The Role of Futures Trading Activity in Exchange Rate Volatility

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INTRODUCTION

The purpose of this study is to examine the relationship between the level of trading in currency futures and the variability in underlying exchange rates. The growth in the popularity of currency futures during the last decade has been noteworthy. For instance, a Commodity Futures Trading Commission (CFTC) report, January, 1983, on the Commitment of Traders indicated that for the deutsche mark futures, there were 16,289 long contracts outstanding, of which 3710 were reported as being held by speculators and 7574 held by hedgers. The March, 1993 report on the currency indicated that there were 102,961 long contracts outstanding of which 16,822 were reported as being held by speculators and 65,676 held by hedgers. The growth in the popularity of currency futures has

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The Journal of Futures Markets, Vol. 16, No. 5, 561–584 (1996)

CCC 0270-7314/96/050561-24

occurred during an interval that has witnessed increased volatility in the major currencies.[1] The coinciding trends raise an important question on the possible relationship between futures trading activity and the behavior of exchange rates: can some of the increased volatility be attribute to futures trading, or are futures traders merely reacting to increased volatility?

The past evidence on the general impact of futures trading has been mixed. Some studies indicate that it has a destabilizing effect, but other studies find a stabilizing influence on underlying cash markets. See, for instance, Karpoff (1987). Despite the inconclusive nature of the evidence, there have been moves toward greater regulation of derivative markets. See Bessembinder and Seguin (1992).[2] The resolution of the role of futures trading on asset volatility thus remains critical to whether or not current regulatory measures need to be reevaluated. Investigating the currency futures-activity versus spot-volatility relationship may also provide important insights into the degree to which futures trading can impact asset pricing in vast cash markets. While there is a great deal of evidence on the general relationship between exchange rates in futures markets and spot markets, there is little evidence on whether or not the level of trading activity in currency futures affects spot exchange rate behavior.[3] Despite the size of the currency market, and the fact that futures contracts are only one of three popular means with which speculators and hedgers can assume positions on future exchange rates (the other two are currency forwards and options), there are indications that the level of futures trading activity can affect currency price volatility. For instance, Clifton (1985) finds that the volume of trading activity in the currency futures market is significantly correlated with exchange rate fluctuations in the interbank foreign exchange market during the early 1980s. Others, including Grammatikos and Saunders (1986), find strong relationships between futures trading volume and futures currency prices. However, these studies fail to consider the prior evidence of non-normal distributions of exchange rates in their measurement of volatility.

This study contributes to the literature on the relationship between currency futures and currency spot rates in the following two respects. First, the study investigates this relationship in the context of the level of

[1]For instance, the average daily absolute change in the British Pound in 1980 was 0.70%. The level of this variable in 1992 was 1%.

[2]Although it is not clear that regulators should be concerned over greater cash market variability per se, some argue that higher cash market variability is reflected in higher costs of capital. See Edwards (1988).

[3]For instance, futures currencies have long been held as important determinants of spot exchange rates, e.g., Maldonado and Saunders (1983) and Jabbour (1994).

futures trading and the volatility in the spot rates of the British Pound (BP), Canadian Dollar (CD), Japanese Yen (JY), Swiss Franc (SF), and the Deutsche Mark (DM). It is expected that the present exercise will provide regulators and traders with important insights into the futures trading—spot volatility relationship. Second, the study employs a volatility measure consistent with the return distribution of the underlying currencies investigated. The conditional variance from Bollerslev's (1986) Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model is found to be the appropriate proxy of volatility of the exchange rate series. It is demonstrated that this measure also captures extreme volatility. The results from a vector autoregressive estimation indicates that currency futures trading has a significant positive impact on the volatility in the exchange rate changes, with a weaker feedback from exchange rate volatility to futures trading.

The remainder of the article is organized as follows. The next section reviews the literature on the futures trading–underlying asset volatility relationship, and on the characterization of exchange rates. The third section describes the data and methodology employed; the fourth presents the empirical results. The last section summarizes the findings of the study and provides some concluding remarks.

