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A note on the impact of options on stock return volatility [1]

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Abstract

This paper measures the impact of option introductions on the return variance of underlying stocks. Past research generally finds a significant reduction in stock return variance following the listing of options through 1986. Using a more extensive sample, I compare changes in the return variance of optioned stocks to changes in the return variance of a control group. Since the average change in the control group is statistically indistinguishable from the average change in the optioned stocks, I conclude that option introductions do not significantly affect stock return variance. © 1998 Elsevier Science B.V. All rights reserved.

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1. Introduction

The recent spectacle of derivatives-related lawsuits and bankruptcies has recharged the debate regarding derivatives regulation. One popular question is

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whether derivatives affect the volatility of related markets. Past research, focusing primarily on stocks and stock options, generally finds a significant reduction in the return variance of underlying stocks following option introductions through 1986. Using a substantially larger sample of option listings, I demonstrate that a control group exhibits an average change in variance that is statistically indistinguishable from the average change in optioned stocks. I conclude that option listings do not significantly affect stock return variance.

These results shed new light on previous studies of the impact of option listings on stock variance. [3] Trennepohl and Dukes (1979) estimate betas for optioned and non-optioned stocks for the periods 1970–1973 and 1973–1976 and find that the betas of optioned stocks decrease more than the betas of non-optioned stocks. Skinner (1989) finds that the total stock return variance falls by an average of 4.8% after options are introduced. Conrad (1989) estimates that the excess return variance decreases from 2.29% for 200 days prior to listing to 1.79% for 200 days after listing. Bansal et al. (1989) find that variance drops by 6.4% after options are listed, while Damadoran and Lim (1991) detect a drop of 20%. Although their samples, methods, and estimates vary, previous studies generally find that option listings are followed by a decrease in the return variance of underlying stocks.

This paper's conclusion differs from those of previous studies. The extensive sample I use provides strong evidence that optioned stocks behave no differently than a control group. I show that market-wide variance was relatively stable for the option listings in the pre-1987 period examined by earlier studies, but that market-wide variance increased significantly, on average, for the option listings in the 1987–1992 period. In both periods, stocks with option introductions exhibit an average change in variance that is equivalent to the average change in a control group. The robust ability of the control group to match the changes in the optioned stocks leads me to conclude that options do not affect stock return variance.

The remainder of this paper is organized as follows. Section 2 discusses the possible theoretical reasons for changes in stock return variance following option introductions. Section 3 explains the empirical methodology used to measure changes in variance. Section 4 describes the data used in the study. Section 5 presents and discusses empirical results. Section 6 concludes.

2. Theoretical reasons for changes in variance

In a world of complete markets and no transaction costs, any new security can be synthesized from existing securities. Consequently, the introduction of

[3] See a survey by Damadoran and Subrahmanyam (1992) for more details.

options should have no effect on underlying assets. As Grossman (1988) makes clear, however, the existence of transaction costs and incomplete markets suggests the possibility that options can have an impact. Grossman uses a theoretical framework to assess the informational content of a traded option relative to its synthetic counterpart, and concludes that derivatives might affect the variance of underlying assets. The empirical question posed by this paper is whether stock return variance changes after options are introduced.

Researchers provide at least one reason why one could expect an increase in the variance of stock returns following option introductions. Nathan Associates (1969) warn that "diversion of speculative interest to the options market" could reduce stock trading. If the introduction of an option lures significant trading volume away from the underlying stock, the reduction in liquidity might increase the stock's return variance. However, studies by Bansal et al. (1989), Skinner (1989), and Damadoran and Lim (1991) find increases in stock trading volume following option listings.

Researchers also suggest at least three reasons why one could expect a reduction in the variance of stock returns following option introductions. Firstly, in order for option exchanges to list an option, the underlying stock must meet certain criteria. As noted by Skinner (1989) and others, the selection criteria might result in a biased sample with expected reductions in stock return variance after options are listed. Exchange officials have indicated that unusually high or rising variance is a criterion for selecting the stocks on which to list options. If variance were mean reverting, one would expect it to revert to its mean some time after option introduction. This may result in a correlation between option listings and reductions in the return variance of underlying stocks.

