Introduction of futures and options on a stock index and their impact on the trading volume and volatility: Empirical evidence from the DJIA components

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Received (in revised form): 27th September, 2004

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Practical applications

The results of this study show that the volatility of the market has significantly increased after the start of futures and options trading on the Dow Jones Industrial Average (DJIA) index. This finding will be of great interest to market participants, especially to those investors who trade stocks that are part of the DJIA index. The higher volatility, as evidenced in the study, should mean higher required rates of return on the underlying stocks. Since investors always look for a stock with minimum risk for a given level of return, the findings of this study will help them to determine the price of the target stock. The findings of this study can also be applied for any future stock index that will be traded in the options or futures markets. The findings on the increased daily trading volume after the introduction of futures and options can also be used by investors to make their investment decisions. A higher trading volume of an asset indicates a high level of liquidity which, in turn, ensures fair pricing. Therefore, it can be a great comfort for the investors that the stock will be priced fairly whenever they want to buy or sell.

Derivatives Use, Trading & Regulation, Vol. 11 No. 3, 2005, pp. 246–260

1747-4426/05 $30.00

Abstract

The effect of the introduction of futures and options on the Dow Jones Industrial Average index on the volatility and trading volume of its underlying stocks is examined. Traditional measures and generalised autoregressive conditional heteroscedastic (GARCH) specification show that the levels of volatility and trading volume significantly increased after the introduction of futures and options on the index. The study provides new evidence in support of the argument that futures trading attracts uninformed or irrational traders along with the rational or informed traders, which causes an increase in stock return volatility. This may indicate that, even though the market may become more liquid, the destabilising effect brought by irrational traders in both the cash and futures markets outweigh the beneficial liquidity effect.

INTRODUCTION

Futures and options on the Dow Jones Industrials Average (DJIA) index have been trading on the Chicago Board of Trade since 6th October, 1997. As the most widely quoted and followed benchmark in the US stock market, the DJIA contains 30 blue chip stocks that have a total market value of more than $2 trillion and represent roughly one-fifth of the total market value of all US stocks. (These estimates are made by the Chicago Board of Trade based on the market values of the Dow 30 stocks at the time when the index futures and options were introduced.) One of the major concerns for both practitioners and academics alike is how the introduction of the index futures and options would affect the volatility of the underlying stock. The effect of stock index futures and options on the stock market has long been a subject of debate, and DJIA futures trading may help spark a new round of debate on this old issue. The different views on this issue can be no better illustrated than by the article published in the 'Abreast of the Market' column of the *Wall Street Journal* on the first trading day of the index futures and options. The front page article reported that Michael Schwartz, Chief Options Strategist at Oppenheimer & Co., believed that the volatility would increase tremendously. Patrick Catania, Executive Vice President at Chicago Board of Trade, argues otherwise, saying that volatility would not increase and the opposite was likely to be true. (For details, see the article on page A1 of the *Wall Street Journal*, 7th October, 1997.)

The purpose of this paper, therefore, is to address whether the introduction of futures and options on DJIA has any impact on the volatility and volume of the DJIA index components. Using both parametric and non-parametric methods, the paper empirically examines whether the introduction of DJIA futures and options trading correlates with any significant change in the volatility and trading volume of the underlying stocks.

A large number of theoretical and empirical studies have examined the effect of stock index futures and options on the volatility of the underlying spot market. Although the academic findings of these studies thus far have not produced any conclusive evidence on this issue, the popular public perception seems to be that index futures and options trading will increase the volatility in the stock market. The negative perception of the stock index futures and options has especially been strengthened after the highly publicised financial debacles of Orange County and Barings Inc.