LITERATURE REVIEW

Opponents of speculative trading activity have generally argued that increased trading in futures leads to unnecessary price volatility in the underlying cash markets. Some researchers suggest that the participation of speculative traders in systems that allow high degrees of leverage lowers the quality of the information in the market, e.g., Figlewski (1981) and Stein (1987). Cox (1976), among others, notes that uninformed traders could play a destabilizing role in cash markets. Others question the role of futures markets as representing an institutional alternative for accurate price forecasting, e.g., Martin and Garcia (1981).

On the other hand, it has been suggested also that the futures markets have become an important medium of price discovery in cash markets, e.g., Schwarz and Laatsch (1991). Several authors have argued that trading in these markets improves the overall market's depth and informativeness, e.g., Powers (1970); enhances market efficiency, e.g., Stoll and Whaley (1988); increases market liquidity, e.g., Kwast (1986); and compresses cash market volatility, e.g., Danthine (1978), Bray (1981), and Kyle (1985).

Questions pertaining to the impact of derivative trading activity on cash market volatility have been empirically addressed in two ways. First, researchers have attempted to establish the impact of speculative trading on cash markets by comparing cash market volatilities during the pre- and post-futures/options trading eras. The majority of this class of studies suggests that speculative markets either add to the stability, or do not impact the volatility of cash markets e.g., Simpson and Ireland (1985), Edwards (1988), and Skinner (1989).[4] Second, researchers have examined the relationship between speculative trading activity and cash markets by directly evaluating the impact of options and futures trading activity (generally proxied by trading volume) on the behavior of cash markets. While the evidence in the earlier studies is inconclusive, the more recent studies mainly suggest that futures trading activity either improves or has no impact on the stability of cash markets.[5] For instance, Edwards (1988) and Bessembinder and Seguin (1992) provide evidence that futures trading activity improves the stability in equity indexes. More recently, Ely (1991) finds no evidence that would indicate the level of trading activity in interest-rate futures and options has a significant impact on the corresponding cash markets.

There are relatively few studies that analyze the trading-volume versus price-variability relationship in the context of currency futures. In contrast with the evidence on the impact of futures trading in other assets, the evidence on the impact of currency futures trading has generally been unfavorable. Eldridge (1984) examines the impact of the futures positions taken by European traders at the end of their business day on the volatility of currency futures traded on the International Monetary Market. The author finds that the price volatility (measured by standard deviation) in DM futures contracts temporarily rises at the close of the European business day. McCarthy and Najand (1993) employ a state-space model to provide mixed evidence on the stabilizing influence of futures trading on daily futures currency prices. While the lagged (day $t = -1$) levels of trading volume on the BP futures, SF futures and DM futures are found to have a negative (stabilizing) impact on the volatility of the respective futures price, the lagged trading volume levels on the

[4]Exceptions include Harris (1989), who documents an increase in volatility in S&P 500 Index subsequent to the introduction of futures trading on the Index.

[5]The inconclusiveness of the evidence from the earlier studies is probably best represented by the string of investigations into the impact of GNMA futures trading. For instance, while Froewiss (1978) documents a negative relationship between open interest in GNMA futures contracts and the volatility in the GNMA cash market, Figlewski (1981) provides evidence to suggest that futures trading activity increases the variability in the GNMA market. In a subsequent study, Simpson and Ireland (1985) find no evidence of an association between GNMA futures trading and GNMA cash prices.

CD futures are found to have a positive (destabilizing) impact. See, also, Grammatikos and Saunders (1986).

The study by Clifton (1985) explicitly examines the relationship between currency futures trading and exchange rate volatility. The author examines the impact of currency futures trading on the interbank currency market during the early 1980s. A strong positive correlation between futures trading volume and intraday exchange volatility (measured for the spread between intraday high and low rates) for the JY, SF, DM, and CD is documented. The study also notes a positive correlation between the monthly volatilities in the DM and CD, and the monthly volume of futures trading. However, the study is not able to provide conclusive evidence on the causality between exchange rate fluctuations and futures trading volume.

The Measurement of Exchange Rate Variability.

