Market Volatility and the Demand for Hedging in Stock Index Futures

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This study examines the relation between stock market volatility and the demand for hedging in S&P 500 stock index futures contracts. Open interest is used as a proxy for hedging demand. The analysis employs unique data that identify separately the open interest of large hedgers, large speculators, and smaller traders. Volatility estimates are decomposed into expected and unexpected components, to assess whether traders' reactions to volatility depend upon its predictability.

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Results indicate that daily open interest for hedgers increases when unexpected volatility increases. Increases in unexpected volatility may cause hedgers to raise their estimates of future expected volatility, and hence increase their demand for hedging. Open interest of speculators is not related to expected volatility, and is only weakly related to unexpected volatility. The increase in the participation of hedgers in periods of higher volatility is significantly larger than the increase in the participation of speculators. The results suggest that increases in stock market volatility increase the demand for hedging. Jrl Fut Mark 20: 105–125, 2000

INTRODUCTION

Many studies document a contemporaneous relation between the extent of futures market participation and price volatility. These studies generally measure the level of futures market participation as either the market's open interest or trading volume. For example, Bessembinder and Seguin (1992) find a negative relation between volatility and open interest in the S&P 500 futures. Bessembinder and Seguin (1993) also find a negative relation between volatility and total open interest in currency, commodity, and interest rate futures markets. In contrast, Chen, Cuny, and Haugen (1995) document a positive relation between the open interest of the S&P 500 stock index futures and the level of volatility. Karpoff (1987) reviews a series of studies that document a positive contemporaneous correlation between trading volume and price volatility.

This study provides additional empirical evidence on the relation between market participation and price volatility in the Standard & Poor's (hereafter S&P) 500 stock index futures market. In particular, it examines whether the participation of large hedgers, as defined by the aggregate daily open interest of their positions, increases in periods of higher volatility. Volatility estimates are decomposed into two components, ex ante (expected) volatility and the unexpected change in volatility, and their correlation with the market participation of hedgers is examined. For comparison purposes, the reaction of the aggregate open interest of speculators to time-varying ex ante volatility and to the unexpected change in volatility is also analyzed. By isolating hedgers' market participation from the rest of the market and examining its relation with the expected and unexpected components of price volatility, this study provides new insights into the extent to which S&P 500 index futures are utilized for hedging during periods of high volatility. If increases in market volatility tend to increase the demand for hedging more than the demand for speculation, then futures markets may provide a useful means of hedging risk. On the other hand, if speculators become far more active than do hedgers in periods of high volatility, futures trading may destabilize the underlying market.

Results indicate that open interest for large hedgers increases during periods of higher volatility. For long open interest, this result holds for both the expected and unexpected components of volatility. Short open interest, however, increases with unexpected volatility, but not with expected volatility. Increases in unexpected volatility may cause hedgers to raise their estimates of future expected volatility, and hence increase their futures market participation.

The regression results examining the relations for large speculators reveal no evidence of a relation between their open interest and expected volatility. Only weak evidence is found of a positive relation between unexpected volatility and open interest, and the results are sensitive to the volatility estimate used. More importantly, the slight increase in demand for speculation in periods of high volatility is far exceeded by the increased demand for hedging, and the difference is statistically significant. The overall findings confirm that the use of stock index futures is consistent with their intended function of hedging facilitation.

LITERATURE REVIEW

The relation between the degree of market participation by various types of traders and price volatility has long been of interest to both researchers and regulators. Whereas financial theory suggests that futures markets exist to facilitate hedging, a more popular perception is that they serve as a means of speculation, and that higher price volatility tends to invite more speculation. This perception has resulted in many legislative attempts, which have been largely unsuccessful, to reduce the amount of trading in futures markets.[1] Despite the considerable discussion on the potential link between volatility and speculation, much less attention has been given to the issue of whether hedgers increase their participation in markets as price volatility increases.

One major reason for the paucity of empirical research investigating such an important economic issue is data limitations. Studies of activities in futures markets have examined only the total open interest or total volume, which represents the aggregate participation of all traders. To

[1]In the history of the United States, over 100 bills have been introduced to curtail, or even abolish altogether, trading in futures markets. In almost every case, however, the measure has failed to pass. One exception occurred in 1958, when Congress passed a bill prohibiting futures trading in onions, which was then an active market. See Teweles, Harlow, and Stone (1974) for details.

address the above issue clearly, researchers are required to quantify the degree of participation of hedgers, and to segregate their participation from that of speculators.

This study uses S&P 500 stock index futures to examine the relation between market volatility and the degree of participation of hedgers. The proxy used to quantify participation is the open interest in index futures contracts. In the study of futures markets, open interest is arguably an appropriate measure of participant activity, as it represents the total demand for futures contracts.[2] Although volume also reflects participation by hedgers and other long-term traders, it includes the activities of day traders and scalpers, which tend to be more transitory in nature. Consider the example of a hedger who is short one futures contract, and who closes his position by buying a contract from another hedger who previously had no position in the market. A trade has occurred and volume has increased, but the aggregate demand (that is, open interest) of all hedgers has not changed. Open interest is therefore superior to volume for the purpose of this study as a measure of aggregate demand. Furthermore, open interest is clearly a participation measure unique from any to be found in equity markets. Because futures contracts are an asset for which the net supply is zero, this measure of participation is determined endogenously in the market. This study uses unique data that permits the characterization of large traders as hedgers or speculators and identifies the open interest of each type of trader on a daily basis. The identification of trader type is important to examine the question of whether the futures markets are primarily used for their intended function of hedging facilitation.