Theoretically, the impact of stock index futures and options on the stock market volatility is still not clear. The linkage between these derivatives markets and the stock market is generally established through arbitraging activities. The results, however, depend, to a large extent, on what assumptions are made about the arbitrageurs. The important assumption is whether index futures and options trading brings in more informed or uninformed investors to the stock market. One school of thought argues that arbitrating or speculating activities in the futures markets add more informed traders to the stock market, thereby increasing the liquidity and decreasing the volatility of the market. The other school of thought asserts that index futures and options introduce more uninformed or irrational traders in both the derivatives and stock markets in search of short-term gains, therefore increasing the stock market volatility. Stein[1] develops a model and shows that futures trading by poorly informed investors or speculators in fact destabilises the stock market and therefore increases its volatility. By contrast, Danthine[2] presents a model which implies that futures markets help improve market depth and reduce volatility, since the cost responding to mispricing is reduced for informed traders. In another study, Weller and Yano[3] use a general equilibrium model to study the effect of stock index futures trading on the volatility of the stock market and conclude that stock market volatility may decrease when index futures are introduced.

The empirical findings on this issue have also been inconclusive. Edwards[4] finds that the market volatility in the S&P500 was greater before the advent of index options and futures trading than that after. Bessembinder and Seguin[5] indicate that active futures markets are associated with decreased rather than increased stock market volatility. Schwert[6] shows that the introduction of stock index futures and options has not increased the stock market volatility. More recent studies, such as that of Pericli and Koutmos,[7] have provided further evidence that index futures and options do not lead to increases in stock market volatility. Some other studies, by contrast, have documented evidence supporting the opposite argument. Maberly *et al.*[8] argue that the introduction of stock index futures increases the volatility of the stock market. Brorsen[9] also shows that stock market volatility increases after the advent of index futures trading, which causes a reduction in autocorrelations in the spot and derivatives markets. Investigating this issue for international markets, researchers have examined some major foreign stock index futures and options and found results similar to those obtained by Maberly *et al.*[8] In short, these studies show that the underlying stock market volatility tends to increase after the introduction of futures and options trading on the market indices. Rahman[10] examines the impact of trading in DJIA index futures and options on the conditional volatility of component stocks. His result suggests that there is no structural change in the conditional volatility due to the introduction of futures and options. When option listing is studied on individual stocks, there are significant number of studies, including Conrad,[11] Detemple and Jorion,[12] Kumar *et al.*,[13] Sorescu,[14] and Pilar and Rafael,[15] which argue that option listing has a significant effect on price and volatility.

Similar to other stock market indices, the effect of DJIA index futures and options trading on the underlying stocks should be an empirical one. The empirical results should be of great significance to general investors. If the market structure after the index futures and options trading remains the same, higher volatility in the market should mean higher required rates of return on the underlying stocks. It is possible that the change in volatility, if any, may be the result of some market structural changes rather than the introduction of index futures and options. This study does not intend to address the causality of this issue. Rather, this research focuses on investigating whether, empirically, the volatility and trading volume of the underlying stocks have increased significantly since the introduction of futures and options trading on the DJIA index. Because of the inconclusive empirical results from the studies on other stock indices, the results of this study on the DJIA index should provide additional insights into the existing literature.

DATA AND METHODOLOGY

The information on the 30 DJIA stocks is obtained from the online Dow Jones News Retrieval System. The data items for these stocks include daily high, low and closing prices and daily trading volumes. The data period covers 7th October, 1996 to 6th October, 1998, in order to have exactly one year of data available for pre-futures and post-futures trading with 253 and 254 trading days, respectively.

The daily returns on the 30 individual stocks are computed based on the daily closing prices. Both the traditional method of volatility estimation and the generalised autoregressive conditional heteroscedastic (GARCH) technique are used. Using the traditional method, both parametric and non-parametric tests are applied to identify whether there is any shift in the volatility after futures and options trading was introduced on the DJIA index. The volatility is measured as the standard deviation of the daily returns for individual stocks. The average trading volume of pre-futures and post-futures periods for all individual stocks are computed and tested for any significant shift by using both parametric and non-parametric techniques. Both prices and trading volume are adjusted for stock splits that took place during the period indicated above. In addition, a volatility measure which considers the daily high and low prices is also employed. This technique, known as Parkinson's efficient variance estimator, takes into consideration the daily high and low prices and is measured as:

$$\frac{[\ln(H_t) - \ln(L_t)^2]}{4\ln 2} \tag{1}$$

where H_t and L_t are the daily high and low prices, respectively. This measure provides additional insights into the understanding of

Table 1: Basic statistics for the 30 Dow Jones Industrial Stocks[a]