The study of the relationship between futures trading activity and the variability of the underlying cash market is complicated by the nature of exchange rate movements. While several early studies on exchange rate movements suggest that currencies behave like random walks, whereby current exchange rate levels are statistically independent of past levels [e.g., Meese and Rogoff (1983)], most recent studies indicate that currencies exhibit nonlinear price dependencies. As demonstrated by Manas-Anton (1986) and Hsieh (1988), among others, it is possible for exchange rates to be linearly unrelated and yet be nonlinearly dependent. Those authors show that the square of some exchange rate series, x_t^2, may be serially correlated; whereas, x_t is not. Furthermore, the general evidence on exchange rates suggests that the dependencies work through conditional variance (and other even-ordered moments) rather than being a result of certain misspecified first-order dynamics.[6] Under these conditions, the applicability of traditional volatility measures, such as the absolute change in prices, would provide inconsistent estimates in the study of the trading-activity versus exchange rate-volatility relationship.

A set of prominent tools to characterize such time variation in return distributions is provided by the Autoregressive Conditional Heteroskedasticity (ARCH) model of Engle (1982) and the Generalized ARCH model of Bollerslev (1986). In the ARCH model, the conditional error distribution is normal, but the conditional variance is a linear function of past squared errors. The GARCH process allows for a more flexible lag

[6] For instance, Hsieh (1989) provides evidence from third-order moments of exchange rates that nonlinearities enter through variances, consistent with the presence of conditional heteroskedasticity.

structure, and is not unlike that of the time series process in a general ARIMA model. Hsieh (1988, 1989) indicates that ARCH/GARCH processes can also be effectively employed to describe nonlinearities in currency data. Hsieh (1988) demonstrates that an ARCH (12) model, with a linearly declining lag structure, captures most of the nonlinear dependencies in the returns of five currencies: the BP, DM, SF, CD, and JY. Hsieh (1989) finds that a GARCH (1,1) model satisfactorily describes the SF, CD, and DM, but not the BP and JY. However, regardless of fit, the GARCH model is found to account for most of the nonlinearities in the currencies investigated. ARCH/GARCH effects in currencies have been noted also by Milhoj (1987), Diebold and Nerlove (1989), and Baillie and Bollerslev (1989), among others. In sum, there is a great deal of evidence that the conditional variance from ARCH-type models provides a superior estimate of exchange rate variability. The use of conditional variance as the measure of exchange rate volatility is motivated also by studies that rely on this measure and find that volatility has a significant impact on the volume of international trade and foreign investment. See Pozo (1992), Baily (1991), Kroner (1993).

DATA AND METHODOLOGY

Daily information on the spot rates for the BP, DM, SF, CD, and JY, along with the corresponding Chicago Mercantile Exchange's currency futures volume and open interest are obtained from the *Futures Industry Institute Data Center*, Washington, D.C. The daily information includes the intervals, December, 1975 through March, 1993 for the BP, DM and SF; December, 1977 through March, 1993 for the CD; and June, 1982 through March, 1993 for the JY. To obtain the daily levels of trading volume and open interest for the currency futures, each contract is followed for the interval in which it is the nearby-contract until the trading day prior to the expiration month, at which point the data switches to the next contract.[7] The rationale for restricting the information in this manner is that the majority of trading activity is generally for the nearby contract, until the end of the pre-expiration month. The spot currency information is synchronized with the close of trading on the currency futures market. (Futures trading for the five currencies occurs between 7:30 AM to around 1:30 PM Central Time.)

The proxy for the level of trading activity is futures volume, V_t, standardized by the futures open interest, OI_t. Leuthold (1983) suggests that

[7]The contract cycles are March, June, September, and December.

this variable also reflects speculative activity. Daily volume largely reflects speculation, since hedgers' transactions comprise relatively minor proportions of daily volume. On the other hand, open interest represents longer-than-intraday trading positions so that OL_t, on average, mostly captures hedging activities, while V_t relative to OI_t (henceforth VOI_t) reflects speculation. See, also, Rutledge (1979) and Garcia, Leuthold and Zapata (1986).[8] There is another rationale for employing VOI_t (rather than V_t) as a proxy for futures trading activity. Garcia, Leuthold, and Zapata (1986) point out that daily volume varies as a function of time to expiration in speculative markets. Thus, there may exist a dual-proxy problem in that trading volume could represent trading activity and/or time to expiration. They suggest that such a problem may be addressed by standardizing the daily volume by the open interest.[9]

