HAS FUTURES TRADING ACTIVITY CAUSED STOCK PRICE VOLATILITY?

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INTRODUCTION

Many analysts and financial market observers have increased their attention to stock price volatility and its deleterious economic and financial effects, particularly since the market crashes of 1987 and 1989.[1] Some researchers contend that stock prices have become more volatile recently and they single out the trading of index futures as the presumed source of increased volatility. Two of the most extraordinary recent innovations in financial markets have been the introduction of stock index futures in April 1982 and the application of computer techniques to monitor price differences and trigger trades between markets. These innovations have reduced the cost of transacting among the markets, resulting in increased intermarket trading activity. However, these activities have also led many observers to argue that index futures trading is a force behind the stock market volatility.

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[1]For an overview and some evidence on these effects, see Mankiw et al. (1985), Higgins (1988), Gertler and Hubbard (1989), and Becketti and Sellon (1990). As Edwards (1988b) noted, more volatile stock prices need not imply market inefficiency unless such volatility becomes excessive; i.e., greater than the level which standard asset-pricing models can justify.

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The spot and futures market prices are linked by arbitrage, i.e., participants liquidating positions in one market and taking comparable positions at better prices in another market, or choosing to acquire positions in the market with the most favorable prices. If, for example, the observed futures price is above (below) the theoretical futures price, arbitrageurs sell (buy) futures and buy (sell) the underlying security, driving down (up) the price of the futures and driving up (down) the prices of security. There are two opposing views regarding the impact of these intermarket activities on the volatility of cash prices. One viewpoint holds that speculation in the futures market tends to stabilize cash prices. One viewpoint holds that speculation in the futures market tends to stabilize cash prices. Futures trading adds more informed traders to the cash market, making it more liquid and, therefore, less volatile. An opposing view suggests that speculation in futures markets destabilizes prices. This is because futures markets result in uniformed (irrational) speculators trading in both futures and cash markets, shocking prices in search of short-term gains. While there is still disagreement as to whether futures trading increases or decreases the volatility of cash prices, the question is essentially an empirical one.

The alleged increase in volatility has led to many proposals for more regulations of the financial markets.[2] While these regulations are certainly costly and may or may not reduce stock price volatility, it is necessary to examine whether futures trading is actually responsible for causing stock market volatility. Using multivariate Granger-causality tests in conjunction with Akaike's final prediction error (FPE) criterion, this article examines whether increased stock price volatility has been caused by futures trading and other relevant macroeconomic and financial variables.

LITERATURE REVIEW

To determine whether stock index futures increase stock price volatility, several authors have examined the level of stock market volatility before and after the introduction of stock index futures. Most of these studies

[2]These proposals include trading halts or circuit breakers, increased margin requirements on futures contracts, limitations on index arbitrage, and the abolishment of portfolio insurance. For more details, see the Committee on Banking, Finance, and Urban Affairs (1988), the Working Group on Financial Markets (1988), the Inter-market Coordination Act of 1988, and the Securities Futures Market Credit Protection Act. Other proposals are more radical, such as the one suggested by Donald Regan to the Senate Banking Committee on May 11, 1988 calling for the abolition of futures markets altogether.

find no increase in overall volatility after the introduction of futures trading. Santoni (1987) finds no evidence of statistically significant changes in either daily or weekly percentage changes in the S&P 500 index following the introduction of index futures. This conclusion is supported by Davis and White (1987) and by Edwards (1988a, 1988b). In particular, Edwards examined the relationship between futures trading and stock market volatility. His analysis of the 1972–1987 period did not indicate that futures trading was associated with an increased stock market volatility. In fact, market volatility in the S&P 500 index was greater in 1973–1982 pre-futures period than it was in the 1982–1986 post-futures period.

Aggarwal (1988) argued that volatility in all markets (with or without futures-related activity) has increased during the post-futures period. However, price and return volatility of the S&P 500 index and DJIA relative to the OTC index (a market without active futures trading) has in fact decreased during the post-futures period, while relative volume volatility has increased. Lee and Ohk (1992) examined the effects of introducing index futures trading on stock return volatility in Australia, Hong Kong, Japan, the U.K., and the U.S. They found that stock market volatility increased significantly soon after the stock index futures were listed on the underlying index, with the exception of stock markets in Australia and Hong Kong.