		Whole period	*Pre-futures period*	*Post-futures period*
Returns	Mean	0.0713	0.1349	0.0008
	SD	1.9377	1.6867	2.1481
	Minimum	–0.0530	–0.0402	–0.1450
	Maximum	0.1819	0.2599	0.2146
Volume	Mean	2,318,495	2,044,339	2,591,568
	SD	1,371,120	1,288,596	1,528,781
	Minimum	504,136	447,204	560,845
	Maximum	5,598,343	5,177,039	6,507,393

[a]The whole time period covers 17th March, 1997–11th March, 1998. The pre-futures period is from 17th March, 1997 to 5th October, 1997, and the post-futures period is from 7th October, 1997 to 11th March, 1998. The measures for returns are percentages and the measures for volumes are in hundreds. Both these measures are on a daily basis.

stock return volatility through intra-day price movements, rather than the daily closing price changes. Table 1 provides some basic returns and volatility measures for the underlying stocks.

The statistical methods used to test the impact of futures and options trading on the underlying stocks include the two-sample *F*-test for the two measures of volatility (standard deviation and high–low variance), and the *t*-test for the return and trading volume. These techniques, which test whether there is any significant change in the average daily return, average volatility and average daily trading volume, are applied for each of the individual stocks. Then, to test whether there is a significant change in return, volatility and trading volume during the post-futures period compared with the pre-futures period for the 30 stocks as a group, the paired *t*-test and the Wilcoxon signed-rank test were applied. In order to perform these tests, average return, standard deviation of stock returns, daily high–low variance and the mean trading volume before and after the DJIA index futures trading date are computed for each stock. The difference between these two tests is that the Wilcoxon test does not require the normality assumption for the testing variable, whereas the *t*-test does. Both tests are applied to check the robustness of the analysis irrespective of the underlying assumptions.

As some of the studies indicate that volatility is created because of the activity of the speculators in the market, it is important to investigate how flow of information and volatility are related. Most of the previous studies, however, do not explicitly investigate this relationship. Since with the change of information volatility of stock price also changes, we attempt to model this relationship as a conditional variance using the GARCH model developed by Engle[16] and Bollerslev.[17] Unlike ordinary least squares regression, GARCH specifically incorporates the conditional variance as a linear function of the lagged squared residuals and lagged conditional variances. In other words, this specification shows how current volatility is affected by past volatility. A GARCH model with orders p and q can be written as

$$R_t = \lambda_0 + \lambda_1 R_{mt} + \varepsilon_t,\ \ \varepsilon_t \mid \Psi_{t-1} \sim N(0,h_t) \quad (2)$$

$$h_t = \alpha_0 + \sum_{i=1}^{p} a_i \varepsilon_{t-i}^2 + \sum_{j=1}^{q} \beta_j h_{t-j} \quad (3)$$

where Equation (2) is the conditional mean equation, and Equation (3) is the conditional variance equation. R_t is the individual stock return and R_{mt} is the market portfolio return. The daily percentage change in S&P500 index is used to proxy the market portfolio. (Since we are testing the overall market reaction due to the introduction of futures and options trading on the DJIA index, the S&P500 index was chosen as the appropriate proxy for the market portfolio.) ψ_{t-1} is the past information set, and h_t represents the variance. The residual term ε_t is conditional on the information set and is assumed to be normally distributed with mean zero and variance h_t. Both Equations (2) and (3) are jointly estimated by maximising the log-likelihood function. GARCH(1,1) is applied to the process to estimate the measures of volatility. (In the empirical model, GARCH(1,1) was used, since the log-likelihood ratio with $p = 1$ and $q = 1$ is the maximum. Additionally, using GARCH(p,q) with $p + q \geq 3$ produces unstable estimates and the marginal benefit is very small.) Under this specification, the values of a_0, a_1 and β_1 show whether the immediate past information is influencing the present volatility of stock returns.

These parameters are estimated for the sub-samples of both pre-futures and post-futures periods. If the values of a_0, a_1 and β_1 for the post-futures period are significantly higher than those for the pre-futures period, this may indicate that there has been an increase in the way current variance is affected by the past. This kind of shift in the return generating process is generally due to the presence of some important event, which can alter the way the information is processed in the market.