The proxy for exchange rate variability is the conditional variance from the GARCH (1,1) model for the *returns* of the five currencies. These returns are obtained by the transformation, $R_{it} = \log(S_{it}/S_{it-1}) \cdot 100$, where $S_{it}(i = 1 \,..\, 5)$ is the spot exchange rates of the currencies. The conditional variance is given by h_t in the maximum likelihood estimation of the model,

$$R_t = \mu_{t-1} + \varepsilon_t$$

$$\varepsilon_t \mid (\varepsilon_{t-1}, \varepsilon_{t-2} \ldots) \sim N(0, h_t)$$

$$h_t = a_0 + a_1\varepsilon_{t-1}^2 + a_2 h_{t-1}$$

where μ_{t-1} is the mean R_t conditional on past information (proxied by R_{t-1}).

Several standard tests are conducted to confirm that the conditional variance from the GARCH model is the appropriate volatility measure for

[8]An evaluation of the extent to which VOI_t reflects the level of speculative activity is conducted. Establishing the link between VOI_t and trader make-up could prove valuable to traders and regulators who would be interested in evaluating the trader patterns on a day-to-day basis [CFTC compiles Commitment of Traders (COT) reports on a weekly basis, and such information is available to the public only on a bi-weekly basis]. The CFTC COT data (month-ending levels from 1/1983 through 3/1993) are used for this purpose. The data are obtained from Pinnacle Data Corporation, Webster, New York. A measure of speculation is derived in the manner suggested by Working (1960), and elaborated on by Peck (1980). The index (SPEC) is given by, SPEC $= 1 + LS/(LH + SH)$ if $LH > SH$, SPEC $= 1 + SS/(LH + SH)$ if $SH \geq LH$, where LS and SS represent speculative long contracts and speculative short contracts, respectively, and LH and SH represent hedging long and hedging short contracts, respectively. Nonreporting traders are not included in the computations. The SPEC index provides an indication of speculative activity over and above that which is required to fill the imbalances between hedgers. The results support the notion that VOI_t partially reflects the level of speculation as defined by SPEC. The average VOI_t—SPEC correlation coefficients range from .25 (BP) to .50 (DM).

[9]The concern that open interest or volume will drop to zero is avoided by stopping data collection at the end of the month prior to the expiration month.

the currency return series. A test is run for nonlinear dependencies as proposed by McLeod and Li (1983) which employs the Box–Pierce Q-statistics of the squared residuals from an ARMA model. Contingent on the evidence of nonlinear dependencies in currency data, and given the prior evidence on the utility of ARCH models in such an event, a test is run to determine whether ARCH/GARCH models adequately capture the nonlinearities in the series. A comparison of the ARCH and GARCH models are facilitated by successively applying likelihood-ratio tests until the improvement in the log-likelihood function becomes negligible, e.g., Akgir (1989).[10] For the data considered, it is found that this function for the GARCH (1,1) is greater than the ARCH (12) model for all the currencies considered.[11] Given the general evidence of the comparability of the GARCH (1,1) model against the ARCH models considered, the GARCH (1,1) model is selected for further analysis of the data. Finally, the standardized residuals given by $z_t = \varepsilon_t/h_t^{1/2}$ are diagnosed for past dependencies. The absence of nonlinear dependencies in the standardized residuals indicates that the model captures the nonlinearities in the currency futures data.

The relationship between cash market volatility and trading activity is investigated by employing the vector autoregressive (*VAR*) system,

$$h_t = a_{1t} + \sum_{j=1}^{k} \tau_j h_{t-j} + \sum_{j=1}^{k} \beta_j \left[\frac{V_{t-j}}{OI_{t-j}}\right] + e_t \tag{1a}$$

$$\left[\frac{V_t}{OI_t}\right] = a_{1t} + \sum_{j=1}^{k} \pi_j \left[\frac{V_{t-j}}{OI_{t-j}}\right] + \sum_{j=1}^{k} b_j h_{t-j} + u_t \tag{1b}$$

where τ_j and π_j are the coefficients for the lagged regressors of the dependent variable, β_j, and b_j are the coefficients for the lagged independent variable; and e_t and u_t are the random error terms. Akaike's final prediction error criterion is employed in the selection of the optimal distribution

[10]The ARCH (p) model is given by

$$R_t = \mu_{t-1} + \varepsilon_t$$

$$h_t = a_0 + \sum_{i=1}^{p} a_i \varepsilon_{t-i}^2$$

Given the general evidence that the GARCH(1,1) is an effective representative of the wider class of GARCH models, this study considers only the ($p = 1, q = 1$) process for this model. ARCH models are estimated for up to ($p = 12$).