Secondly, the introduction of options may attract new informed traders to trade. Black (1975) notes that the financial leverage provided by stock options can lower transaction costs, thereby attracting otherwise unprofitable informed trades. Options could also attract informed trades by enabling more efficient trading on negative information than is possible in the stock market. Evidence suggests, however, that innovations in the stock prices originate in the stock market, not the option market, indicating that the informed traders prefer the stock market. Stephan and Whaley (1990) report that the price changes in the stock market lead the option market as much as by fifteen minutes. [4] Also, Fleming et al. (1996) show that the relative illiquidity of the option market creates a price effect for block trades, such that an informed trader would rationally prefer the stock market.

Thirdly, as discussed by Fedenia and Grammatikos (1992), bid–ask spreads in the stock markets could narrow after the option listings, thereby reducing

[4] See Chan et al. (1993) who confirm and reinterpret Stephan and Whaley's results.

the bid–ask bounce in stock prices and the variance of stock returns. The introduction of options might allow market makers to hedge their risks more efficiently, allowing them to narrow the spreads they charge.

In summary, there are several theoretical arguments supporting the hypothesis that option introductions might affect the underlying stock return variance. To test whether the variance in fact does change, the null hypothesis in this paper is that the listing of an option has no effect on the underlying stock's return variance.

3. Empirical methodology

I estimate the change in total stock return variance after options are introduced in order to measure the impact of option trading on stock return variance. To determine whether the options are the cause of observed changes in variance, I use a control group of stocks to account for market-wide and industry-wide influences. I construct the control group of stocks by matching the optioned stocks one-for-one with control stocks in the same trading location and industry, as identified by the first two digits of the SIC code. If the control group exhibits an average change in variance that equals the average change in the optioned sample, then I can conclude that the option listings do not, on the average, affect stock return variance.

The market model states that the return on stock i can be expressed as a linear function of the market's return:

$$R_{i,t} = \alpha + \beta R_{m,t} + \varepsilon_t, \quad \varepsilon \sim (0, \sigma^2). \tag{1}$$

To test for shifts in the return variance, I incorporate an indicator variable I_t that equals zero for observations recorded before option listing and unity otherwise. The model of returns I estimate can be expressed as follows:

$$R_{i,t} = \alpha + \beta R_{m,t} + \varepsilon_t, \quad \varepsilon_t \sim (0, \sigma_0^2 + \sigma_1^2 I_t). \tag{2}$$

Under the null hypothesis that option listings have no effect on stock trading, σ_1^2 should be equal to zero. The model in Eq. (2) restricts the firm's α and β to be constant. Neither Skinner (1989) nor Bansal et al. (1989) find evidence that β shifts when the options are introduced. Though Conrad (1989) reports a price effect within a five day period around option listing, there is no reason to expect the mean returns to be affected. Since there is no empirical or theoretical support for the shifts in α and β, I estimate their average values over the measurement period.

I use Hansen's (1982) G.M.M. to estimate parameters. G.M.M. provides three benefits. Firstly, a variance–covariance matrix of parameter estimates is generated, thereby permitting rigorous inference regarding the significance of the change in return variance. Secondly, as will be clear, parameter estimation is naturally accomplished using moment conditions in a G.M.M. framework. Thirdly, the only distributional assumptions necessary are that stock returns are stationary and ergodic.

The model of returns specified in Eq. (2) imposes the following restrictions on the data:

$$E\begin{bmatrix} R_{i,t}-\mu_t \\ (R_{i,t}-\mu_t)R_{m,t} \\ (R_{i,t}-\mu_t)^2-\sigma_t^2 \\ \left[(R_{i,t}-\mu_t)^2-\sigma_t^2\right]I_t \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \end{bmatrix}, \tag{3}$$

where:

$$\mu_t = \alpha + \beta R_{m,t},$$

$$\sigma_t^2 = \sigma_0^2 + \sigma_1^2 I_t.$$

Under the assumptions of stationarity and ergodicity, the sample moments should be close to the population moments. Define $g_T(\theta)$ as the vector of sample moments, where T denotes the sample size and θ denotes the parameter vector. The sample approximation of the expectations in Eq. (3) can be expressed as

$$g_T(\theta) = \frac{1}{T}\sum_{t=1}^{T}\begin{bmatrix} R_{i,t}-\mu_t \\ \vdots \end{bmatrix}. \tag{4}$$

