

Karen Salmansohn

From: Director - FASB
Sent: Tuesday, February 04, 2003 7:17 AM
To: Karen Salmansohn
Subject: FW: additional filing: File reference 1102-001



sibsonstudy.doc



Empirical
Black-Scholes.pdf

have sent a letter before th

Letter of Comment No: 155A
File Reference: 1102-001
Date Received: 2-3-03

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' submission.

Len

-----Original Message-----
From: Jennifer Dowling [mailto:jcdowling@nvca.org]
Sent: Monday, February 03, 2003 5:12 PM
To: Director - FASB
Subject: additional filing: File reference 1102-001

Please find attached below an additional submission for the above referenced matter, based on an empirical study that has just been brought to our attention.

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National Venture Capital Association

February 3, 2003

VIA E-MAIL AND OVERNIGHT COURIER

Financial Accounting Standards Board
MP&T Director – File Reference 1101-001
401 Merritt 7
P.O. Box 5116
Norwalk, CT 06856-5116

Re: Invitation to Comment on Accounting for Stock Options

Dear Sir or Madam:

The National Venture Capital Association offered its comments on the *Invitation to Comment* on accounting for stock options, dated November 18, 2002 (the “Invitation”), by letter dated January 31, 2003. A new study has come to our attention that is important to the current debate. This study, described in *Empirical Research Reveals that the Black-Scholes Model Does Not Predict the Value of Long-Term, Employee Options*, prepared by Blair Jones, Rodney Mollen and David Harper (copy attached), is directly relevant to the questions raised by the Board regarding valuation.

In the study, “Sibson Consulting conducted an extensive test of the predictive power of the Black-Scholes [model].” The study compared the value of the options at grant date, using Black-Scholes, to the actual realized value of the options. A large number of companies chosen from the Russell 3000 index were tested for selected periods from 1972-2002.

The study concludes that market movements appear to be the primary cause of inaccurate Black-Scholes valuations and that no prior correction or modification of the Black-Scholes model will be sufficient to correct for the model’s inaccuracies. The study states that

Because market movements – which appear to be the primary cause of inaccurate Black-Scholes estimates – are unpredictable, it appears we can safely say that no prior adjustments can be made to the Black-Scholes model that will correct for its inaccuracy when predicting actual gains to options holder. . . . In fact, the results demonstrate that any predictive power the Black Scholes model may offer is *utterly overwhelmed by*

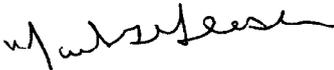
subsequent market movements. [emphasis in original]. . . . [W]e know that key underlying assumptions [of the Black-Scholes model] are violated when its application is extended to long-term, employee options. The most important underlying assumption, at least theoretically, is the requirement that volatility remain constant over the life of the option – an assumption that can hardly be considered defensible over the relatively long term of an employee option.

The study concludes:

Regardless of whether the Black-Scholes model does a good job of estimating the ex ante fair value of the employee option *at the time of grant* (our study does not exactly test for this, for what study can without a public market for employee options), our study can safely assert that Black-Scholes does a poor job of estimating or predicting the ultimately realized (ex post) *actual cost of the option to the company*. In short, the accrued and generally fixed expense, as determined by the Black-Scholes option-pricing model, is unlikely to approximate – or even come close – to the actual expense. (emphasis in original)

Thank you in advance for including this letter and the Sibson study in the record of comments.

Sincerely,



Mark Heesen
President

Empirical Research Reveals that the Black-Scholes Model Does Not Predict the Value of Long-Term, Employee Options

By Blair Jones, Rodney Mollen and David Harper

- I. Introduction
- II. Methodology
- III. Observations
- IV. Implications

I. Introduction

Because the Financial Accounting Standards Board (FASB) is likely to mandate that companies expense their employee stock options, there is widespread and renewed focus on the effectiveness of option-pricing models. The Black-Scholes Option-pricing Model is easily the most popular. For several years, almost all publicly traded companies have used this model to estimate the cost of their options. While they currently tuck away this estimate into a footnote, if and when expensing is mandated, the cost estimate will become a non-cash expense charge.