[11]The ARCH(12) model is selected for comparative purposes because Hsieh (1988) demonstrated that this model captures most of the nonlinear dependencies in the five currencies analyzed in the current study.

lag structure.[12] The test for causality is based on an F-statistic that is computed by employing the residual sum of squares from the reduced and full-form solutions of (1a) and (1b). The VAR specification of the volatility-trading activity relationship is especially meaningful since several researchers [including Rogalski (1978)] are not able to identify unidirectional causality between asset price and trading volume.

Prior to reporting the empirical results from the VAR model, some methodological notes are in order. The VAR model is based on a bivariate relationship between the exchange rate volatility and futures trading activity. Besides futures trading, other factors, such as a country's inflation rates, money supply, industrial production and trade are likely to impact volatility. See, for example, Koray (1989), Salyer (1989), Kroner (1993). Rather than attempting to identify the spectrum of factors that may impact exchange rate volatility via, for instance, a method like mulivariate Granger-causality test [see Darrat (1990)], it was decided to focus on the internal dynamics of daily exchange rate volatility and futures trading.[13] Moreover, an argument may be made that the fundamental economic variables are reflected in the level of the futures trading activity and/or in the exchange rate volatility in the VAR model (1a, 1b). In fact, the mixture of distributions hypothesis [Tauchen and Pitts (1983)] implies that innovations in trading volume are closely related to the number of information arrivals. Relying on this implication, several researchers have deployed trading volume as a proxy for information arrival in the context of the financial markets, e.g., Lamoureux and Lastrapes (1990).

EMPIRICAL RESULTS

Summary Statistics and Exchange Rate Volatility Measures

The summary statistics for the spot returns and futures trading activity are presented in Table I. The results for the spot returns are similar to those of Hsieh (1989) in several respects. As in Hsieh, the BP and CD mean returns are negative, while the other returns are positive. Similarly, the SF and DM rates have the largest standard deviations in the group, while the CD rate has the smallest. Interestingly, the highest futures volume relative to open interest also occurs for SF and DM contracts, and the lowest for the CD contract. The kurtosis coefficients for all the spot

[12]An intuitive guide to establish the optimal length in a VAR model is to select k that results in an estimated model without significant autocorrelation. Also see Sims (1982) and Litterman (1986).
[13]Furthermore, most macroeconomic series are available on monthly and quarterly basis, while the interest here is in the day-to-day interactions of the cash market and futures market.

TABLE I

Summary Statistics: Exchange Rates and Futures Trading

Log Futures Changes: $R_t = \log(S_t/S_{t-1}) \cdot 100$; Futures Trading: Volume/Open Interest (V_t/OI_t)[a,b]

	BP		*DM*		*SF*		*CD*		*JY*	
Sample	*12/01/75–03/31/93*		*12/01/75–03/31/93*		*12/01/75–03/31/93*		*12/01/77–03/31/93*		*06/01/82–03/31/93*	
Variable	R_t	V_t/OI_t	R_t	V_t/OI_t	R_t	V_t/OI_t	R_t	V_t/OI_t	R_t	V_t/OI_t
Mean	−0.0067	0.3695	0.0111	0.4866	0.0133	0.5752	−0.0033	0.2417	0.0276	0.4661
SD	0.7176	0.2065	0.7709	0.2531	0.9651	0.3227	0.2817	0.1570	0.6684	0.2215
Skewness	−0.1035	0.8564	−0.0269	0.5816	0.6541	2.9045	−0.2872	1.7046	0.5132	1.1529
Kurtosis	6.7563	1.2239	16.2772	0.6180	54.5707	56.2238	11.5958	4.6681	4.4443	2.5969
Maximum	6.1034	1.4006	9.8284	1.6190	18.8002	7.7729	2.9895	1.5455	5.0979	2.1205
Minimum	−6.8437	0.0110	−9.9008	0.0018	−15.7190	0.0010	−3.3433	0.0129	−3.6168	0.0432
ADF	−26.689[c]	−14.870[c]	−26.606[c]	−12.981[c]	−27.201[c]	−12.537[c]	−24.476[c]	−17.230[c]	−20.283[c]	−13.782[c]
N	4375	4376	4375	4376	4375	4376	3871	3872	2740	2741