EMPIRICAL TEST RESULTS

Traditional results

Tables 2–6 show the results of the tests which examine whether there is any change in return, volatility and trading volume during the post-futures period compared with the pre-futures period for the DJIA stocks. Table 2 shows the results of the F-test, comparing the volatility of the 30 individual stocks before and after index futures trading. Two types of volatility measures are specified: variance of daily individual stock returns and the

Parkinson's daily high–low variance estimator. The *F*-test is used to examine whether the post-futures variance has increased significantly by comparison with the pre-futures variance. The *p*-values for these tests are provided to show the significance of the tests. The results show that volatility — as measured by daily stock return variance — increased significantly after introducing the index futures and options on the DJIA. Of the 30 underlying individual stocks, 28 stocks showed an increase in stock return. Of these 28 stocks, the increase in volatility of 25 stocks is significant at the five per cent level and of the two stocks whose volatilities decreased, only one stock is significant at the five per cent level. To measure the economic significance, the figures in Table 2 are converted to standard deviations, which is the commonly used measure of stock return volatility. The average increase in volatility for all 30 stocks from the pre-futures to post-futures period is about 62 per cent. The average increase in volatility for the 28 stocks is about 70 per cent, while the average decrease for the two stocks is about 18.5 per cent. These results indicate that the volatility of the underlying stocks increased significantly after the introduction of DJIA index futures and options.

To examine whether the increased volatility is accompanied by any change in returns, the two-sample *t*-test is used to compare the mean returns before and after the index futures trading. Contrary to the evidence found in the case of volatility change, most of the stocks in this research show a significant decline in the return during the post-futures period compared with the pre-futures period. Since the main objective is to investigate the effect on the volatility and trading volume, the test results on the change in the return of individual stocks are not presented here. The results from the pairwise *t*-test and the Wilcoxon test for the sample are provided in Table 4.

Table 2 also provides the results from the Parkinson's efficient high–low variance estimator as a measure of stock return volatility. The results are similar to those found using the standard deviation technique. The results from Parkinson's method are consistent with those from standard deviation in the sense that the same 28 stocks showed an increase and two stocks showed a decrease in volatility. The only difference is that the increase in the volatility of IBM is significant using the standard deviation method, while it is insignificant using Parkinson's method, while Merck has an insignificant increase using standard deviation method, but increases significantly using Parkinson's method. The average increase in volatility for all 30 stocks is about 51.80 per cent. The average change in volatility for the 28 stocks with increased volatility is 59.05 per cent, while the average change for two stocks with decreased volatility is –17.42 per cent.

Table 3 presents the results of the t-test, examining the effect of introducing index futures and options on the trading volume of the underlying individual stocks. It is interesting to see whether index futures and options trading have led to increases in the trading volumes of the underlying stocks. The test may also help ascertain whether

Table 2: Individual DJIA stocks' volatility before and after DJIA index futures trading[a]