In addition to the research cited above, several existing studies also examine the relation between speculators' open interest and price volatility in futures markets. Ward (1974) tests the relation between the level of speculative activity and price volatility in the frozen orange juice futures market. Peck (1981) uses monthly data to devise a speculative index and tests the relation between levels of speculation and price volatility in three agricultural futures markets. Both studies find a negative relation between the degree of market participation by speculators and futures price volatility. Streeter and Tomek (1992) develop a model with a large

[2]Considerable research has been done regarding financial market participation and price volatility using volume as the measure of participation. For example, Clark (1973), Cornell (1981), Tauchen and Pitts (1983), Garcia, Leuthold, and Zapata (1986), and Grammatikos and Saunders (1986) have studied the relationship between volume and volatility in futures markets. Epps and Epps (1976) and Smirlock and Starks (1985) studied similar phenomena for equities. Karpoff (1987) summarizes the results of several studies of the relation between price changes and trading volume. A positive relation between volume and the magnitude of price changes is a common empirical finding for commodity and currency futures, common stocks, and stock indexes.

number of variables, including Peck's speculative index and a market concentration variable. Using monthly data for soybean futures, they find that the speculative index has a negative relation with price volatility, and market concentration has a weak positive relation with price volatility. Figleswki (1981) finds a positive relation between volatility and open interest in a study of the GNMA futures market. Bessembinder and Seguin (1993) find that trades resulting in changes in open interest appear to have a larger impact on prices than do trades that leave open interest unaltered. Their findings suggest that the relation between trading activity and volatility may depend on whether trades are undertaken by hedgers or speculators.

DATA

The data analyzed in this article are daily observations on open interest in the S&P 500 futures contract over the period from January 1984 through April 1990. For each day and for each type of trader, the open interest of all outstanding contracts is aggregated. Daily open interest and high, low, opening, and closing prices come from the CFTC's "Permanent Record." A unique feature of the data is that it permits the identification of traders as large hedgers, large speculators, and small traders using the CFTC's "01" data. These data are filed by futures commission merchants, clearing members, and foreign brokers, and contain daily reportable positions. Positions in a given futures contract market and contract month are reportable when they exceed the minimum level set forth in CFTC Regulation 1503. The CFTC annually classifies reportable positions as either commercial or noncommercial. Because a commercial position is one that is taken to hedge a specific risk, investors taking commercial positions are referred to as hedgers. Noncommercial positions are taken for reasons other than hedging, and investors taking these positions are therefore referred to as speculators. Traders are characterized as "large" if their positions exceed a threshold size defined by the CFTC.[3]

The summary statistics reported below contain information for both long and short hedging positions. The concept of hedging with futures contracts is often viewed in the context of a commodity producer who uses a short position to hedge against falling spot prices or a commodity consumer who uses a long position to hedge against rising spot prices; hedging with financial futures may also take the form of long or short

[3]For example, as of January 1991, the reporting threshold for the S&P 500 futures was 300 contracts. Investors taking positions that do not exceed the minimum reporting size are referred to in this study as "small" traders.

positions. For example, equity fund managers who wish to insure their portfolio against a general market decline may take short positions in index futures. Alternatively, an index arbitrageur may take either a long or a short position in index futures. In addition, investors may use long or short positions in index futures to achieve a desired asset allocation, in an attempt to time the market, or for tax-motivated reasons. Financial institutions may use long or short futures positions to hedge the risk of customized securities that they have created for clients. As a result, the counter-party to a trade initiated as a short hedge may be a long hedger, or a long speculator.

Table I reports the average daily open interest for each year on an aggregate basis, as well as the average open interest for large hedgers, large speculators, and small traders. For the entire sample period, the average daily open interest was slightly less than 83,000 contracts. Of this amount, approximately 63% represented long positions of large hedgers, and 57% represented short positions of large hedgers. Large speculators' positions tended to be smaller, with their long positions accounting for less than 9% of open interest and short positions accounting for 13.5%. The positions of small traders account for approximately 28% of long open interest and 29% of short open interest.

The annual averages of daily open interest show a marked increase over time. For example, total open interest averaged 31,182 contracts in 1984, and grew to 112,714 in 1989. Examination of the trends for hedgers and speculators separately reveals that the increase in total open interest was due mainly to an increase in open interest of hedgers' positions. Open interest of long hedging positions averaged 10,331 contracts per day in 1984, and 80,657 contracts per day in 1989. Open interest of short hedging positions increased similarly, averaging 11,218 contracts per day in 1984 and 69,699 contracts per day in 1989.