[a]ADF represents the Augmented Dickey Fuller Statistic for β_1 in

$$\Delta X_t = \beta_0 + \beta_1 X_{t-1} + \sum_{i=1}^{n} \gamma_i \Delta X_{t-i} + u_t$$

The statistic rejects
the null hypothesis of nonstationarity if significant and negative.

[b]SD and N represent the standard deviation and number of observations, respectively.

[c]Represents the 1% level of significance.

returns are much higher than those of the standard normal distribution (which is 3). Hsieh also notes heavy tails in cash market data of the five currencies he examined. This study presents the additional Augmented Dickey Fuller (ADF) statistic for stationarity of the spot return and futures trading activity series Engle and Granger (1987).[14] The ADF statistics are consistently negative and significant at the 1% level, rejecting the null hypothesis of nonstationarity of the series. This finding is important since the VAR model is strictly appropriate only when the variables involved are stationary, e.g., Charemza and Deadman (1992).

The upper panel of Table II presents the autocorrelation coefficients and Box–Pierce Q-statistics for the return and square-of-return series for the five currency futures. The standard errors and Q-statistics have been adjusted for heteroskedasticity according to Diebold (1988). The marginal significance levels are evaluated from the test of the null that the coefficients are equal to zero. None of the autocorrelation coefficients are significant for the BP, DM or JY returns. Moreover, significant coefficients for the SF and CD occur only for the first lag. Further, the Q-Statistics for all but one of the R_t series are insignificant at the 5% level. Thus, the autocorrelation coefficients and Q-statistics for the return series provide little evidence of linear dependencies. On the other hand, the autocorrelation coefficients and Q-statistics for the squared series, R_t^2, clearly suggest nonlinear dependencies. The evidence of the lack of linear dependencies and the presence of nonlinear dependencies in the returns of currency futures is similar to Hsieh's (1989) findings for cash returns on these five currencies.

The lower panel of Table II evaluates the fit of the GARCH (1,1) model by diagnosing the standardized residuals (z_t) for past dependencies. The autocorrelation coefficients and Q-statistics provide no evidence of first-order or second-order dependence for any of the currency returns investigated. Thus, the preliminary results indicate that the GARCH model is successful in accounting for the nonlinear dependencies in the futures data. As suggested earlier, this evidence is indicative of correctly specified conditional variances for the five series examined. Further, the null hypotheses that the standardized residuals are non-normally distrib-

[14]The Augmented Dickey Fuller (ADF) statistic is a widely employed technique to test for nonstationarity, and involves the solution of the equation,

$$\Delta X_t = \beta_0 + \beta_1 X_{t-1} + \Sigma_i \gamma_i \Delta X_{t-i} + u_t,$$

where the null hypothesis of nonstationarity is rejected if β_1 is negative and significant. The optimum lag structure is provided by Akaike's (1973) minimum Final Prediction Error criterion. The significance levels are evaluated from Engle and Yoo (1987).

TABLE II

Linear and Nonlinear Dependencies in Exchange Rates and Standardized Residuals from the GARCH (1,1) Model[a,b]