In spite of its prevalence, the Black-Scholes model is not widely trusted for this purpose. In addition to objections concerning its mathematical complexity, many have asserted that the model cannot successfully be applied to long-term, non-traded stock options. In light of this controversy, Sibson Consulting conducted an extensive test of the predictive power of the Black-Scholes. Put another way, Sibson sought to determine whether the Black-Scholes can accurately predict the actual gains to an employee who holds a stock option. And, additionally we asked, if the Black-Scholes cannot accurately predict actual future option gains, do any mis-pricing patterns emerge that suggest some kind of adjustment that would increase the accuracy of the Black-Scholes (i.e., when applied to employee stock options).

Our test compares value *at grant*, as calculated by the Black-Scholes model, to the actual realized value of the option. The Black-Scholes by definition produces a present value at grant. In order to make an “apples-to-apples” comparison *in time*, we *discounted* the actual gains to present value. In scientific parlance, the grant value is *ex ante* (i.e., before the gains), while the actual realized value is *ex post* (i.e., after the gains). If the Black-Scholes happened to be perfectly predictive, then we would expect calculated *ex ante* values to equal discounted *ex post* gains.

After testing a large sample of 1,445 companies across size and sector categories, from 1972 – 2002, we found that the Black-Scholes option-pricing model is largely unable to predict the actual gains generated by long-term employee stock options. Although the Black-Scholes model has been proven to be accurate for short-term, traded options,¹ in five of the six periods we analyzed, the Black-Scholes values were statistically different from the actual option gains. Additionally, in each period only 3-5% of actual gains were within an acceptable range of 90 – 110% of the Black-Scholes estimates.

II. Methodology

Sample Set

To create a sample set, we used the Russell 3000 composite index as it was listed on March 28, 2002. The Russell 3000 index is a broad market index that includes small-, mid-, and large-cap companies across all industries.

We first explain how we calculated both the Black-Scholes values and the actual gains on our hypothetical option grants.

The Black-Scholes Values

There are six standard inputs for the Black-Scholes model: the current stock price, the exercise price, the option term, the risk-free interest rate, dividend yield, and volatility. The following paragraph describes how we defined each input when calculating the Black-Scholes values on the hypothetical option grants.

The exercise price was set equal to the stock price at grant. In order to correlate with our hypothetical exercise assumptions (see below), we assumed an expected actual life of seven years. Consequently, we assumed an input of seven years for the term and the risk-free rate was set equal to the seven-year U.S. Treasury yield at the time of grant. We used actual dividends and stock prices to calculate the dividend yield² and volatility³ for each company. Specifically, volatility is the annualized standard deviation of total monthly returns for the three years prior to grant; i.e., we followed FASB's methodology of three year trailing volatility. We employed the Black-Scholes-Merton version of the model which is arguably the most common form and which incorporates dividends.

The Actual Option Gains

Exercise assumptions were necessary to calculate actual gains on the option grants. We assumed that the option holder exercised the options four to seven years after the grant date – consistent with observed option exercise behavior.⁴ If the option was “*in the money*” — i.e. the stock price was higher than the exercise price of the option — during an exercise window, then the employee exercised a portion of the option grant.⁵ The exercise windows were defined at four, five, six, and seven years after the grant.⁶

We *discounted* the present value of the gain from each exercise window (e.g. five years after the grant date) back to the grant date, using the seven-year risk-free rate identified at the date of grant. Finally, we calculated the total option gains by summing the present value gains at each exercise window. It is this number – the total option gains – to which we refer when discussing the actual gains that the employee realized on the hypothetical options.

Testing Selected Periods

In order to test the accuracy of Black-Scholes under various market conditions, we selected six different historical periods. Each period was defined by the hypothetical grant date and spanned seven years. Our original intent in selecting the periods was to identify extended bear, stable, and bull markets during which to test the Black-Scholes values. However, due to consistent

long-term growth in the U.S. equity market, we were unable to identify a single *sustained* bear market from 1972 – 2002 for seven years – the expected actual life of our option term.