The trends discussed above indicate the increased use of S&P 500 futures contracts by large hedgers over the sample period. In 1984, large hedgers held 33% of the long positions and 36% of the short positions, on average. By 1989, these percentages had risen to approximately 72% and 62%. Conversely, the relative participation of large speculators decreased over the period: They held 28% of the long positions and 34% of the short positions in 1984, and only 6% of the long positions and 13% of the short positions in 1989. In percentage terms, the participation of small traders also decreased over the sample period, although to a lesser degree than that of large speculators. In summary, trading in the S&P 500 futures markets was divided fairly evenly among large hedgers, large speculators, and small traders in 1984, but became dominated by large

TABLE I

Daily Open Interest of Large Hedgers, Large Speculators, and Small Traders in S&P 500 Stock Index Futures

	Entire Time Period	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*1990 (Jan.–Apr.)*
Panel A: Long open interest								
Hedgers	52,126.6	10,330.8	24,068.8	48,242.3	66,219.5	75,443.1	80,656.8	75,300.6
	(62.91%)	(33.13%)	(45.50%)	(56.68%)	(64.18%)	(72.19%)	(71.56%)	(71.65%)
Speculators	7,220.5	8,785.8	7,181.2	10,161.8	7,067.9	4,244.3	6,774.1	4,531.2
	(8.71%)	(28.18%)	(13.58%)	(11.94%)	(6.85%)	(4.06%)	(6.01%)	(4.31%)
Small traders	23,505.1	12,065.0	21,649.5	26,710.0	29,884.7	24,814.2	25,282.7	25,262.2
	(28.37%)	(38.69%)	(40.93%)	(31.38%)	(28.97%)	(23.75%)	(22.43%)	(24.04%)
Panel B: Short open interest								
Hedgers	47,370.6	11,217.7	26,982.9	44,509.4	60,048.3	68,985.5	69,699.4	55,376.9
	(57.17%)	(35.98%)	(51.01%)	(52.29%)	(58.20%)	(66.01%)	(61.84%)	(52.69%)
Speculators	11,193.6	10,478.5	7,317.7	12,447.5	11,582.8	8,123.0	14,470.3	19,509.0
	(13.51%)	(33.60%)	(13.83%)	(14.62%)	(11.23%)	(7.77%)	(12.84%)	(18.56%)
Small traders	24,288.0	9,485.4	18,598.9	28,157.2	31,541.0	27,393.1	28,543.9	30,208.1
	(29.31%)	(30.42%)	(35.16%)	(33.08%)	(30.57%)	(26.21%)	(25.32%)	(28.74%)
Total	82,852.2	31,181.6	52,899.5	85,114.1	103,172.1	104,501.6	112,713.6	105,094.0

Notes: This table reports average values of daily open interest in S&P 500 futures contracts for large hedgers, large speculators, and small traders. Numbers in parentheses are percentages of the total for each year. The data cover the period from January 1984 through April 1990.

hedgers in 1989. The increased importance of hedgers in the stock index futures market may be due to the increased investment in mutual and pension funds over the same period, the increased supply of customized over-the-counter financial products or to an increased understanding and acceptance of futures contracts as a financial instrument.

RELATIVE MEASURES OF PRICE VOLATILITY

Having identified daily hedging demand from data on open interest, the next step is to construct measures of daily price volatility. Two estimators of time-varying price volatility are used. The first is the extreme value estimator developed by Parkinson (1980). The second is an estimator based on the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) process of Bollerslev (1986).

In addition, both measures of price volatility are decomposed into their *expected* and *unexpected* components. Existing research suggests that further insights may be gained from this decomposition of volatility measures. Using a generalized autoregressive conditional heteroskedasticity model with mean effects (GARCH-M), French, Schwert, and Stambaugh (1987) find a positive relation between expected returns and expected volatility in equity markets.[4] Whitelaw (1994) finds that lagged conditional volatility is positively related to future expected returns.

The link between expected return and expected volatility has implications for the relation between hedging demand and volatility. With a higher expected volatility in the beginning of the day, hedgers are expected to adjust their portfolios accordingly. However, the additional innovation in the time-varying volatility sensed by hedgers during the trading day may also induce further portfolio adjustments. This is because a rise in unexpected volatility may cause investors to raise their future estimates of expected volatility, and hence increase the demand for hedging. Indeed, one might expect the relation between hedging demand and expected volatility to be weaker than that for unexpected volatility.

The first measure of volatility, the extreme value estimator developed by Parkinson (1980), is defined as

$$\sigma^2_{HL,t} = 0.3607^* \; [\ln(H_t/L_t)]^2 \qquad (1)$$

where H_t and L_t are the highest and lowest prices of the futures contract on day *t*. Wiggins (1991) finds that, after removing outliers from the data,

[4]In contrast, Glosten, Jagannathan, and Runkle (1993) use a modified GARCH-M model and find a negative relation.

this estimate is more efficient for estimating the volatility of individual stocks than the standard volatility estimate. This estimate is constructed using the daily high and low prices from the contract with the highest open interest, which is generally the most nearby contract.

For the reasons cited above, the extreme-value estimate of volatility is decomposed into expected and unexpected components. A time series model of volatility is estimated to divide it into expected and unexpected components. Using standard Box-Jenkins techniques, the volatility time series is identified as an ARIMA(3,0,2) process with the following parameter estimates:

$$(1 - 0.184L - 0.125L^2 - 0.295L_3)\sigma_{HL,t} = 0.334 + (1 - 0.262L - 0.167L^2)e_t \quad (2)$$

For the specification in eq. (2), none of the Ljung-Box Q-statistics for lag lengths 1–20 are significant at the 5% level. Hence, this specification is supported by the data.