Company	Variance (close-to-close) After	Before	p-value	Variance (high-low) After	Before	p-value
Alcoa	5.69	2.13	**0.0000**	2.42	1.82	**0.0017**
Allied Signal	4.16	2.26	**0.0000**	4.77	1.84	**0.0000**
American Express	6.37	3.59	**0.0000**	4.15	2.64	**0.0021**
ATT	5.13	3.02	**0.0000**	3.31	2.58	**0.0339**
Boeing	6.11	2.95	**0.0000**	3.86	1.96	**0.0002**
Caterpillar	5.95	3.07	**0.0000**	4.42	1.94	**0.0000**
Chevron	3.26	2.09	**0.0002**	2.53	1.76	**0.0000**
Coca–Cola	3.89	2.73	**0.0027**	3.20	2.04	**0.0038**
Disney	5.23	1.89	**0.0000**	3.62	1.66	**0.0002**
DuPont	5.40	3.00	**0.0000**	4.13	2.50	**0.0000**
Exxon	2.69	2.29	0.0976	2.57	2.17	0.0781
General Electric	3.44	2.39	**0.0020**	3.02	2.02	**0.0014**
General Motors	3.72	2.28	**0.0000**	2.74	1.84	**0.0000**
Goodyear	3.63	1.50	**0.0000**	2.56	1.46	**0.0000**
HP	6.46	4.96	**0.0186**	4.58	3.88	**0.0354**
IBM	4.85	3.82	**0.0306**	3.23	2.86	**0.1469**
International Paper	4.89	3.27	**0.0009**	3.94	2.66	**0.0008**
Johnson & Johnson	2.83	3.12	0.2196*	2.44	2.48	0.4368*
Kodak	3.88	3.68	0.3340	2.85	2.08	**0.0026**
McDonald's	3.97	1.93	**0.0000**	2.70	1.67	**0.0005**
Merck	3.99	3.30	0.0670	2.94	2.36	**0.0444**
MMM	3.21	2.05	**0.0002**	2.33	1.63	**0.0002**
Morgan, J.P.	6.34	2.31	**0.0000**	4.00	1.66	**0.0000**
Philip Morris	3.85	5.08	**0.0142***	2.87	3.95	**0.0392***
Proctor & Gamble	4.40	2.70	**0.0000**	3.36	2.24	**0.0005**
Sears	6.42	3.21	**0.0000**	4.51	2.34	**0.0000**
Traveler	9.03	5.18	**0.0000**	5.80	3.74	**0.0005**
Union Carbide CP	4.06	2.25	**0.0000**	3.21	1.65	**0.0000**
United Technology	3.62	2.02	**0.0000**	2.41	1.79	**0.0012**
Wal-Mart	4.89	3.28	**0.0008**	4.42	2.56	**0.0002**
Average	4.61	2.84	**0.0000**	3.42	2.26	**0.0000**

[a]The post-futures and pre-futures variances are computed over the periods after and before the introduction of index futures trading using daily stock returns. The bold *p*-values indicate the significance of the tests at the 5 per cent level. The *p*-values with an asterisk imply that the volatility decreased after index futures trading.

Table 3: Individual DJIA stocks' trading volumes before and after DJIA index futures trading[a]

Company	*Post-futures volume*	*Pre-futures volume*	*p-value*
Alcoa	948,890	706,878	**0.0000**
Allied Signal	1,582,440	639,646	**0.0000**
American Express	1,558,040	1,403,384	0.0135
ATT	5,361,527	5,177,039	0.2083
Boeing	4,472,504	2,262,191	**0.0000**
Caterpillar	1,536,617	813,816	**0.0000**
Chevron	1,399,375	1,178,249	**0.0000**
Coca-Cola	3,559,766	3,397,542	0.1239
Disney	3,041,902	1,389,308	**0.0000**
DuPont	2,968,578	1,663,325	**0.0000**
Exxon	3,294,694	2,436,233	**0.0000**
General Electric	4,828,320	3,564,899	**0.0000**
General Motors	2,577,379	2,479,568	0.1239
Goodyear	560,844	447,204	**0.0000**
Hewlett Packard	3,409,062	3,154,183	0.0577
IBM	4,258,971	3,823,329	**0.0038**
International Paper	1,337,568	1,243,394	**0.0380**
Johnson & Johnson	2,323,359	2,494,191	**0.0073***
Kodak	1,528,392	1,521,012	0.4773
McDonald's	2,275,683	2,326,919	0.3017*
Merck	3,035,837	2,795,800	**0.0154**
MMM	1,050,375	920,649	**0.0004**
Morgan, J.P.	1,035,618	705,091	**0.0000**
Philip Morris	6,507,393	4,685,686	**0.0000**
Proctor & Gamble	2,193,536	1,271,451	**0.0000**
Sears	1,862,932	1,416,620	**0.0000**
Traveler	4,584,587	2,495,974	**0.0000**
Union Carbide CP	685,114	566,608	**0.0003**
United Technology	830,756	651,660	**0.0000**
Wal-Mart	3,136,967	3,698,013	**0.0000**
Average	2,591,568	2,044,339	**0.0000**

[a]The average daily trading volumes in post-futures and pre-futures periods are computed over 220 trading days around the introduction of the DJIA index futures. The bold *p*-values indicate the significance of the tests at the 5 per cent level. The *p*-values with an asterisk imply that the volatility decreased after index futures trading.