Consequently, we identified two seven-year periods that culminated with times that investors commonly identify as bear markets – periods ending in January, 1989 (thereby including the crash of 1987) and in February, 2002. Because these bear markets were relatively short and occurred after sustained bull markets, we dubbed these periods Retreating Bull Markets.

Since we used the March 28, 2002 make-up of the Russell 3000 index as the data set, we applied a filter during each selected period. The filter excluded all companies that did not have stock price data for the seven-year duration after the option grant date, as well as for the three years prior to the grant date (to allow for the calculation of the volatility measure). Hence, we tested as few as 555 companies for a January 1973 grant date, and as many as 1,445 companies for the February 1995 grant date.

The following exhibit shows the six periods that we tested, as well as the sample size for each period.

Exhibit 1 – The Selected Periods

Historical Period	Grant Date	Sample Size
Stable A	January – 1973	555
Stable B	January – 1988	948
Retreating Bull A	January – 1982	706
Retreating Bull B	February – 1995	1,445
Bull A	November – 1990	1,151
Bull B	September – 1980	668

The Tests

The primary statistical test of this study is the comparison of Black-Scholes values to the present value of the actual gains to the option holder. To do this, we constructed a *comparison statistic* for each hypothetical option. The comparison statistic simply equals Actual Gains divided by the Black-Scholes Value for each tested option. It is with this comparison statistic that we are able to quantitatively evaluate the predictive efficacy of the Black-Scholes model.

The null hypothesis for a given grant date period is that the average comparison statistic is equal to 100%. We used statistical *t*-tests to test whether the null hypothesis could be confidently rejected at various levels of statistical significance. The number of companies tested within each of the six periods determined the degrees of freedom for the *t*-test.

As an additional test of precision (using a non-traditional definition of precision⁷), we measured how many comparison statistics fell within an *acceptable range*. We defined the acceptable range for the comparison statistic between 90 – 110%. In other words, how many options would have generated (present value) gains to the employee that were within 10% of the Black-Scholes value at the date of grant?

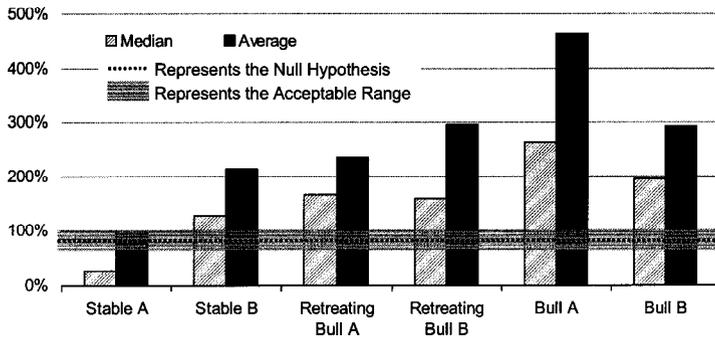
III. Observations

Overall, we have found that the Black-Scholes model performed poorly when given the task of predicting the actual option gains to a long-term option holder.

Lack of Accuracy

In five out of the six periods we selected, the null hypothesis was rejected with 99% confidence. This means that the actual gains to the employee option holder were statistically different from the Black-Scholes values at the date of grant. The exhibit below depicts the median and average comparison statistic for each of the selected periods.

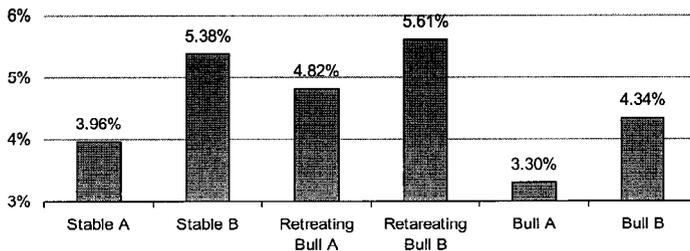
Exhibit 2 – Median and Average Comparison Statistics



Lack of Precision

We have also found that very few options generated actual gains to the employee option holder that were within the acceptable range. In fact, only 3-5% of the comparison statistics fell within the acceptable range for any given period. Please view the exhibit below for details.