The second measure of volatility is constructed using a GARCH model. Following the seminal article by Engle (1982), the innovation in the mean of the relative daily close-to-close futures prices of the most active contract, e_t, is assumed to be serially uncorrelated with mean zero. The conditional variance of e_t is $\sigma^2{}_t$, which is a time-varying, positive and measurable function of the time $t - 1$ information set. As suggested in Bollerslev (1986), one possible parameterization is to express σ_t^2 as a linear function of past squared values of e_{t-1} and σ_{t-1}^2. For this study, a GARCH (1,1) model appears to be appropriate.[5] Specifically, the estimated model for the return on the S&P 500 index futures contract, R_t, is of the form:

$$R_t = 0.091 + e_t e_t | I_{t-1} \approx N(0,\sigma_t^2)\sigma_t^2 = 0.195 + 0.194e_{t-1}^2 + 0.684\sigma_{t-1}^2 \quad (3)$$

Note that because σ_t^2 is a linear function of past squared values of e_{t-1}^2 and σ_{t-1}^2, the fitted value, although varying over time, is known at the beginning of the trading day. Thus it is hereafter referred to as the expected conditional volatility as of date t. Accordingly, the difference be-

[5]As reported in Bollerslev, Chou, and Kroner (1992), the GARCH(1,1) specification is frequently supported in many studies. This model is a simple one. More elaborated models incorporating GARCH-in-mean, first order serial correlation, and weekend effects in the mean and in the variance have been estimated as well. The results are very similar; hence this simple model is used in our analysis.

tween e_t^2 and σ_t^2 is referred to as the unexpected change in the volatility of the day. The variable I_{t-1} denotes the information set available at time $t - 1$.

It is interesting to note the parameter estimates in the variance equation that measure the persistence of volatility shocks. The coefficients of the lagged innovation squared and the lagged volatility are 0.194 and 0.684. Using Chou's (1988) formula, this implies a normalized monthly persistence parameter of 0.065. In other words, only 6.5% of a volatility shock remains in effect after one month (21 trading days). This persistence is smaller than what is reported in French, Schwert, and Stambaugh (1987) and Chou (1988). It is, however, consistent with Poterba and Summers (1986) and the observation made in Schwert (1990) that, after the crash of 1987, stock market volatility quickly returned to lower pre-crash levels.

The patterns in the two measures of expected volatility over time are illustrated in Figures 1 and 2. Both volatility estimates show a pronounced spike at the time of the stock market crash in October 1987. The correlation coefficient between the two estimates of expected volatility is 0.85, and the correlation between the two estimates of unexpected volatility is 0.47. As expected and by construction, the correlation coefficient between the expected and unexpected components of volatility is close to zero for both the extreme-value and GARCH estimate.

EMPIRICAL RESULTS ON THE RELATION BETWEEN VOLATILITY AND HEDGING DEMAND

The relation between open interest and volatility is examined using the following multivariate regression:

$$\begin{aligned} OI_t = \alpha_0 + \alpha_1 OI_{t-1} + \alpha_2 \alpha_{e,t}^2 + \alpha_3 \alpha_{u,t}^2 \\ + \alpha_4 TTM_t + \alpha_5 TIME_t + e_t \end{aligned} \tag{4}$$

where OI_t and OI_{t-1} are the values of open interest on day t and t − 1, $\sigma_{e,t}^2$ and $\sigma_{u,t}^2$ are the expected and unexpected components of volatility, TTM_t is the remaining time to maturity for the contract with the highest open interest to control for patterns in open interest over the life of each contract, $TIME_t$ is a time counter to control for trends in open interest, and e_t is an error term. The lagged value in open interest is included to control for persistence. The above model is similar to that of Chen, Cuny, and Haugen (1985), and is estimated separately for long and short open

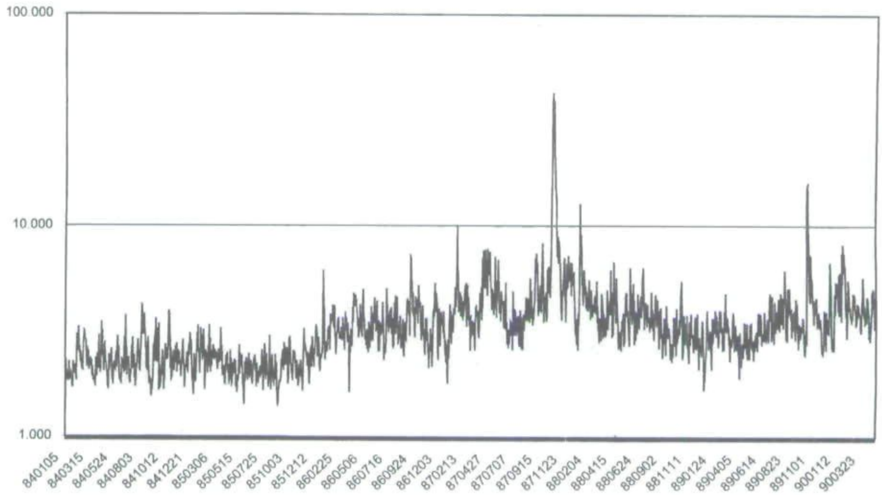

FIGURE 1
Expected Volatility in S&P 500 Index Futures (Extreme value estimator).