Table 4: Comparison of return, risk and volume before and after futures trading[a]

	Post-futures	*Pre-futures*	*Wilcoxon statistic*	p-*value of paired* t-*test*
Returns	0.08	13.49	–4.27	0.00
SD	2.15	1.69	4.62	0.00
Volatility-hi/lo	3.43	2.26	4.45	0.00
Trading volume	2,591,568	2,044,339	4.12	0.00

[a]Two volatility measures have been used both for pre- and post-futures periods. The first is the standard deviation of the daily stock returns based on daily closing prices and the second is the Parkinson's efficient high-low variance estimator. The bold numbers indicate that the difference is significant at least at the 5 per cent level.

the increased volatility can be partially attributed to an increase in trading volume. The trading volumes for the stocks are adjusted for stock split factors over the time period. That is, if a stock has a 2-for-1 stock split, the trading volume for that stock is multiplied by a factor of 2 for trading volumes before the occurrence of the split. Then, for each stock, a two-sample *t*-test is applied to examine whether the average trading volume after the introduction of the index futures has increased significantly. The *p*-values of these tests are shown in the table with significant values at the five per cent level in bold. As in Table 2, an asterisk indicates that the post-futures trading volume has decreased for that stock. Table 3 shows that average trading volume increased for 28 stocks and decreased for only two stocks after index futures trading started. Of the 28 stocks, the increases for 23 stocks are significant at the five per cent level; of the two stocks that decreased, the decrease for one stock is significant at the five per cent level. The average increase in the daily trading volume from the pre-futures to post-futures period for all 30 stocks is about 26.77 per cent. The average change for the 28 stocks with increased daily volume is 29.44 per cent, while the average decrease in daily trading volume for the remaining two stocks is –4.61 per cent. These results strongly indicate that the daily trading volume of the underlying individual stocks have increased significantly after the introduction of the DJIA index futures and options.

The pairwise *t*-test and the Wilcoxon test were also used to test the significance of the difference in post-futures and pre-futures values of return, standard deviation, high-low variance and trading volume for the 30 stocks. These results are presented in Table 4. Jointly analysing Tables 2, 3 and 4, one finds that there is an evident positive association between the change in trading volume and the change in volatility. Of the 28 stocks showing an increase in volatility in return, 27 stocks also show an increase in daily trading volume. There is only one stock (McDonald's) that shows an increase in volatility but a decrease in trading volume and one stock (Philip Morris) that shows a decrease in volatility with an increase in trading volume. These results provide strong support for the argument that volatility and trading volume have a positive association and are consistent with the findings from previous studies that greater volatility may lead to greater trading volume (see, for example, Bessembinder and Seguin[5]).

Econometric results (GARCH model)

Given the evidence that, using traditional methods, that there has been an increase in the volatility of underlying stocks after futures trading on the DJIA index, further testing of how past information and volatility may have influenced the current volatility of those stocks will shed additional light. For this purpose, the GARCH(1,1) model was used. The parameters of the variance equation (Equation 3) provide explanations on how past information and volatility have influenced current volatility. (The parameters of the return equation [Equation 2] are not presented here, since the objective in this section is to test how past information affects current volatility.) The estimated parameters for α_0, α_1 and β_1 of both pre-futures and post-futures periods are presented in Table 5. Any change in α_0 during the post-futures period compared with the pre-futures period shows whether there is a change in unconditional variance. The average change in the value of α_0 is –0.0001, which is not statistically significant, implying that the unconditional variance has remained the same since the start of futures trading on the DJIA index. During the post-futures period, however, 17 stocks showed significant values of α_0 compared with 13 stocks during the pre-futures period.

Similarly, a change in the value of α_1 relates to the change in the impact of past news on the current stock price changes. For example, an increase in α_1 indicates a greater impact of yesterday's news on the current price changes. The average change in the value of α_1 is 0.1106, with the p-value of the paired t-test equal to zero and the Wilcoxon statistic equal to 3.57. The number of stocks with significant values of α_1 during the post-futures period was 20, whereas only six stocks had significant values of α_1 during the pre-futures period. These results imply that the impact of past news on the current price change has increased significantly during the post-futures period compared with the pre-futures period. This shift, again, can take place only when any major event occurs in the market. One such event is the introduction of futures trading on the DJIA. α_1 is the coefficient that relates to the lagged error term ($p = 1$); therefore, the increase in the value of α_1 means that the effect of yesterday's difference in expected and actual return has increased today's volatility of stock returns. In other words, the change in the value of α_1 shows that today's stock return volatility is caused by the yesterday's information changes.