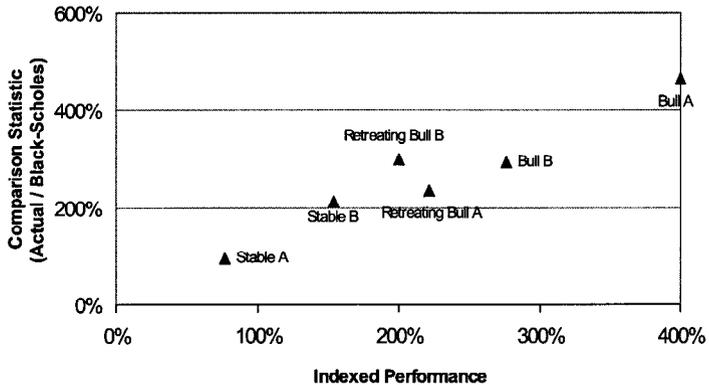
Exhibit 3 – Percent of Comparison Statistics within the Acceptable Range



Correlation with Market Performance

We have found that the discrepancy between the Black-Scholes values and actual gains was correlated with actual market performance for the six selected periods. Actual gains compared to the Black-Scholes values were lowest during the stable periods and highest during the bull markets. Please see the following graph for details.

Exhibit 4 – Correlation with Market Performance



Detailed Results

Please view the exhibit below for a more detailed look at the results.

Exhibit 5 – Detailed Results

Historical Period	Grant Date	Sample Size	Mean	Standard Error	T-score	Accuracy		Precision
						Reject Null with 95% Confidence	Reject Null with 99% Confidence	Acceptable Range
Stable A	January - 1973	555	96.9%	7.6%	-0.404	NO	NO	4.0%
Stable B	January - 1988	948	212.5%	20.2%	5.563	YES	YES	5.4%
Bull A	November - 1990	1,151	466.7%	31.4%	11.672	YES	YES	3.3%
Bull B	September - 1980	668	294.9%	13.7%	14.226	YES	YES	4.3%
Retreating Bull A	January - 1982	706	266.7%	10.9%	15.336	YES	YES	4.8%
Retreating Bull B	February - 1995	1,445	295.2%	15.0%	13.035	YES	YES	5.6%

Critical t-test values are as follows: 95% Confidence - 1.9700; 99% Confidence - 2.5966

Additional Analyses –

Uncorrectable Disparity Between Black-Scholes Values and Option Gains

In order to determine if our results were due to testing the six periods that we have selected, we analyzed the results for a number of other historical periods as well. We found similar results, with frequent rejection of the null hypothesis, and a low number of comparison statistics falling within the acceptable range.

We also explored variations of the Black-Scholes model, and we continued to find similar results. For example, in one approach we “plus-ed up” the risk-free rate input. Instead of using only the U.S. Treasury rate as the Black-Scholes model input for the risk-free rate, we added an equity premium to the U.S. Treasury rate, to construct an inflated risk-free rate. Similar to other experiments, we were not able to engineer modified versions of the model that increased its accuracy in any sustainable way.

Correlation with Actual Market Movements

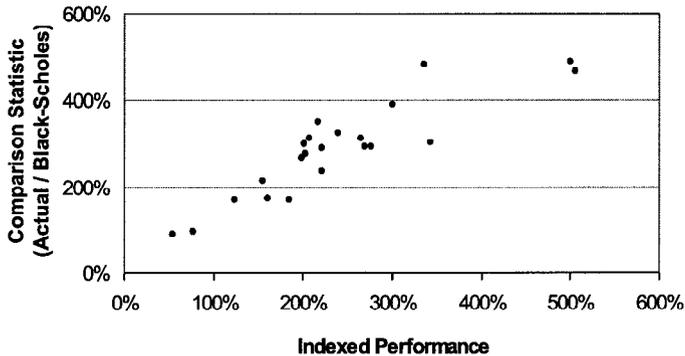
Recognizing that we selected six historical periods that are defined by the market’s average trend, we were intrigued in finding a correlation between the disparity between Black-Scholes and long-term gains to the employee option holder. In order to substantiate or disprove this claim, we performed additional statistical tests.