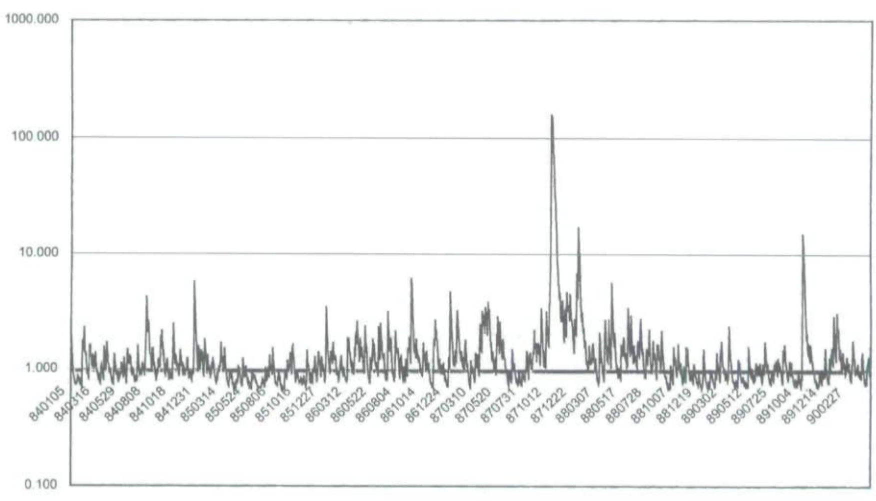

FIGURE 2
Expected Volatility in S&P 500 Index Futures (GARCH estimator).

interest for each type of trader using both the extreme-value and GARCH volatility measures.

Regression Results for Large Hedgers

Panels A and B of Table II report, respectively, the regression results for large hedgers using the extreme-value and GARCH(1,1) estimates of vol-

TABLE II

Regressions of the Daily Open Interest of Large Hedgers in the S&P 500 Stock Index Futures Markets on Expected and Unexpected Volatility

	Intercept	OI^L_{t-1}	OI^S_{t-1}	σ^2_t-Expected	σ^2_t-Unexpected	TTM_t	$TIME_t$	Adj-R^2
Panel A: Extreme-value estimator								
Long Open Interest	−2,463.42	0.973		369.246	892.152	47.983	1.302	0.994
(OI^L)	(−13.85)[b]	(248.57)[b]		(3.50)[b]	(10.45)[b]	(22.19)[b]	(5.29)[b]	
	[−11.6][b]	[172.49][b]		[3.47][b]	[4.47][b]	[13.46][b]	[3.54][b]	
Short Open Interest	−2,068.89		0.967	274,255	823.79	46.210	1.240	0.989
(OI^S)	(−10.60)[b]		(209. 61)[b]	(2.32)[a]	(8.79)[b]	(19.43)[b]	(5.20)[b]	
	[−7.89][b]		[146.99][b]	[1.13]	[2.12][a]	[12.44][b]	[3.66][b]	
Panel B: GARCH estimator								
Long Open Interest	−2,232.68	0.975		28.874	23.127	47.903	1.236	0.994
(OI^L)	(−13.76)[b]	(248.55)[b]		(3.64)[b]	(8.65)[b]	(21.91)[b]	(4.99)[b]	
	[−12.78][b]	[180.10][b]		[1.82]	[3.43][b]	[14.63][b]	[3.50][b]	
Short Open Interest	−1,904.92		0.969	15.485	27.408	46.045	1.161	0.990
(OI^S)	(−10.67)[b]		(212.06)[b]	(1.75)	(9.47)[b]	(19.42)[b]	(4.88)[b]	
	[−11.37][b]		[147.77][b]	[0.67]	[3.21][b]	[13.46][b]	[3.45][b]	

Notes: This table reports results of regressions of the daily open interest of large hedgers in the S&P 500 stock index futures markets on expected and unexpected volatility over the period of January 1984 through April 1990. Volatility is estimated using the extreme-value method in Panel A and a GARCH technique in Panel B. The model estimated is of the form

$$OI_t = \alpha_0 + \alpha_1 OI_{t-1} + \alpha_2\sigma^2_{e,t} + \alpha_3\sigma^2_{u,t} + \alpha_4 TTM_t + \alpha_5 TIME_t + e_t$$

Where OI_t and OI_{t-1} are the values of open interest on day t and t − 1, $\sigma^2_{e,t}$ and $\sigma^2_{u,t}$ are the expected and unexpected components of volatility, TTM_t is the remaining time to maturity for the contract, and $TIME_t$ is a time counter to control for trends in open interest. T-statistics computed from ordinary least squares standard errors are in parentheses; T-statistics computed from robust standard errors are in brackets. ([a]) indicates significance at the 5% level; ([b]) indicates significance at the 1% level.

atility. Separate models are estimated for both long and short open interest. Because hedgers may take long or short positions for different reasons, it is important to examine the determinants of each type of open interest separately. For each model, two sets of standard errors are reported: The first is estimated via ordinary least squares, and the second is estimated via the autocorrelation- and heteroskedasticity-consistent correction of White (1980, 1984). The spectral-based estimator of Newey and West (1987), with two lags, is used in computation. Other lag lengths were also examined and the results were similar.