To estimate the parameters, values are chosen which set the sample moments as close to zero as possible. In Eq. (4), the system is just-identified, so parameter values exist which will set $g_T(\theta)$ equal to zero. The values are in fact identical to OLS estimates, but the standard errors are not (see Hansen, 1982). I construct test statistics based on the parameter estimates' known asymptotic distributions and verify their small sample properties using simulated data. [5]

Previous studies have recognized the potential problems in inference caused by cross-sectional dependence among contemporaneous measurements of returns and variances for stocks with options listed on the same date. I incorporate cross-sectional dependence in tests of significant change in variance for the individual stocks by grouping those stocks with options listed on the same date and using the variance–covariance matrix of the grouped stocks' parameter estimates. To estimate the joint distribution, I simply expand the vector of sample moments as follows:

[5] These simulation experiments show that the small sample properties of the test statistics are quite good. Results are available from the author.

$$g_T(\theta_j, \theta_k, \theta_l, \ldots) = \frac{1}{T}\sum_{t=1}^{T}\begin{bmatrix} R_{j,t} - \mu_{j,t} \\ R_{k,t} - \mu_{k,t} \\ R_{l,t} - \mu_{l,t} \\ \vdots \end{bmatrix}, \tag{5}$$

where j, k, and l indicate parameters of stocks j, k, and l.

4. Data

The Chicago Board Options Exchange supplied a history of 1942 option listings on domestic exchanges through 30 July 1993. Records with omitted or ambiguous information were eliminated from the sample. In addition, listings that occurred after 31 December 1992 were excluded from the study since one year of post-event data is required for the analysis. Daily stock data were extracted from the Center for Research in Security Prices 1994 NYSE–AMEX and Nasdaq tapes. The final sample includes 745 NYSE–AMEX stocks and 265 Nasdaq stocks, all with no missing observations of returns. Option listings for Nasdaq stocks do not begin until 1985. [6] Thus, to the extent that stock return distributions are affected by time-varying variables such as the market return, the Nasdaq sample should exhibit behavior different than the NYSE–AMEX sample. The average firm from the NYSE–AMEX sample also differs substantially from the average firm in the Nasdaq sample due to the competitive structure of the stock exchanges. As seen in Table 1, the average Nasdaq sample stock has a larger β and variance and a smaller size (dollar value of outstanding shares on the listing date) than the average NYSE–AMEX sample stock.

I construct the control group by matching each stock in the sample group one-for-one with another stock within the same trading location. Each control stock is selected in the same industry as its paired sample stock, as identified by the first two digits of the SIC code. The control stock is rejected if it has an option listed within a four year window surrounding the sample stock's option introduction. Table 1 compares the average sample and control stocks. For both the NYSE–AMEX and Nasdaq stocks, the optioned sample has a higher beta than the control group. [7] The sample and control group stocks also differ along the size dimension. The average NYSE–AMEX stock in the sample is

[6] A regulatory relaxation of listing criteria enabled exchanges to list options on Nasdaq stocks in 1985.

[7] As discussed by Skinner (1989) and others, option exchanges are more likely to list options on large and risky stocks.

Table 1
Summary statistics

	Sample and control group summary statistics					
	NYSE–AMEX (745 obs.)		Nasdaq (265 obs.)		Combined (1,010 obs.)	
	Sample	Control	Sample	Control	Sample	Control
Size in $000s	581,761	428,478	193,298	207,213	479,838	370,424
Beta	1.27	1.06	1.81	1.29	1.41	1.12
Variance	12.15%	11.45%	27.07%	43.36%	16.07%	19.82%

The sample and control groups are compared. Size equals stock price multiplied by outstanding shares on the listing date. Beta and variance are estimated using 250 daily observations prior to the option listing date.

about 36% larger than the average NYSE–AMEX control stock, whereas the average Nasdaq stock in the sample is about 7% smaller than the average Nasdaq control stock. Though size is often cited as a determinant of stock return volatility, there is no compelling reason why size should affect changes in volatility. For this reason, I do not incorporate size in my analysis. [8]

5. Results

I estimate parameters for the market model using 500 daily observations centered around the option listing dates. In order to incorporate possible correlation among the stocks with the listings occurring on the same date, parameters were estimated jointly for those stocks with shared listing dates, as described in Section 2. Of the 1,010 listings in the study, 662 occurred on a date with at least one other listing. These 662 listings occurred on 169 unique dates, 140 for the NYSE–AMEX stocks and 29 for the Nasdaq stocks, with the number of listings per date ranging from 2 to 15. Parameters for the remaining 348 option listings were estimated individually.