Schwert (1989, 1990a, 1990b) as well as Shiller (1989) found that the volatility level in U.S. stock markets has, with the exception of the Great Depression, been stable since the mid-19th century. A similar conclusion was drawn by Becketti and Sellon (1989), Fortune (1989), Jones and Wilson (1989), and Gerety and Mulherin (1990). Schwert analyzed the long historical series of standard deviations of monthly returns to the S&P 500 index and concluded that the general level of stock return volatility has not risen recently. Schwert (1990a) found little evidence that the introduction of stock index futures is associated with an upward trend in stock volatility.

There have been other studies examining the impact of futures trading in individual financial assets on cash market volatility. A partial list of such studies include Corgel and Gay (1984), Froewiss (1978), Figlewski (1981), Moriarty and Tosini (1985), Seider (1981), and Simpson and Ireland (1982) for the GNMA market; Charles and Workman (1981), Ely (1988), Simpson and Ireland (1985), and Taylor and Leuthold (1974) for the Treasury bill market; and Bortz (1984) for the Treasury bond market. These studies suggest that the introduction of futures trading has not increased the volatility of cash prices.

Other studies examined the impact of introducing futures trading upon cash prices in the commodities markets. Gray (1963), Peck (1976), Powers (1970), and Taylor and Leuthold (1974) concluded that futures trading reduces the random variation in cash prices. Cox (1976) investigated the effect of organized futures trading on information in spot markets. Empirical evidence showed that futures trading increases traders' information about fundamentals underlying supply and demand. Cox concluded that spot markets seem to operate more efficiently because of futures trading. Weaver and Banarjee (1990) investigated whether futures trading of cattle and other related commodities destabilizes cash prices. They argued that futures trading did not lead to dynamic instability of cash prices. However, in contrast to the above researchers, Tomek (1979/1980) concluded that an active futures market increases the residual variance of cash prices.

This study is different from previous research in several ways. First, rather than addressing normal volatility, this article focuses on the jump volatility that concerns many observers like legislators, government regulators, and market analysts. Second, it uses the FPE/Granger-causality modeling technique in a multivariate context which has not been used by previous researchers in this area. Third, unlike prior causality studies, this research explores whether stock market volatility is caused by activity in the futures market such as trading volume. Fourth, the current study tests for the causal impact of several macroeconomic variables that have been proposed in the literature as possible sources of stock market volatility. Finally, while previous studies did not adequately control for extraneous influences, this study uses a better statistical methodology to control for these influences.

Stock market volatility can be divided into two types: normal volatility and jump volatility [see Becketti and Sellon (1989) and Becketti and Roberts (1990)]. Normal volatility is the ordinary variability of stock prices, that is, the ordinary ups and downs in stock prices. Jump volatility, on the other hand, refers to occasional and sudden extreme changes in stock prices. Two leading examples of jump (or spike) volatility are the price shocks of October 19, 1987 and October 13, 1989. There are other instances of jump volatility in the stock market [see Jones and Wilson (1989) for details]. Jumps in stock prices over a relatively short period of time (a few hours or a day) can temporarily disrupt capital markets and strain market mechanisms [see Becketti and Roberts (1990) for further discussion]. Furthermore, increased jump volatility could lessen investors' confidence in the stock market, leading to decreased trading activity, lower liquidity, and higher investment cost, all of which could seriously threaten market stability.

One way that stock index futures might increase jump volatility is through making stock price jumps more likely. Researchers measure jumps by setting a band within which stock price movements are considered normal or ordinary. Movements outside the band are identified as jumps because they are considered exceptional. For example, some researchers identify jumps in daily data as price changes (up or down) in excess of 1–2% [Schwert (1990a)].

MODEL SPECIFICATION

While several studies have examined the volatility of cash prices before and after the introduction of futures, such a procedure has some limitations. For example, the increase in volatility may be attributed to factors other than futures trading. In addition, if the volatility remains the same after the introduction of futures, it is conceivable that futures-stimulated volatility is neutralized by other factors. It is, therefore, possible that volatility in the spot market is related not only to activities in the futures market, but also to other fundamental factors.

It is useful to provide a brief theoretical account of the sources of stock market volatility. Since stock price is the discounted present value of expected future cash flows, the volatility of stock prices depends upon the uncertainty associated with the future cash flows (including dividends) and future discount rates. A change in the level of uncertainty about future macroeconomic conditions would cause a proportional change in the stock price volatility at the aggregate level. Schwert (1989) argued that if marcoreconomic data provide information about the volatility of either future expected cash flows or future discount rates, they should be able to explain stock market volatility over time.

