(-0.6)	**(3.18)**	**(-2.41)**			(2.12)	(-6.85)

Panel B: Subset with at least 24 months to calculate realized volatility

Dep. Var.	β_1	β_2	β_3	β_4	β_5	*Adj. R^2*	*N*	$\beta_1+\beta_4$	$\beta_2+\beta_5$
<u>Pooled Regression</u>									
σ^D	0.203	0.607	-0.070	0.570	-0.537	68.5%	7,330	0.774	0.070
	(19.57)	(31.72)	(-8.13)	(16.65)	(-16.51)			(21.62)	(1.86)
σ^R	0.022	0.744	0.071	0.278	-0.249	51.2%	7,330	0.300	0.496
	(1.76)	(32.6)	(6.94)	(6.80)	(-6.41)			(7.02)	(11.01)
σ^D - σ^R	0.182	-0.137	-0.14	**0.292**	**-0.289**	17.6%	7,330	0.474	-0.426
	(11.22)	(-4.59)	(-10.54)	**(5.49)**	**(-5.70)**			(8.51)	(-7.24)
<u>Summary of Annual Regressions (Fama-Macbeth)</u>									
σ^D	0.227	0.682	-0.013	0.577	-0.58	70.8%	7,330	0.804	0.102
	(4.06)	(14.71)	(-1.23)	(17.39)	(-13.79)			(23.32)	(4.06)
σ^R	0.188	0.721	-0.004	**0.255**	**-0.276**	53.7%	7,330	0.443	0.445
	(3.58)	(16.66)	(-0.35)	**(3.79)**	**(-5.96)**			(3.01)	(19.14)
σ^D - σ^R	0.039	-0.038	-0.009	**0.322**	**-0.304**	15.8%	7,330	0.361	-0.343
	(0.79)	(-0.78)	(-1.08)	**(5.26)**	**(-4.05)**			(2.86)	(-11.68)

σ^D is the volatility used by the firm in calculating the value of option grants, disclosed in Form 10-K. σ^H is historical stock-price volatility, calculated using monthly returns over a period equal to the expected option life which ends on the balance sheet date. σ^I is implied volatility, calculated using the prices of traded call and put options at the end of the fiscal year. σ^R is realized volatility, calculated using monthly stock returns over a period equal to the expected options life which starts on the balance sheet date. If the estimation period for realized volatility is less than 24 months, daily instead of monthly returns are used (a minimum of 50 daily returns is required). HI_IMP is a dummy variable that equals 1 if $\sigma^I > \sigma^H$ and 0 otherwise. The regressions include fixed effects for industry-year groups for the pooled regressions and industry groups for the year by year regressions, where industry is determined at the 3-digit SIC code level. In Panel B, only those observations are used where 24 months of monthly returns are available for the calculation of realized volatility.

Table 7 Regressions examining the effect of managerial incentives on firms' propensity to incorporate forward-looking information in estimating expected volatility

$$\sigma^D = \alpha_{indu,year} + \beta_1\sigma^H + \beta_2\sigma^I + \beta_3 HI\_IMP + \beta_4 HI\_IMP\times\sigma^H + \beta_5 HI\_IMP\times\sigma^I + \varepsilon$$

Panel A: Partitions based on benefits from manipulation of expected volatility (incentives to manipulate)

PARTITION	β_1	β_2	β_3	β_4	β_5	*Adj.* R^2	*N*	$\beta_1+\beta_4$	$\beta_2+\beta_5$
Option Grants									
Small Grants	0.298	0.444	-0.077	0.404	-0.364	66.5%	4,594	0.752	0.08
	(18.05)	(16.19)	(-7.96)	(8.80)	(-8.3)			(15.43)	(1.54)
Large Grants	0.214	0.568	-0.064	0.539	-0.531	64.3%	4,591	0.753	0.037
	(16.41)	(22.58)	(-5.06)	(11.03)	(-11.73)			(14.89)	(0.71)
Large – Small	-0.084	0.125	0.013	**0.135**	**-0.168**			0.001	-0.043
	(-4.00)	(3.36)	(0.83)	**(2.02)**	**(-2.66)**			(0.02)	(-0.58)
Option Holdings									
Low Holdings	0.322	0.392	-0.04	0.371	-0.307	64.2%	4,595	0.693	0.035
	(18.11)	(13.10)	(-4.78)	(9.28)	(-7.69)			(15.84)	(0.70)
High Holdings	0.202	0.507	-0.106	0.522	-0.434	54.2%	4,590	0.723	0.073
	(15.63)	(20.49)	(-6.75)	(9.61)	(-8.58)			(12.97)	(1.29)
High - Low	-0.12	0.115	-0.066	**0.151**	**-0.127**			0.031	0.038
	(-5.46)	(2.96)	(-3.74)	**(2.23)**	**(-1.97)**			(0.43)	(0.50)
Capital Market Issuance									
Low Issuance	0.387	0.379	-0.066	0.459	-0.354	61.3%	5,308	0.846	0.025
	(23.02)	(13.01)	(-6.28)	(9.83)	(-8.02)			(17.04)	(0.47)
High Issuance	0.166	0.606	-0.082	0.515	-0.506	68.2%	3,877	0.682	0.100
	(13.16)	(24.70)	(-6.28)	(10.25)	(-10.75)			(13.15)	(1.88)
High - Low	-0.221	0.227	-0.016	**0.056**	**-0.152**			-0.165	0.075
	(-10.48)	(5.95)	(-0.97)	**(0.82)**	**(-2.35)**			(-2.29)	(1.00)