All of the slope coefficients for the time trend variable are positive, reflecting an increase over the sample period in the use of futures contracts by hedgers. This is consistent with the participation patterns observed in Table I. The slope coefficients for the time to maturity variable are also positive. It suggests that, other things constant, hedging demand tends to be higher when the remaining life of the futures contract is longer. Hedgers are likely to have longer investment horizons than other types of traders and thus prefer to use longer-term futures contracts to hedge their price risk. In all four models, the first lag of open interest is highly significant, with a coefficient close to one. This is not surprising, as much of today's hedging demand comes from the "carry over" of yesterday's hedging demand.

The relation between open interest and the extreme value estimate of volatility is examined in Panel A of Table II. After all of the above effects are taken into account, the regression with long open interest as the dependent variable indicates a positive and significant relation between open interest and both the expected and unexpected components of volatility.[6] For the regression with short open interest as the dependent variable, the coefficient on unexpected volatility is positive and significant at the 10% level. Using the robust standard errors, the coefficient on expected volatility is positive but is not significant. For both long and short open interest, the coefficients on unexpected volatility are larger than the coefficients on expected volatility, suggesting that hedgers respond more to surprises in volatility than to volatility they can predict. It could also be the case that expected volatility is mostly known on the previous trading day, and is therefore captured in OI_{t-1}, especially as open interest has a slow decay.

[6]The significance of the changes in open interest is economic as well as statistical. The standard deviation of the expected and unexpected components of volatility are 2.35 and 2.62. These values would imply a change in open interest (using Table II) for large hedgers of 866 (expected) and 2339 (unexpected) contracts for the long positions and 643 (expected) and 2158 (unexpected) contracts for the short positions. The standard deviations of daily changes in open interest are 2670 and 2819, respectively, for long and short positions. Hence the volatility-induced changes in open interest are significant economically.

Panel B of Table II reports the regression results for large hedgers using the GARCH estimate of volatility. In this set of regressions, long and short open interest are related to the unexpected volatility component, and the coefficients are positive and significant. Only weak evidence (t-statistic = 1.82) is found of a relation between expected volatility and long open interest. The greater significance of the coefficients on the unexpected volatility component confirm the results obtained with the extreme-value estimate, which suggest that hedgers are more concerned with surprises in volatility than with predicted volatility.

In summary, the results suggest that large hedgers increase their demand for both long and short hedging in periods of higher volatility. This result is strongest for the unexpected component of volatility. Increases in unexpected volatility may cause hedgers to raise their estimates of future expected volatility, and hence increase their demand for hedging. The results are consistent with those of Chen, Cuny, and Haugen (1995), who also find a significantly positive relation between *total* open interest of S&P 500 futures contracts and stock market volatility. Models similar to eq. (4) were run with total open interest as the dependent variable. The results, which are available upon request, indicate that the results of Chen, Cuny, and Haugen (1995) are driven by the unexpected component of volatility, especially for large hedgers.

Regression Results for Large Speculators

The results discussed in the previous section suggest that the demand for hedging increases with volatility. It is also of interest to examine the relation between changes in volatility and the demand for speculation. If the demand for speculation increases more than the demand for hedging in periods of high volatility, then speculation may become excessive and destabilizing.

Table III reports the regression results for the open interest of large speculators. Similar to the results for large hedgers, the coefficient on lagged open interest is positive and highly significant, indicating persistence in open interest. The results for the time trend variable, however, differ from those found for large hedgers. The coefficient in the model of long open interest is negative. In the model of short open interest, the coefficient for the time trend variable is positive, but is much smaller than the time trend coefficient in the model for the short open interest of large hedgers. These results are consistent with the summary statistics reported in Table I, which did not indicate a significant time trend effect

TABLE III

Regressions of the Daily Open Interest of Large Speculators in the S&P 500 Stock Index Futures Markets on Expected and Unexpected Volatility