Using the FPE/multivariate Granger-causality modeling technique, this study examines whether activities in the futures market and other relevant factors have Granger-caused jump volatility of stock prices. To test for the potential causal effect of several factors on jump volatility, the following specification is used:

$$VJ_t = \beta_0 + \beta_1^{n1}(L)VJ_t + \beta_2^{n2}(L)VC_t + \beta_3^{n3}(L)F_t + \beta_4^{n4}(L)Z_t + \beta_5 D_t + e_t \qquad (1)$$

where L is the lag operator, VJ is the log of the monthly frequency of hourly stock price jumps, VC is the volatility measure of the OTC index, F is the log of the monthly measures of futures market activity (trading volume or open interest), Z is a vector representing volatility of other general economic state variables that may influence the behavior (volatility) of stock prices, D is a dummy variable to allow for possible shifts due to the maturation of futures market, and e is a white-noise error term.

The measure of jump volatility described in Becketti and Sellon (1989) is used. It is based on a statistical technique designed to highlight potential outliers—abnormally small or large values—to identify stock price jumps. The method consists of constructing a band based on a robust measure of the dispersion of price observations in the sample [Hoaglin et al. (1986) and Hoaglin and Iglewicz (1987)]. Observations that fall outside this band are identified as price jumps. This procedure considers observations as outliers (or jumps) if they are less than $(V_L - 1.5V_Q)$ or if they exceed $(V_U + 1.5V_Q)$, where V_L and V_U denote the 25th and 75th percentile and $V_Q = (V_U - V_L)$ is the interquartile range.[3] Using this technique, an hourly jump is defined as any hour in which the S&P 500 index rises more than 0.6218% or falls more than 0.5963%. These bands correspond to those in Becketti and Roberts (1990), who considered hourly price changes greater than 0.5386% or less than −0.5151% as jumps in the S&P 500 index for their period of February 1983 through May 1990. Following these latter authors, jump volatility of stock market is defined as the monthly frequency of stock price jumps. The monthly frequency of stock price jumps is measured by the number of hourly jumps during a month in the S&P 500 index divided by the number of trading hours in the month.

Following Chen et al. (1986), general economic state variables considered in the vector Z include the volatility of the monthly growth rate of industrial production, the volatility of inflation, the volatility of the term structure of interest rates, and the volatility of the risk premium (the spread between low and high grade bond returns). These variables have been proposed as potential determinants of stock prices [Fama (1981) and Schwert (1981)].

A number of theoretical reasons suggest that the above macroeconomic variables may be related to jump volatility of stock prices. For example, Mishkin (1989) pointed out that large changes in stock prices reflect large shifts in rational agents' expectations about future

[3]The 25th percentile, 75th percentile, and interquartile range of −0.1395%, 0.1650%, and 0.3045%, respectively, are calculated as well. The values for $(V_L - 1.5V)$ and $(V_U + 1.5V)$ are −0.5963% and 0.6218%, respectively.

values of the fundamental economic variables affecting stock prices. These price changes occur because of the arrival of new information. Bookstaber and Pomerantz (1989) and Ross (1989) further showed that the volatility of stock prices is directly related to the rate of information flow. Any event that increases the rate of information flow would simultaneously increase price volatility. Therefore, excessive volatility could be considered a result of greater frequency of information flowing into the market.

Shiller (1989) also used market efficiency to relate stock volatility to macro variables. He argued that it would be reasonable to expect that changes in volatility of stock prices would respond to changes in the volatility of certain marcroeconomic variables. In particular, the efficient market theory contends that prices in speculative markets are driven by fundamentals, where the fundamentals are economic variables that ought to affect security prices. Officer (1973) and Schwert (1989) related the stock market volatility to the volatility of macroeconomic variables such as inflation, money growth, and industrial production. Moreover, Chen et al. (1986) contended that, through the diversification argument implicit in capital market theory, macroeconomic variables are expected to influence the volatility of large stock market aggregates like the S&P 500 index.

Two alternative measures of the intensity of futures trading activity (F) are employed. These are the monthly stock index futures trading volume (FA), and the monthly open interest (FB) in the S&P 500 index futures contract. The former is measured by the median daily number of S&P 500 futures contracts traded during the month. The latter is measured by the monthly average of daily open interest in the S&P 500 index futures contract. The daily open interest is the total number of outstanding futures contracts at the end of the trading day. These measures have been used by several previous researchers to represent futures trading activity.

DATA AND ECONOMETRIC METHODOLOGY

Monthly data spanning the period, May 1982 through June 1991, are used. The start of the sample is dictated by the introduction of S&P 500 index futures trading, while the end of the sample represents the last month for which data were available at the time the empirical analysis began. The data sources are as follows. Data on the S&P 500 index spot prices and the S&P 500 index futures trading volume and open interest were provided by the Chicago Mercantile Exchange with the permission of Standard and Poor's Corporation. The OTC composite index prices were obtained from the National Association of Security Dealers (NASD). Data for the industrial production index, the inflation rate, the term structure, and low and high grade bond returns were all complied from the Citibase Data Tape.