Conversely, β_1 is the coefficient of lagged variance ($q = 1$) which reflects the information prior to yesterday's price

Table 5: Estimation from GARCH(p,q) model[a]

	Post-futures			*Pre-futures*		
Company	α_0	α_1	β_1	α_0	α_1	β_1
Alcoa	**0.00006**	**0.1866**	**0.7209**	**0.00036**	–0.0246	–0.7079
Allied Signal	**0.00008**	**0.2268**	**0.5895**	**0.00038**	–0.0448	–0.7014
American Express	**0.00005**	**0.1837**	**0.7355**	**0.00056**	0.0926	**–0.6757**
ATT	**0.00035**	**0.3783**	–0.0253	**0.00052**	**0.0659**	**–0.8218**
Boeing	**0.00020**	**0.1467**	0.5327	0.00048	–0.0228	–0.6161
Caterpillar	**0.00017**	**0.2250**	0.5029	**0.00022**	0.1469	0.1427
Chevron	0.00008	0.0930	0.6726	0.00018	–0.0427	0.1609
Coca–Cola	**0.00010**	**0.4273**	0.3476	**0.00023**	0.1825	–0.0170
Disney	**0.00029**	**0.2431**	0.1779	0.00024	0.0633	–0.3380
DuPont	0.00038	0.0673	0.2246	0.00009	**0.1786**	**0.5055**
Exxon	0.00008	**0.2078**	**0.5131**	0.00003	0.1355	0.2152
General Electric	0.00002	**0.2040**	**0.7417**	**0.00042**	0.0537	–0.8254
General Motors	0.00007	**0.1389**	**0.6831**	**0.00041**	0.05379	**–0.8984**
Goodyear	**0.00021**	**0.2650**	0.1685	0.00007	0.02480	0.4894
HP	**0.00098**	**–0.0269**	–0.4976	0.00046	0.0798	0.0000
IBM	**0.00011**	**0.3686**	**0.4484**	0.00019	0.03037	0.4774
International Paper	**0.00034**	**0.3648**	–0.0270	0.00001	0.04333	**0.9342**
Johnson & Johnson	0.00008	0.0960	**0.6365**	**0.00024**	**0.2189**	–0.0083
Kodak	**0.00053**	0.0792	–0.4725	**0.00051**	0.0716	–0.4736
McDonald's	**0.00032**	0.1069	–0.1154	**0.00230**	0.0799	–0.2704
Merck	0.00023	0.1389	0.2748	0.00011	**–0.0494**	**0.7266**
MMM	0.00041	–0.0236	–0.2618	**0.00043**	**0.0454**	**–0.9960**
Morgan, J.P.	0.00002	**0.0623**	**0.9073**	0.00001	0.04021	**0.9318**
Philip Morris	0.00012	**0.1828**	**0.4989**	0.00034	0.1273	0.2021
Proctor &Gamble	0.00024	0.0985	**0.6786**	0.00027	–0.0575	0.0544
Sears	**0.00069**	0.0712	–0.1610	0.00003	0.0546	**0.8378**
Traveler	**0.00034**	**0.0184**	**0.4621**	0.000,017	0.03548	**0.9329**
Union Carbide	0.00006	0.0792	**0.7852**	0.00016	0.0817	0.2000
United Technology	0.00002	**0.1503**	**0.8099**	0.00018	0.1023	0.0088
Wal-Mart	**0.00032**	**0.5088**	**–0.1212**	**0.00035**	**0.1830**	–0.2364
Average	0.00023	0.1756	0.3477	0.00033	0.0650	–0.0256

[a]This table presents the estimated parameters of the GARCH model. GARCH(1,1) is estimated for each of the stocks in the DJIA index. The daily percentage change in S&P500 index value is used as the explanatory variable. The bold parameters are significant at least at the 5 per cent level.