	Intercept	OI^{L}_{t-1}	OI^{S}_{t-1}	σ^2_t-*Expected*	σ^2_t-*Unexpected*	TTM_t	$TIME_t$	$Adj\text{-}R^2$	F_1	F_2
Panel A: Extreme-value estimator										
Long Open Interest	1,951.64	0.821		−130.691	153.934	−3 156	−0.479	0.716	12.66[b]	43.26[b]
(OI^L)	(9.14)[b]	(57.21)[b]		(−1.48)	(2.06)[a]	(−1.65)	(−4.19)[b]			
	[1.97]	[8.62][b]		[−1.75]	[1.36]	[−0.96]	[−1.94]			
Short Open Interest	342.95		0.955	−154.945	221.605	2.868	0.184	0.918	11.94[b]	23.42[b]
(OI^S)	(2.60)[b]	(123.79)[b]	(−2.49)[a]	(4.20)[b]	(2.13)[a]	(2.25)[a]				
	[2.43][b]		[100.11][b]	[−1.51]	[5.54][b]	[2.09][a]	[2.38][a]			
Panel B: GARCH estimator										
Long Open Interest	−1,857.68	0.821		−9.570	4.106	−3.116	−0.480	0.717	13.89[b]	28.94[b]
(OI^L)	(9.08)[b]	(57.19)[b]		(−1.44)	(1.77)	(−1.62)	(−4.20)			
	[1.84]	[8.47][b]		[−1.08]	[3.87][b]	[−0.85]	[−2.03][a]			
Short Open Interest	232.23		0.954	−9.358	2.364	2.929	0.187	0.918	6.38[b]	56.71[b]
(OI^S)	(1.89)		(122.88)[b]	(−1.99)[a]	(1.44)	(2.16)[a]	(2.28)[a]			
	[1.94]		[99 41][b]	[−1.26]	[0.87]	[2.09][a]	[2.40][b]			

Notes: This table reports results of regressions of the daily open interest of large speculators in the S&P 500 stock index futures markets on expected and unexpected volatility over the period of January 1984 through April 1990. Volatility is estimated using the extreme-value method in Panel A and a GARCH technique in Panel B. The model estimated is of the form

$$OI_t = \alpha_0 + \alpha_1 OI_{t-1} + \alpha_2\sigma^2_{e,t} + \alpha_3\sigma^2_{u,t} + \alpha_4 TTM_t + \alpha_5 TIME_t + e_t$$

where OI_t and OI_{t-1} are the values of open interest on day t and t − 1, $\sigma^2_{e,t}$ and $\sigma^2_{u,t}$ are the expected and unexpected components of volatility, TTM_t is the remaining time to maturity for the contract, and $TIME_t$ is a time counter to control for trends in open interest. T-statistics computed from ordinary least squares standard errors are in parentheses; T-statistics computed from robust standard errors are in brackets. F_1 is an F-test statistic for the equality of the coefficients on expected volatility for the models in this table and those for large hedgers in Table 2. F_2 is a similar F-test statistic for the equality of the coefficients on unexpected volatility. The F-statistics have 1 and 3,174 degrees of freedom. ([a]) indicates significance at the 5% level; ([b]) indicates significance at the 1% level.

in the open interest of large speculators. The coefficients on time to maturity do not reveal an obvious relationship between it and open interest of large speculators.

Panel A of Table III reports the regression results for large speculators using the extreme-value estimate of volatility. Interestingly, no evidence is found of a significant relation between volatility and long open interest for large speculators. The coefficients on expected volatility for both long and short open interest are negative, but not significantly different from zero. This result suggests that speculators do not increase the size of their overnight positions if they expect volatility to increase. The data also exhibit a significant and positive relation between short open interest and unexpected volatility. Speculators may believe that unexpected increases in volatility will result in market declines, as investors raise their demanded risk premium and prices subsequently fall.

Panel B of Table III reports the regression results for large speculators using the GARCH estimate of volatility. Similar to the results using the extreme-value estimate, this set of regressions produces negative but insignificant coefficients on expected volatility. The results for unexpected volatility, however, are different. They indicate a significant and positive relation between long open interest and unexpected volatility, but no effect for short open interest.

In summary, the regression results for large speculators are sensitive to the volatility estimate used. The consistent results for both volatility estimates are that coefficients on expected volatility are negative and insignificant. The coefficients on unexpected volatility are positive, but with varying significance as noted above.

It is interesting to examine the difference between hedgers and speculators in their reaction to changes in volatility. A comparison of the coefficients on expected and unexpected volatility in Tables II and III reveals that the demand for hedging increases substantially more than does the demand for speculation when volatility rises. Statistics for tests on the equality of coefficients on volatility across the two models are reported in Table III. The statistic F_1 tests the hypothesis of the equality of coefficients on expected volatility for large hedgers and large speculators. The statistic F_2 reports a similar result for the coefficients on unexpected volatility. In all cases the null hypothesis of equality of coefficients is rejected at the 1% level. In summary, the findings provide clear evidence that increases in market volatility tend to increase the demand for hedging more than the demand for speculation.

Regression Results for Small Traders

To assess how the demand of small traders is related to market volatility, regressions are run with the open interest of small traders as the dependent variable.

Panels A and B of Table IV report the regression results for small traders. Most of the coefficients on expected and unexpected volatility are insignificantly different from zero. The only exception is the negative and significant relation between long open interest and expected volatility. The results suggest that small hedgers and speculators do not change their demand for overnight futures positions on the basis of market volatility.

In summary, the results for small traders indicate little evidence of a relation between open interest and market volatility. The results in Table III indicated similar results for large speculators. Because the increase in hedging demand in periods of higher volatility was observed for both long and short open interest, the counter-party to a trade initiated by a hedger in periods of high volatility is more likely to be another hedger instead of a speculator. In other words, the increase in long hedging demand was generally offset by the increase in short hedging demand.