A procedure similar to one used by Chen et al. (1986) is used to define the term structure and the risk premium. Volatility in each of the macroeconomic variables is measured by the 12-month moving-average standard deviation of the respective variable. This particular measure of volatility is recommended by Davis and White (1987), Lauterback (1989), and Becketti and Sellon (1990), among others. Furthermore, Modigliani and Shiller (1973), Evans (1984), Pindyck (1984), Tatom (1985), Mehra (1989), and Darrat (1990) have all used moving-average standard deviation to represent volatility (variability) of several economic and financial time series. As Lauterback (1989) noted, this moving-average standard-deviation estimator is usually selected because it is simple and intuitively appealing.

Most empirical research in this area attempted to control for other market factors that might affect the underlying cash market volatility by including yields, price, or variability of a cash market security without a futures market. For example, to control for extraneous factors, Aggarwal (1988) used an index without an active futures market (OTC composite), Froewiss (1978) and Figlewski (1981) used Treasury bonds, Simpson and Ireland (1982) used FNMA securities, and Simpson and Ireland (1985) used Bankers' Acceptance. This methodology assumes that financial markets are completely segmented. Edwards (1988b) criticized this practice and argued that financial markets are rather highly integrated. As such, these economic factors are not independent of futures trading. Consequently, Edwards argued that the use of such "interdependent control variables" does not permit a correct statistical inference regarding the impact of futures trading.

To resolve this problem, the control variable (volatility of the OTC composite index) is regressed on the measure of futures activity. The estimated residuals from the regression are then used as an independent variable in the model explaining jump volatility of stock prices. Clearly, these residuals can be considered independent of futures activity, primarily reflecting shocks (or excess) volatility in the OTC index. Such surprises occur primarily due to the arrival of new information. Recently, Bookstaber and Pomerantz (1989) and Ross (1989) showed that the volatility of prices is directly related to the rate of information flow. Any event that increases the rate of information flow simultaneously increases price volatility. Within this framework, greater excess or surprise volatility (beyond that which is explained by futures activity) can be considered the result of greater frequency of new information flowing into the market. Since financial markets are highly integrated, it is hypothesized that the excess volatility of the OTC index can capture the impact of information arrival on the volatility of the S&P 500 index.

To specify the appropriate lag lengths [the n_i's in eq. (1)], Akaike's Final Prediction Error (FPE) criterion is used [see Darrat (1988, 1990) for details]. Several comments are called for concerning the Granger-causality tests applied in this research.[4] First, besides futures trading measures, other potential causal factors are included in the jump volatility models to avoid biasing the causality inferences due to the "omission of variables" phenomenon [see Luthkepohl (1982)]. Consequently, the Granger-causality tests are multivariate in nature and can thus provide information on whether index futures trading *and* other relevant factors have Granger-caused jump volatility in the stock market.

Second, typical applications of multivariate Granger-causality tests [e.g., Mishkin (1982)] regress the dependent variable on its own lagged values and the lagged values of other possible independent variables, imposing a common lag length on all variables. Causality inferences are then generated on the basis of the joint significance of the coefficients. However, as Ahking and Miller (1985) argued, the use of a common lag is theoretically baseless and may produce biased results if some variables exhibit alternative lag structures. To resolve this problem, the Akaike FPE criterion is employed. Recent empirical research relies on similar techniques for model identification. Thornton and Batten (1985), for example, reported evidence supporting the use of the FPE criterion over other lag-length selection procedures [including Akaike's Information Criterion (AIC) and Schwartz's Criterion].

Although the FPE procedure has been widely used in applied literature to identify appropriate lag structures, the resulting lag specification in any given case may not be the optimal choice. Consequently, it seems prudent to check the sensitivity of the results by employing alternative lag specifications. To do that, AIC and other lag structures (see next section) are used. To further guard against possible biases due

[4]Causality in the sense of Granger (1969) has been quite popular in applied econometrics. Briefly, a covariance stationary time series $\{Y_t\}$ is said to Granger-cause another stationary time series $\{X_t\}$ if the prediction error of current X significantly declines by using past values of Y in addition to past values of X. Of course, such a concept of causality is not universally accepted, and many researchers remain skeptical [e.g., Zellner (1979) and Cooley and LeRoy (1985)]. See also Edwards (1988b) regarding the application of the Granger-causality concept to the issues at hand. For a recent exposition of Granger-causality tests, see Maddala (1992) and Darrat and Suliman (1994).

to improperly ordering the variables, the variables for inclusion in the equations are ranked, based on the "specific gravity" criterion of Caines et al. (1981).