Table 6: Comparison of GARCH(1,1) parameters before and after futures trading[a]

	Post-futures	*Pre-futures*	*Wilcoxon statistic*	p-*value of paired* t-*test*
α_0	0.00023	0.00033	–1.3367	0.1245
α_1	0.1756	0.0650	**3.5686**	**0.0000**
β_1	0.3477	–0.0256	**2.6019**	**0.0036**

[a]The parameters of the GARCH(1,1) model are tested using both parametric and non-parametric tests. The tests used are the *p*-value of the paired *t*-test and the Wilcoxon statistic. The bold numbers indicate that the difference between post-futures and pre-futures parameters is significant at least at the 5 per cent level.

changes and thus shows the effect of the news that arrived before yesterday. The average increase in the value of β_1 is 0.3733, which is significant using both the *t*-test (*p*-value 0.0036) and the Wilcoxon test (2.60). The number of stocks with a significant value of β_1 is 19 during the post-futures period compared with ten during the pre-futures period. These results imply that past information has a significant impact on the change in volatility of underlying stocks after the introduction of futures trading on the DJIA. Therefore, combining the results of α_1 and β_1, the implication is that there has been a significant change in the process of volatility formation of the underlying stocks due to futures trading on the DJIA.

As a whole, the GARCH test shows a significant increase in the volatility during the post-futures period compared with the pre-futures period. The results of the pairwise *t*-test and Wilcoxon test for α_0, α_1 and β_1 for the pre-futures and post-futures periods are presented in Table 6. As shown in the table, the average difference in α_0 between the post- and pre-futures periods is not statistically significant, whereas the average differences in α_1 and β_1 are highly significant. As mentioned earlier, α_0 is the measure of unconditional volatility and α_1 and β_1 are measures of conditional volatility. Even though the unconditional variance did not change after the introduction of futures trading, the conditional variances have increased significantly. This result reinforces the contention that the increase in volatility found using the traditional volatility estimation is due to the increase in the conditional volatility, ie the volatility that is induced by some important event such as futures trading on the DJIA.

CONCLUSION

A large number of prior studies have investigated the impact of derivatives on the financial markets, especially on the underlying assets. Results of research of both a theoretical and an empirical nature are inconclusive. The introduction of DJIA futures and options in October, 1997, provided an opportunity to investigate this issue empirically in order to bring more insights into this debate.

The empirical results of this study show that the volatility of the market significantly increased after the start of futures and options trading on the DJIA index. On an individual basis, a majority of the 30 DJIA stocks showed an increase in volatility after the introduction of futures and options on the index, with significant increases for a large number of them. On a sample basis, both parametric and non-parametric tests displayed significant increases in volatility measures after trading of futures and options on the index. Efforts were made to study whether stock returns and trading volume also increased over this period. A significant increase in the daily trading volume was found for 23 stocks in the index after the introduction of futures and options trading. There is evidence, however, that the average daily rate of return on these 30 underlying stocks decreased significantly.

The increase in the volatility found using a traditional measure is also tested using the GARCH(1,1) model to identify the process of volatility formation. The results from the GARCH model are similar to results from the traditional measure. This shows that the impact of past news (α_1) and past variance (β_1) on the current price change is significantly higher during the post-futures period than during the pre-futures period. The difference in the values of α_0 that measures the unconditional variance between the two sub-periods, however, is not statistically different. Therefore, the results from the GARCH model indicate that the volatility increase during the post-futures period is due to the increase in conditional volatility, not due to the change in unconditional volatility.

The empirical analysis of this study provides new evidence in support of the argument that futures trading attracts uninformed or irrational traders along with the rational or informed traders, which causes an increase in stock return volatility. This may indicate that, even though the market may become more liquid, the destabilising effect brought by irrational traders in both cash and futures markets outweigh the beneficial liquidity effect. It is possible that the increase in volatility may be due to some structural changes in the financial market as a whole rather than to the introduction of futures and options trading, which is worth further study. Nonetheless, this study provides new findings about the volatility change of the 30 Dow Jones Industrial stocks after futures and options trading on the index. It also provides further insight into the effects of derivatives on the underlying stocks.

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