First, we created a simple indexed performance statistic for each time period selected. To do this, we examined the overall stock price performance for each specific company through the duration of the period. For example, if a stock traded at \$10 at grant and rose to \$15 seven years later at expiration, the performance statistic was simply +50%. The indexed performance statistic was then defined as the average performance statistic for the given period.

In a way, the indexed performance statistic and actual option gains are likely to be correlated by definition. As market performance goes up, stock options generate greater gains to employee option holders, as they did during the late 90’s. As market performance goes down, we would likewise expect stock options to generate lower returns to employee option holders.

After analyzing the results from twenty-two grant date periods (including the original six), we continue to find strong correlation between indexed performance and the comparison statistic (Actual Gains divided by the Black-Scholes values). In fact, the statistical correlation was equal to approximately 90% for the periods tested. One interpretation of this is that actual subsequent market movements explain 90% of the variation in the comparison statistic. Had there been sustained bear markets that lasted for a seven-year period, we would conjecture that the actual option gains to the employee would have been significantly lower than the Black-Scholes values at grant.

Exhibit 6 – Correlation with Market Performance



Because market movements — which appear to be the primary cause of inaccurate Black-Scholes estimates — are unpredictable, it appears we can safely say that no prior adjustments can be made to the Black-Scholes model that will correct for its inaccuracy when predicting actual gains to option holder.

In a way, the findings are not surprising. We did not expect a high degree of predictive efficacy from the Black-Scholes model. Furthermore, we expected market movements to explain some of the difference between predicted and actual values. We did hope, however, that the volatility input would be somewhat adaptive because markets move in cycles. But the results do not support this. In fact, the results demonstrate that any predictive power the Black-Scholes model may offer is *utterly overwhelmed by subsequent market movements*.

IV. Implications

Most people appear to acknowledge that the Black-Scholes model does a good job of estimating the *ex ante* value of short-term, traded stock options.⁸ However, we know that key underlying assumptions are violated when its application is extended to long-term, employee options. The most important underlying assumption, at least theoretically, is the requirement that volatility remain constant over the life of the option—an assumption that can hardly be considered defensible over the relatively long term of an employee option. For this reason alone, we can rightly suspect that the Black-Scholes will have trouble when it comes to pricing long-term employee options. Our study empirically justifies this suspicion and highlights the danger in using Black-Scholes to predict actual gains to option holders.

Implications for Accounting Expense

The accounting standard for options is probably going to be *fair value at grant*. That is, an option-pricing model such as the Black-Scholes (subject to adjustments) will be employed to estimate the fair value of the option *at the time of grant*. We have referred to this as the ex ante value.

The full set of issues concerning the expensing debate is beyond the scope of this study, as it concerns Generally Accepted Accounting Standards (GAAP) and, importantly, the purposes and limitations of the income statement. However, we can offer one implication of the study. Our study estimated actual pre-tax gains to option holders, under methodological assumptions. If a company repurchases shares, then pre-tax gain to option holders is *equivalent to the pre-tax cost to the company* (i.e., a share repurchase effectively quantifies the opportunity cost to shareholders).

Regardless of whether the Black-Scholes does a good job of estimating the ex ante fair value of the employee option *at the time of grant* (our study does not exactly test this, for what study can without a public market for employee options), our study can safely assert that Black-Scholes does a poor job of estimating or predicting the ultimately realized (ex post) *actual cost of the option to the company*. In short, the accrued and generally fixed expense, as determined by the Black-Scholes option-pricing model, is unlikely to approximate—or even come close—to the actual expense.

Option Value from the Employee's Perspective

We defined the value of a stock option from the employee's perspective as the actual gains realized assuming that the options are exercised between four and seven years subsequent to grant. Based on this methodology, we have shown that the Black-Scholes value at grant *is not* an appropriate estimator for an option value to the employee. As we would expect, the primary driver of inaccuracy appears to be actual subsequent market movements, and the Black-Scholes appears unable to anticipate these movements.

While many people remain focused on predicting the actual value of an option, it is important to remember that for compensation purposes, perceived value to the employee is as important as actual award value. Let us consider an example. A company grants a stock option award that will eventually offer substantial gains to an employee. However, since the employee does not understand how, nor believe that stock price appreciation will occur, the employee feels as if he is receiving nothing. From the company's perspective, the valuable compensation award is rendered useless — the option will not motivate, attract, or retain this employee.