Third, it is well-known that the Granger-causality tests require the data to be generated by a covariance stationary process [see Kang (1985)]. To check for stationarity of the variables, Dickey and Fuller (1979) tests of unit roots are used and an appropriate degree of differencing is determined for each variable in the models. As Stock and Watson (1989) pointed out, the conventional test statistics (like F and χ^2) would not exhibit standard distributions if the variables under examination have unit roots and are thus nonstationary. Fourth, having specified the final models, a battery of tests are applied to check for autcorrelation in the residuals and general misspecification, and to examine the temporal stability of the estimated models. Finally, F-tests are performed on the final models to generate the multivariate Granger-causality inferences.[5]

EMPIRICAL RESULTS

As discussed earlier, the intensity of futures trading activity is measured by two alternative variables: the futures trading volume (FA) and the open interest (FB) in the S&P 500 index futures. Therefore, the FPE/specific gravity methodology results in jump volatility model (2) for the trading volume, and model (3) for the open interest:

$$VJ_t = \Psi_0 + \Psi_1^2(L)VJ_t + \Psi_2^4(L)VS_t + \Psi_3^1(L)VC_t + \Psi_4^2(L)VR_t + \Psi_5^1(L)VF_t + \Psi_6^1(L)FA_t + \Psi_7^3(L)VP_t + \Psi_8 DUM + \mu_t \quad (2)$$

$$VJ_t = \phi_0 + \phi_1^2(L)VJ_t + \phi_2^4(L)VS_t + \phi_3^1(L)VC_t + \phi_4^3(L)VP_t + \phi_5^2(L)VF_t + \phi_6^1(L)VR_t + \phi_7^2(L)FB_t + \phi_8 DUM + v_t \quad (3)$$

where the superscripts in the polynomials indicate the appropriate (FPE-selected) lag lengths; VJ is the jump volatility of stock prices; VS is the volatility of the term structure of interest rates; VC is the volatility of the OTC index; VR is the volatility in the risk premium; VF is the volatility of the inflation rate; FA is the measure of futures trading volume; VP is the volatility of the industrial production index; FB is

[5] Note that Granger-causality models are inherently short-term processes. As such, the results do not cover long-run relationships that can be represented by, for example, vector error-correction (cointegration based) models [See, for example, Hendry (1986) and Engle and Granger (1987)]. Further research in this direction could lead to greater insights.

the measure of futures open interest; DUM is the dummy variable representing the maturation of futures market and is equal to unity for May 1982 through December 1984 and zero otherwise; and μ and v are the associated white-noise error terms. It should be noted that the variables in eqs. (2) and (3) are ranked according to the "specific gravity" criterion. Results from the unit root tests (not reported here to conserve space) indicate stationarity for most variables in levels. However, both measures of futures activity, as well as inflation volatility, require first-differencing to achieve stationarity.[6] The regression estimates from the jump volatility equation in the case of trading volume (FA) are displayed in Table I, while those in the case of the open interest (FB) are displayed in Table II.

As seen in Tables I and II, the estimated models fit the data reasonably well ($R^2 > 0.50$ for both models). All tests of autocorrelation suggest the absence of significant serial correlation. Since a lagged

TABLE I

Coefficient Estimates of Model (2) Using Futures Trading Volume (FA)

Variables	*Coefficient Estimates*	*Absolute Values of t-Statistics*	*Variables*	*Coefficient Estimates*	*Absolute Values of t-Statistics*
Constant	−0.923	0.32			
$VJ(t-1)$	0.290	2.34	$VF(t-1)$	−0.409	1.00
$VJ(t-2)$	0.235	2.33			
			$FA(t-1)$	**0.527**	**1.30**
$VS(t-1)$	0.059	0.07			
$VS(t-2)$	−2.751	2.04	$VP(t-1)$	3.703	0.31
$VS(t-3)$	3.710	2.55	$VP(t-2)$	22.224	1.33
$VS(t-4)$	−1.721	1.95	$VP(t-3)$	−26.058	2.15
$VC(t-1)$	702.791	3.93	DUM	0.096	0.27
$VR(t-1)$	−0.630	0.55			
$VR(t-2)$	1.180	1.03			