Panel B: Partitions based on monitoring that may constrain manipulation (ability to manipulate)

PARTITION	β_1	β_2	B_3	β_4	β_5	*Adj.* R^2	*N*	$\beta_1+\beta_4$	$\beta_2+\beta_5$
Analyst Following									
High	0.427	0.327	-0.046	0.353	-0.295	73.5%	4,403	0.780	0.032
Following	(24.79)	(12.11)	(-5.16)	(8.24)	(-7.09)			(16.88)	(0.65)
Low	0.187	0.580	-0.083	0.556	-0.517	60.2%	4,782	0.742	0.062
Following	(14.42)	(22.79)	(-6.41)	(11.17)	(-11.17)			(14.43)	(1.18)
Low-High	-0.240	0.253	-0.037	**0.203**	**-0.223**			-0.037	0.030
	(-11.16)	(6.82)	(-2.35)	**(3.09)**	**(-3.58)**			(-0.54)	(0.42)
Institutional Ownership									
High	0.454	0.316	-0.064	0.412	-0.300			0.866	0.016
Ownership	(22.39)	(9.54)	(-4.90)	(6.71)	(-5.25)	62.58%	3,922	(13.39)	(0.25)
Low	0.145	0.640	-0.07	0.555	-0.558			0.700	0.082
Ownership	(11.62)	(25.92)	(-6.28)	(11.18)	(-12.21)	69.78%	3,909	(13.67)	(1.58)
Low-High	-0.309	0.325	-0.006	**0.143**	**-0.259**			-0.166	0.066
	(-12.99)	(7.86)	(-0.36)	**(1.81)**	**(-3.54)**			(-2.01)	(0.78)
Board Independence									
High	0.529	0.257	-0.033	0.207	-0.190			0.736	0.067
Independence	(22.79)	(7.50)	(-3.32)	(4.00)	(-3.81)	73.1%	3,081	(13.00)	(1.12)
Low	0.463	0.309	-0.041	0.337	-0.312			0.799	-0.003
Independence	(19.39)	(8.49)	(-3.20)	(6.30)	(-5.99)	62.9%	3,478	(13.66)	(-0.04)
Low-High	-0.066	0.052	-0.008	**0.130**	**-0.122**			0.064	-0.070
	(-1.99)	(1.04)	(-0.47)	**(1.75)**	**(-1.70)**			(0.78)	(-0.80)

Panel C: Partitions based on interaction of expected costs and benefits of manipulation

Group	*COST-BENEFIT PARTITION*	β_1	β_2	β_3	β_4	β_5	*Adj. R^2*	*N*
(1)	*Low Benefit & High Cost*	0.465	0.257	-0.096	0.333	-0.136	64.39%	2,188
		(17.04)	(5.99)	(-6.33)	(4.35)	(-1.89)		
(2)	*Low Benefit-Low Cost or High Benefit-High Cost*	0.302	0.461	-0.055	0.406	-0.373	64.10%	3,557
		(15.74)	(13.89)	(-4.29)	(6.84)	(-6.68)		
(3)	*High Benefit-Low Cost*	0.132	0.648	-0.083	0.545	-0.546	67.24%	2,086
		(8.37)	(19.43)	(-4.60)	(7.69)	(-8.46)		
	(3) – (1)	-0.333	0.391	0.014	**0.212**	**-0.410**		
		(-10.57)	(7.21)	(0.58)	**(2.03)**	**(-4.24)**		

σ^D is the volatility used by the firm in calculating the value of option grants, disclosed in Form 10-K. σ^H is historical stock-price volatility, calculated using monthly returns over a period equal to the expected option life which ends on the balance sheet date. σ^I is implied volatility, calculated using the prices of traded call and put options at the end of the fiscal year. Panel A considers partitions based on incentives (expected benefits) to manipulate expected volatility. The first partition is the size of the option grant, defined as the total options granted by a firm to all employees in the year of analysis scaled by shared outstanding. If option grants are greater than (less than or equal to) the contemporaneous median for firms in the same 2 digit SIC code it is considered a large (small) grant. The second partition is option holdings, defined as the cumulative number of options outstanding in the firm, scaled by shares outstanding. Option holdings greater than (less than or equal to) the contemporaneous median for firms in the same 2 digit SIC code are considered high (low) holdings. The third partition uses a measure of external financing raised from Richardson and Sloan (2003) as the sum of external financing raised from equity, short term debt and long term debt (change in #60 – data172 + change in #9 + change in #34 + change in #130), scaled by total assets. Panel B considers partitions based on the strength of monitoring mechanisms (expected costs). The first partition is based on analyst following which is measured as the number of analysts issuing one-year ahead EPS forecasts at the fiscal year end. Firms with analyst following greater than (less than or equal to) the contemporaneous median for firms in the same 2 digit SIC code are considered to have high (low) following. The second partition is the extent of institutional ownership. Firms with institutional ownership proportion greater than (less than or equal to) the contemporaneous median for firms in the same 2 digit SIC code are considered to have high (low) institutional ownership. The final partition is the extent of board independence, defined as the proportion of board directors that are deemed independent. Firms with proportion of independent directors greater than (less than or equal to) the contemporaneous median for firms in the same 2 digit SIC code are considered to have high (low) independence of boards. In Panel C, we interact one partition based on benefits from manipulation (option grants) with one partition based on costs of manipulation (institutional ownership.)