It follows that communication to employees about the value of stock options and other long-term incentive awards is crucial. Because the Black-Scholes does not accurately predict the actual value of long-term options, companies cannot rely on it to communicate the value of a stock option to the employee.

Compensation Benchmarking

In summary, we have found no evidence supporting the ability of the Black-Scholes to predict the *actual* future realized gains to option holders; however, we also found that Black-Scholes' inability to predict future gains is almost entirely explained by subsequent overall market movements. It follows that it may be acceptable to use Black-Scholes to make *relative comparisons* between companies whose stocks are already highly correlated (i.e., stocks in the same industry or sector).

Let us illustrate. Assume that both Executive Andy and Executive Barbara work at different companies *in the same industry*. Company A grants Executive Andy 100 stock options on a stock that trades at \$10. Our study has shown that we will have trouble using Black-Scholes to estimate the likely actual gain Andy will realize from this grant. For example, assume that we run a Black-Scholes on the grant and determine an option value of 40%. Our study shows that we *cannot* really predict that Andy is going to realize \$400 in option gains (i.e., in today's present value dollars). We know the predictive power of Black-Scholes is low, and we have no idea how the market will influence our stock.

Additionally we assume that Company B grants Executive Barbara 50 options on a stock that trades at \$20. Let's assume the Black-Scholes says the value on an option at Company B is 60%. In this case, Barbara's calculated grant is "worth" \$600 (50 options x \$20 face value x 60%) while Andy's calculated grant is worth \$400 (100 options x \$10 x 40%). Our study suggests that it is acceptable to say that Barbara's grant is worth *roughly* 50% more than Andy's grant. We can say for two reasons: first, our reasonable expectation that overall market movements will impact both stocks similarly (i.e., as they occupy the same industry or sector); second, because we found Black-Scholes distortions to be largely a linear function of the market movements.

Put another way, we can believe that the calculated \$600 and \$400 grant values are likely to either over-estimate or under-estimate the *actual future gains* to each option holder. But we have a reasonable expectation *at the time of grant* that our error will be similar for both option-holders in both direction and degree. Without knowing where the market will go, and exactly how each stock will be influenced, we can say Barbara's grant has an expected value that is 50% higher than Andy's.

Conclusion

Our study confirms the risks in using Black-Scholes to value long-term employee stock options. First, we have shown that, regardless of whether *fair value at grant* is an appropriate expensing methodology for accounting purposes, fair value (i.e., as determined by Black-Scholes) is unlikely to correlate with actual company cost. Second, we have shown that Black-Scholes is unlikely to predict the actual gain realized by the employee. In other words, the Black-Scholes value is not a good *present-value equivalent* of the expected future gain.

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- ¹ Popular studies that are referenced are the Galai studies, Bhattacharya, Macbeth-Merville, and Rubenstein
 - ² We calculated a rolling 12-month dividend yield for each company
 - ³ The volatility measure was calculated as the standard deviation of the natural log of a company's wealth ratio. A company's wealth ratio is a measure of total shareholder return that incorporates shareholder appreciation and dividends.
 - ⁴ Huddart and Lang, *Employee Stock Option Exercises, An Empirical Analysis*, The Journal of Accounting and Economics. Volume 21 (1996), pp. 5 - 43
 - ⁵ Since the employee exercises a portion of the in-the-money option grant during an exercise window, it is as if the employee assumed that the stock price would continue increase through the duration of the option
 - ⁶ For example, if the option was in the money at each of the four exercise windows, then the employee exercised 25% of the option grant in years four, five, six, and seven after the grant date. However, if the option was "underwater," or out of the money four and five years after the grant, and it subsequently was in the money, then we assume that the employee exercised 50% of the option grant in years six and seven after the grant.
 - ⁷ Technically, because this statistic determines represents the portion of the estimates that were accurate, this statistic is a measure of scientific precision AND accuracy
 - ⁸ Popular studies that are referenced are the Galai studies, Bhattacharya, Macbeth-Merville, and Rubenstein