Dependent variable: VJ_t = log (frequency of hourly stock price jumps). Monthly data: 1982:05–1991:06.
Model summary statistics: $R^2 = 0.53$, $SE = 0.69542$, $Dm = -0.14$, $BG(8) = 14.21$, $BG(10) = 8.48$, $BG(12) = 10.01$, $RESET = 1.04$.
Notes: VJ = jump volatility in stock prices; VS = volatility in the term structure of interest rates; VC = volatility in the OTC index; VR = volatility in the risk premium; VF = volatility in the inflation rate; FA = the measure of futures market activity (trading volume); VP = volatility in the industrial production index; and DUM = (0, 1) dummy variable representing the maturation of the futures market. Dm is the Durbin-m statistics; BG's are the Breusch–Godfrey (chi-square) statistics for alternative orders; and $RESET$ is the Ramsey (F) statistic.

[6]Thus, the estimated coefficient on, for example, the trading volume variable reflects the response of jump volatility in stock prices to *changes* in the futures trading index. Similar interpretations hold for the estimated coefficients on the open interest index and on inflation volatility.

TABLE II
Coefficient Estimates of Model (3) Using Futures Open Interest (*FB*)

Variables	*Coefficient Estimates*	*Absolute Values of t-Statistics*	*Variables*	*Coefficient Estimates*	*Absolute Values of t-Statistics*
Constant	−1.906	0.68			
$VJ(t-1)$	0.384	3.11	$VF(t-1)$	−0.166	0.43
$VJ(t-2)$	0.153	1.59	$VF(t-2)$	1.017	2.51
$VS(t-1)$	−0.026	0.03	$VR(t-1)$	0.585	1.33
$VS(t-2)$	−3.043	2.33			
$VS(t-3)$	4.271	3.01	**$FB(t-1)$**	**0.070**	**1.24**
$VS(t-4)$	−1.830	2.19	**$FB(t-2)$**	**0.065**	**1.10**
$VC(t-1)$	586.304	3.09	*DUM*	0.264	0.84
$VR(t-1)$	10.292	0.90			
$VR(t-2)$	22.916	1.32			
$VP(t-3)$	−32.847	2.71			

Dependent variable: VJ_t = log (frequency of hourly stock price jumps). Monthly data: 1982:05–1991:06.
Model summary statistics: $R^2 = 0.55$, $SE = 0.69076$, $Dm = -0.62$, $BG(8) = 11.30$, $BG(10) = 12.94$, $BG(12) = 5.23$, $RESET = 0.62$.
See notes to Table I for abbreviations.

dependent variable appears as a regressor in the equations, the Durbin-*m* statistics (instead of the D.W. test) are employed to check for first-order autoregressive order, and none is found.[7] The Breusch–Godfrey test also found no significant autocorrelation of the eight, tenth, and twelfth orders. As Johnston (1984) noted, the virtue of the Breusch–Godfrey procedure is that it is a robust test against autoregressive and moving-average processes of the error terms. Evidence against the presence of significant autocorrelation may be taken to imply the appropriateness of the specification in that there is no important omission of variables from the model. Interestingly, this implication receives support from the Ramsey test (Regression Specification Error Test, RESET) that examines the likelihood of an omitted variable or some other specification errors.

Further indication of the adequacy for the estimated models of eqs. (2) and (3) comes from applying alternative stability tests; namely, the Chow test (using several breaking dates) and the Farley–Hinich test. While the Chow procedure examines whether the estimated equation has undergone a single-point shift, the Farley–Hinich procedure checks for a continuous drift in the equation. Neither test rejects the null

[7]Dezhbakhsh (1990) reported results indicating the superiority of the Durbin-*m* procedure over alternative first-order autocorrelation tests.

hypothesis that both estimated equations are structurally stable during the estimation period.

A possibly more robust test of structural stability is to assess the record of the estimated models for out-of-sample forecasts. To do so, the estimation period is terminated at three alternative dates; namely, September 1989, December 1989, and December 1990. Equations (2) and (3) are then reestimated over each of the three truncated periods and the resultant equations are used to ex post forecast the dependent variable for each of the remaining time periods. The resultant Theil's inequality coefficients for the ex post forecasts are sufficiently small, indicating a structurally stable equation throughout the estimated period. This stability evidence is corroborated by Davidson et al.'s post-sample predictive test [see Harvey (1981)].[8] Such systematic evidence of structural stability is encouraging in light of Lutkepohl's (1989) recent conclusion that structural stability is an important prerequisite for reliable Granger-causality results.