All parameter estimates are tested for significance using their asymptotic normal distribution. The number and percentage of the 1,010 option listings in the full sample which reject the null hypothesis that changes in variance equal to zero are listed in panel A of Table 2. Results are broken down by trading location of the underlying stock. Under the null hypothesis, one would expect significant changes in variance to appear at the rate of the significance level. However, the test for significant change in return variance rejects the null hypothesis much more frequently, both in the combined sample and in the trading location subsamples. In the combined sample, for example, 46% of the

[8] Unreported regressions show that firm size is not correlated with changes in variance following option listings.

Table 2
Changes in stock return variance

	NYSE–AMEX (745 obs.)			Nasdaq (265 obs.)			Combined (1,010 obs.)		
	Sample	Control	Test	Sample	Control	Test	Sample	Control	Test
Panel A: Full sample									
# of rejections	354	328	–	108	111	–	462	439	–
% rejections	47.52%	44.03%	0.54	40.75%	41.89%	0.91	45.74%	43.47%	0.65
Initial variance	12.15%	11.45%	–	27.07%	43.36%	–	16.07%	19.82%	–
Change in variance	−0.05%	0.30%	0.51	1.61%	0.82%	0.80	0.38%	0.44%	0.95
% change in variance	17.10%	18.83%	0.73	24.30%	26.43%	0.79	18.99%	20.83%	0.67
	NYSE–AMEX (409 obs.)			Nasdaq (43 obs.)			Combined (452 obs.)		
Panel B: April 1973–December 1986									
# of rejections	210	186	–	19	17	–	229	203	–
% rejections	51.34%	45.48%	0.42	44.19%	39.53%	0.86	50.66%	44.91%	0.41
Initial variance	12.48%	13.07%	–	14.82%	24.68%	–	12.70%	14.17%	–
Change in variance	−1.96%	−1.60%	0.49	4.47%	0.66%	0.29	−1.35%	−1.39%	0.93
% change in variance	−2.98%	2.53%	0.29	39.27%	22.55%	0.16	1.04%	4.43%	0.38
	NYSE–AMEX (336 obs.)			Nasdaq (222 obs.)			Combined (558 obs.)		
Panel C: January 1987–December 1992									
# of rejections	144	142	–	89	94	–	233	236	–
% rejections	42.86%	42.26%	0.95	40.09%	42.34%	0.84	41.76%	42.29%	0.94
Initial variance	11.76%	9.48%	–	29.45%	46.98%	–	18.79%	24.40%	–
Change in variance	2.27%	2.62%	0.72	1.05%	0.85%	0.96	1.79%	1.92%	0.93
% change in variance	41.55%	38.68%	0.77	21.40%	27.18%	0.53	33.53%	34.11%	0.93

Panel A lists the number and percentage of stocks with significant changes in variance after options are listed. Rejections of the null hypothesis are recorded at 5% significance level using the asymptotic normal distribution of the parameter estimates. Also displayed are the average annual return variance prior to option listing, the average change in annual variance, and the average percentage change in annual variance after option listing. The tests for difference show the two-tailed probability of a larger difference between the sample and control group under the null hypothesis of equality. Panels B and C show the results for two subsamples.

events in the sample group witnessed a change in variance significant at a 5% level. The control group rejects the null hypothesis 43% of the time. [9] Though the variance changes significantly for many option introductions, it changes just as frequently for the control group. A generalized likelihood ratio test for a significant difference in the sample and control group's rejection rates fails: under the null hypothesis that the rejection rates are the same, the statistic would generate a more extreme value 65% of the time.