The Effects of the October 1987 Stock Market Crash

As noted in Figures 1 and 2, volatility rose sharply during the stock market crash in October 1987. As a result, the robustness of the results in Tables II, III, and IV to the exclusion of the crash period was examined. Although it is useful to assess the relation between volatility and open interest over periods excluding the crash, it is precisely during such periods of market stress that the demand for hedging should increase the most.

In general, the results excluding the crash are qualitatively similar to those obtained for the full sample period. For long open interest of large speculators, the positive significant coefficient on unexpected volatility using the GARCH estimate becomes negative and insignificant when the crash period is excluded. For short open interest of large hedgers, the coefficient on the unexpected component of volatility decreases and becomes insignificant, and for large speculators the coefficient on the unexpected component of volatility increases.

In summary, the main results of the study are not driven by the effects of the October 1987 stock market crash. The entire sample was also divided into two subperiods of equal length to check for differences

TABLE IV

Regressions of the Daily Open Interest of Small Traders in the S&P 500 Stock Index Futures Markets on Expected and Unexpected Volatility

	Intercept	OI^{L}_{t-1}	OI^{S}_{t-1}	σ^2_t*-Expected*	σ^2_t*-Unexpected*	TTM_t	$TIME_t$	$Adj\text{-}R^2$
Panel A: Extreme-value estimator								
Long Open Interest	1,340.30	0.913		−131.128	−82.641	5.749	0.661	0.872
(OI^L)	(4.91)[b]	(84.83)[b]		(−1.20)	(−0.89)	(2.44)[a]	(4.19)[b]	
	[1.88]	[22.87][b]		[−1.19]	[−0.65]	[2.45][a]	[2.20][b]	
Short Open Interest	374.17		0.956	−68.160	−137.599	5.858	0.563	0.948
(OI^S)	(1.82)		(121.72)[b]	(−0.74)	(−1.77)	(2.93)[b]	(3.68)[b]	
	[1.81]		[99.50][b]	[−0.52]	[4.97]	[3.01][b]	[3.40][b]	
Panel B: GARCH estimator								
Long Open Interest	1,285.25	0.911		−16.888	2.604	5.717	0.670	0.872
(OI^L)	(4.86)[b]	(85.28)[b]		(−2.06)[b]	(0.91)	(2.43)[b]	(4.25)[b]	
	[1.62]	[21.92][b]		[−2.03][a]	[1.57]	[2.44][b]	[2.23][b]	
Short Open Interest	345.32		0.956	−7.717	−1.723	5.819	0.570	0.948
(OI^S)	(1.78)		(121.58)[b]	(−1.12)	(−0.72)	(2.91)[b]	(3.72)[b]	
	[1.93]		[98.44][b]	[−0.74]	[−0.31]	[2.77][b]	[3.28][b]	

Notes: This table reports results of regressions of the daily open interest of small traders in the S&P 500 stock index futures markets on expected and unexpected volatility over the period of January 1984 through April 1990. Volatility is estimated using the extreme-value method in Panel A and a GARCH technique in Panel B. The model estimated is of the form

$$OI_t = \alpha_0 + \alpha_1 OI_{t-1} + \alpha_2\sigma^2_{e,t} + \alpha_3\sigma^2_{u,t} + \alpha_4 TTM_t + \alpha_5 TIME_t + e_t$$

Where OI_t and OI_{t-1} are the values of open interest on day t and t − 1, $\sigma^2_{e,t}$ and $\sigma^2_{u,t}$ are the expected and unexpected components of volatility, TTM_t is the remaining time to maturity for the contract, and $TIME_t$ is a time counter to control for trends in open interest. T-statistics computed from ordinary least squares standard errors are in parentheses; T-statistics computed from robust standard errors are in brackets. ([a]) indicates significance at the 5% level; ([b]) indicates significance at the 1% level.

in coefficients over time. Again, the results were qualitatively similar for both subperiods.

CONCLUSIONS

This study examines the relation between stock market volatility and the demand for hedging in equity index futures contracts. It employs unique data that identify separately the daily open interest of large hedgers, large speculators, and small traders. The ability to distinguish between the activity of different types of traders is critical to understanding whether futures markets fulfill their intended function of efficiently allocating resources and risk. It is an issue of interest to academics, practitioners, and regulators.

Volatility estimates are constructed using an extreme-value method and GARCH techniques. The estimates are then decomposed into expected and unexpected components, to assess whether traders' reactions to volatility depend upon its predictability. The results yield important insights about the relations between volatility and the demand for hedging in equity markets.

Open interest for large hedgers increases in periods of higher volatility. For long open interest, this result holds for both the expected and unexpected components of volatility. Short open interest, however, increases with unexpected volatility, but not with expected volatility. Increases in unexpected volatility may cause hedgers to raise their estimates of future expected volatility, and hence increase their demand for hedging.

The regression results examining the relations for large speculators reveal no evidence of a relation between open interest and expected volatility. Only weak evidence is found of a positive relation between unexpected volatility and open interest, and the results are sensitive to the volatility estimate used. More importantly, the slightly increased demand for speculation in periods of high volatility is exceeded by the increased demand for hedging, and the difference is statistically significant. The findings suggest that stock index futures are used for their intended purpose of hedging, and that speculation does not become excessive in periods of high volatility.

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