The main focus of this article is on testing the hypothesis that futures trading, however measured, has caused higher jump volatility of stock prices. The empirical results displayed in Tables I and II are remarkably unambiguous in rejecting this hypothesis. First, according to the "specific gravity" criterion, the two alternative measures of futures activity (trading volume and open interest) do not have sufficient explanatory power to qualify for early entry into the model. Second, and perhaps more importantly, the coefficients on the measures of futures trading (albeit appearing with the correct positive signs) are statistically insignificant at conventional levels.

Further evidence on the insignificant role of futures trading in causing jump volatility of the stock market can be gleaned from Tables III and IV, which report the likelihood ratio (LR) statistics for the multivariate Granger-causality tests. In particular, test 6 in Table III indicates non-rejection of the null hypothesis that futures trading volume does not Granger-cause jump volatility in stock prices. Similarly, test 7 in Table IV also suggests non-rejection of the null hypothesis that futures open interest does not Granger-cause jump volatility in stock prices. It appears, therefore, that futures trading (however measured) should not be blamed for any increased volatility of stock prices in recent years. Such empirical evidence supports theoretical conjectures in some previous research in this area [e.g., Shiller (1989)]. It may be argued then that recent regulations aimed at reducing the general

[8]Full account of all stability results are available from the authors upon request.

TABLE III

Likelihood Ratio (LR) Tests for Model (2) of Jump Volatility Using Futures Trading Volume (*FA*)

Null Hypotheses[a]	*Chi-Squared Statistics* [b]	*Degrees of Freedom (Number of Restrictions)*
1. $\Psi_1(L) = 0$	20.54**	2
2. $\Psi_2(L) = 0$	13.67**	4
3. $\Psi_3(L) = 0$	3.69*	1
4. $\Psi_4(L) = 0$	1.89	2
5. $\Psi_5(L) = 0$	0.53	1
6. $\Psi_6(L) = 0$	**1.40**	**1**
7. $\Psi_7(L) = 0$	4.59	3

[a]The hypotheses are (1) lagged values of stock price jump volatility do not Granger-cause stock price jump volatility (*VJ*); (2) volatility in the term structure of interest rates does not Granger-cause *VJ*; (3) volatility in the OTC index does not Granger-cause *VJ*; (4) volatility in the risk premium does not Granger-cause *VJ*; (5) volatility in inflation does not Granger-cause *VJ*; **(6) futures market activity (trading volume) does not Granger-cause *VJ***; and (7) volatility in the industrial production index does not Granger-cause *VJ*.

[b]An * indicates rejection of the hypothesis at the 10% level of significance, and ** indicates rejection of the hypothesis at the 5% level.

level of futures activity appear unnecessary because they would unlikely contribute to achieving a more stable environment for the stock market.

The empirical results thus far are quite systematic in suggesting that futures trading has not significantly caused an increase in jump volatility of stock prices. It bears emphasis that these results are

TABLE IV

Likelihood Ratio (LR) Tests for Model (2) of Jump Volatility Using Futures Open Interest (*FB*)

Null Hypotheses[a]	*Chi-Squared Statistics* [b]	*Degrees of Freedom (Number of Restrictions)*
1. $\phi_1(L) = 0$	22.00**	2
2. $\phi_2(L) = 0$	16.32**	4
3. $\phi_3(L) = 0$	2.68*	1
4. $\phi_4(L) = 0$	8.43**	3
5. $\phi_5(L) = 0$	3.55	2
6. $\phi_6(L) = 0$	1.22	1
7. $\phi_7(L) = 0$	**1.75**	**2**

[a]The hypotheses are (1) lagged values of stock price jump volatility do not Granger-cause stock price jump volatility (*VJ*); (2) volatility in the term structure of interest rates does not Granger-cause *VJ*; (3) volatility in the OTC index does not Granger-cause *VJ*; (4) volatility in the industrial production index does not Granger-cause *VJ*; (5) volatility in inflation does not Granger-cause *VJ*; (6) volatility in the risk premium does not Granger-cause *VJ*; and **(7) futures market activity (open interest) does not Granger-cause *VJ***.

[b]An * indicates rejection of the hypothesis at the 10% level of significance, and ** indicates rejection of the hypothesis at the 5% level.

obtained from FPE-based specifications. Clearly, one way to further strengthen the above inferences is to show that futures trading remains statistically insignificant across other (non-FPE) lagged specifications. A specification procedure, Akaike's Information Criterion (AIC), was shown by Priestly (1981) to be a reliable method to handle statistical model identification in a variety of situations. The AIC method yields very similar lag structures to those obtained from the FPE procedure. (Details of the AIC results are available upon request.) Another, perhaps simpler, method of lag selection is to arbitrarily impose a given lag length on the regressors. Leamer's (1978) suggestion of experimenting with richer (longer) lag structures is followed to gain insights into the robustness of the results, particularly since adding irrelevant lags would be unlikely to yield incorrect test statistics [see Leamer (1978) for a proof]. Accordingly, the longest lags possible are chosen: namely, nine lags for each of the seven regressors in each of the alternative models. The results (available upon request) do not alter the conclusions reached when using the FPE strategy.