The average parameter estimates of the 1,010 events are also listed in panel A of Table 2. The estimates of the average initial variance and the average change in variance are annualized by multiplying by 252, representing the approximate number of trading days in a year. The average initial variance is 16% for the full sample and 20% for the control group. Most of this difference occurs in the Nasdaq subsample. The average change in variance is 0.38% for the full sample, and 0.44% for the control group. A *t*-test fails to reject the null hypothesis that the population average change is in fact equal across the two groups. The average percentage change is 19% for the combined sample and 21% for the control group. Though the average percentage change in variance is quite different from zero, a *t*-test again fails to find a significant difference between the two average changes. This evidence indicates that the average impact of option introductions on variance is insignificant, since a control group exhibits changes in variance that match the changes in the optioned stocks.

This conclusion differs from those of previous studies. Skinner, for example, reports an average percentage reduction in the total variance of 4.8% upon option introduction, and an average percentage reduction of 0.8% after controlling for market variance. The difference between Skinner's conclusion and mine is due to differences in our samples and methodologies. To determine where we diverge, I categorize my results by time period and trading location in order to select a subsample that most closely matches Skinner's sample. Panel B of Table 2 shows the results for option listings between April 1973 to December 1986, a period that corresponds to Skinner's sample. Consider the NYSE–AMEX subsample, since his sample includes only NYSE–AMEX stocks. Using my methodology, the average percentage reduction in variance for the NYSE–AMEX 1973–1986 subsample is 3%. Using Skinner's methodology and the NYSE–AMEX 1973–1986 subsample, the average percentage reduction is 2%. Our methodologies give slightly different results for the same data. Furthermore, since he reports an average percentage reduction of 4.8%, our samples of listings of options on NYSE–AMEX stocks between 1973–1986 are somewhat different. Note, however, that the control group exhibits changes that match the optioned stocks in this subsample. The average reduction in variance, for example, is 1.96% for the optioned sample and 1.60% for the

[9] Evidence of time-varying volatility is consistent with ARCH and stochastic volatility models.

control group. A t-test fails to reject the null hypothesis that the two population averages are in fact the same.

There are two other reasons why my results differ from Skinner's. First, since he uses variance ratios to estimate changes in variance, he focuses more on the median ratio rather than the average ratio, since the average ratio biases the change due to Jensen's inequality. He reports a median reduction of 19.8% in total variance, and a median reduction of 9.7% after controlling for market variance. Since I estimate the change in variance directly, the average change in variance is a more appropriate measure. Secondly, and perhaps more important, I show that the match between the optioned sample and the control group is maintained for more recent option listings. Panel C of Table 2 shows the results for the period spanning January 1987 to December 1992. For the NYSE–AMEX stocks, the average percentage increase is 42% for the optioned sample and 39% for the control group. A t-test for a difference in means again fails to identify a significant difference between the sample and the control group. In fact, for every subsample listed in Table 2, the sample and control group have average changes in variance that are statistically indistinguishable.

The match between the optioned sample and the control group is maintained over two subperiods that exhibit quite different levels of change in market variance. To illustrate this, I compute the initial level of annual market variance prior to each option listing and the change in annual market variance after each listing. For the option listings in the period 1973–1986, the average initial market variance is 1.66%, the average change is −30%, and the average percentage change is 5.5%. For option listings in the period 1987–1992, the average initial market variance is 1.53%, the average change is 0.26%, and the average percentage change is 84%. Across both the full sample and these two subsamples, changes in the control group match changes in the sample. This result indicates that option listings do not affect stock return variance.

6. Conclusions

This paper seeks to determine whether the introduction of options affects the return variance of underlying stocks. The heightened regulatory interest regarding the economic impact of derivatives on related markets provides motivation for the study. I demonstrate that a carefully constructed control group exhibits changes in variance that match changes in the variance of optioned stocks. A t-test fails to reject the null hypothesis that the two groups have equal average changes in variance. This evidence supports the hypothesis that option listings have no significant effect on stock return variance.

My findings should allay some of the concerns regulatory agencies and the investing public have about derivatives trading. Though many issues in the regulation of derivatives demand attention, such as the corporate use and abuse of derivatives, the systemic risk in derivative markets, and proper accounting and disclosure rules, I provide evidence that regulators need not be concerned about the impact of options on underlying stocks. To the extent that stock options are representative of other types of derivatives, my conclusions support the continued use and development of derivative markets.

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