The empirical results in Tables I–IV reveal some mixed evidence about the impact of other independent variables on the jump volatility of the S&P 500 index. The volatility of the term structure and also the volatility of the OTC index seem to have caused important changes in the jump volatility, as shown by their respective t-statistics reported in Tables I and II, and by the corresponding LR statistics reported in Tables III and IV. However, unlike results in Pindyck (1984) but similar to the findings of Schwert (1989) and Shiller (1989), the volatility of other macroeconomic variables such as inflation and the risk premium have no important effects. Indeed, the results suggest that jump volatility in the stock market is caused, to a large extent, by the volatility in the financial market (as represented by the term structure of interest rates). This inference suggests that participants in the stock market assign considerable importance to uncertainty surrounding movements in financial market yields. It is conceivable that these market participants interpret volatility of interest rates as indicative of the overall economic uncertainty, which, in turn, leads to changes in stock market volatility. Such a prominent role of the term structure in determining the behavior of stock prices supports the evidence reported by Campbell (1987) and Harvey (1989). On the other hand, the noticeable effect of the volatility of the OTC index on the stock price volatility provides some empirical support to the hypothesis that the frequency of information arrival on the market does have an impact on its volatility. This result lends credence to the theoretical conjecture of Bookstaber and Pomerantz (1989) and

Ross (1989) that the volatility of stock prices is directly related to the rate of information flow.

CONCLUDING REMARKS

This article presents an empirical examination of the view that futures trading activity has contributed to jump volatility of the stock market. One of the most extraordinary recent developments in financial markets has been the advent and explosive growth of index futures trading. Two characteristics of stock index futures that make them popular with investors are that index futures prices are very closely linked with the spot index, which allows hedgers to reduce their risk exposure, and that stock index futures are relatively inexpensive to trade [Becketti and Roberts (1990)]. Both features make stock index futures useful in a variety of investment programs. However, these same characteristics have also led some observers to attribute stock market volatility to futures trading.

The increased volatility in stock prices has intensified calls for more regulation of the financial markets. Becketti and Roberts (1990) found that these market regulations impose excessive costs on participants in the futures market. In view of that, it is important to investigate whether index futures trading has actually contributed to stock market volatility.

This article extends previous studies in several ways. A better statistical methodology is used to adequately control for extraneous factors affecting stock market volatility and some additional tests are introduced (e.g., Granger-causality and the FPE methodology) that have not been previously considered in the literature. Several possible determinants of stock market volatility that have not been examined previously are incorporated. This study focuses on the jump (not normal) volatility of stock prices that seems to be the focus of government regulators and financial analysts. The mixed empirical evidence of previous studies regarding the impact of futures trading on stock market volatility stem, in part, from their limitations as well as from differences in the time periods examined and the methodology used.

The empirical results of this study support Becketti and Roberts (1990) and suggest that futures trading activity (however measured) is not a force behind the recent episodes of jump volatility. Moreover, the volatility of other macroeconomic variables, such as inflation and risk premium, are not responsible for the recent volatility in stock prices. In fact, the evidence assigns a significant role to two factors, namely the volatility of the term structure and the volatility of the OTC index, in causing stock price volatility.

It therefore appears that futures trading should not be blamed for causing jump volatility of stock prices. Such a finding is consistent with some previous research and suggests that recent regulations aimed at reducing the general level of futures activity are unwarranted and would not contribute to a more stable environment in the stock market. On the contrary, these proposed regulations may be counterproductive, because they may divert attention from perhaps more relevant and urgently needed policy options and/or research efforts that address, for example, the increased volatility in the U.S. financial markets [Evans (1984) and Kaufman (1991)], market psychology [Pearce (1987) and Shiller (1989)], trading mechanism [Amihud and Mendelson (1987, 1991)], the information flow [Ross (1989) and Brennan and Hughes (1991)], the microstructure of the stock market [Haugen et al. (1991)], and the integration and interdependencies between the U.S. and foreign stock markets [Schollhammer and Sand (1985) and Jaffe and Westerfield (1985)].

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