	BP		DM		SF		CD		JY	
	R_t	R_t^2	R_t	R_t^2	R_t	R_t^2	R_t	R_t^2	R_t	R_t^2
Autocorrelation coefficients (lag)										
1	0.021	0.256[d]	−0.104	0.403[d]	−0.155[d]	0.449[d]	0.042[d]	0.371[d]	−0.017	0.134[d]
2	0.010	0.053[d]	0.016	0.060[d]	0.012	0.041[d]	−0.002	0.040[d]	0.015	0.066[d]
3	−0.014	0.048[d]	0.016	0.030[c]	0.012	0.049[d]	−0.005	0.030[c]	0.021	0.075[d]
4	0.010	0.058[d]	0.003	0.011	−0.007	0.016	0.005	0.020	0.006	0.168[d]
5	0.032	0.059[d]	0.017	0.013	−0.017	0.027	0.020	0.023	0.015	0.135[d]
Q(12)	14.89	403.92[d]	55.29	721.31[d]	118.83[d]	893.11[d]	15.87	547.86[d]	10.69	232.35[d]
Q(24)	36.71	473.62[d]	71.98	723.27[d]	131.73[d]	896.66[d]	31.32	557.43[d]	26.86	240.18[d]
Q(36)	51.27	504.97[d]	80.02	744.64[d]	144.87[d]	918.89[d]	38.91	603.64[d]	34.26	257.88[d]
	z_t	z_t^2	z_t	z_t^2	z_t	z_t^2	z_t	z_t^2	z_t	z_t^2
Autocorrelation coefficients (lag)										
1	0.015	0.029[c]	0.005	0.011	0.009	0.019	0.015	0.017	0.003	0.013
2	0.008	−0.006	0.015	−0.005	0.005	−0.008	0.014	−0.007	0.017	−0.003
3	−0.006	−0.001	0.020	−0.004	0.008	−0.008	−0.001	0.006	0.016	0.006
4	0.021	−0.011	0.026	−0.009	0.001	−0.005	0.005	−0.013	0.023	−0.022
5	0.032[c]	0.002	0.029	0.001	0.016	−0.006	0.020	−0.008	0.014	0.004
Q(12)	19.62	8.44	17.38	1.66	11.00	3.20	7.83	9.05	12.54	12.94
Q(24)	42.79	15.99	34.44	2.48	27.77	3.76	21.91	22.68	28.14	24.10
Q(36)	56.37	20.62	40.64	3.75	34.91	8.19	26.44	32.88	35.73	48.35

[a] z_t represents the standardized statistic, $\varepsilon_t/h_t^{1/2}$ and h_t is the conditional variance.
[b] $Q(x)$ represents the Box–Pierce Test Statistics of order x.
[c,d] Represent significance levels of 5% and 1%, respectively.

uted is rejected by the goodness-of-fit chi-square statistics which is consistently significant at the 1% level.[15]

To evaluate the extent to which the conditional variance measure differs from the more traditional volatility measures, h_t from the GARCH (1,1) is correlated with more traditional volatility measures and with those from a sample of alternate ARCH models. These correlations are presented in Panel A of Table III. As expected, the GARCH (1,1) measure is most closely related to the three ARCH measures. The relationships between h_t and the other measures of volatility are relatively weaker.

[15] It is notable that while the GARCH(1,1) model satisfactorily describes the five exchange rates series for the sample period, for smaller (and especially earlier samples) the standardized residuals are non-normally distributed in some cases. This finding is consistent with Hsieh (1989), who analyzes the five currencies over the January 2, 1974 to December 30, 1983, interval.

TABLE III

Correlations Between Conditional Volatility Measures and Alternative Volatility Measures[a,b]

Panel A. Correlation of h_t *with Traditional Volatility Measures*

Currency	$\lvert R_t - R_{t-1} \rvert$	*Daily Range*	ε_t^2	$h_{t(ARCH=8)}$	$h_{t(ARCH=12)}$
BP	.402	.450	.190	.896	.937
DM	.483	.475	.222	.946	.961
SF	.464	.432	.264	.865	.926
CD	.294	.413	.158	.813	.839
JY	.341	.335	.184	.887	.890

Panel B. Correlation of h_t *and Jump Volatility*

		Dummies Representing Percentile Jump in Exchange Rates			
Currency	$D_{(50\%)}$	$D_{(75\%)}$	$D_{(90\%)}$	$D_{(95\%)}$	$D_{(99\%)}$
BP	.189	.216	.342	.353	.365
DM	.153	.204	.356	.361	.358
SF	.189	.284	.312	.314	.317
CD	.151	.204	.240	.246	.251
JY	.131	.178	.298	.308	.329

[a]Daily Range is defined as $(H_t - L_t)/\frac{1}{2}(H_t + L_t)$ where H_t and L_t are the intraday high and low levels of exchange rates; ε_t^2 is from the regression, $R_t = aR_{t-1} + \varepsilon_t$; $h_{t(ARCH=x)}$ is the conditional variance from the ARCH ($p = x$) model.
[b]$D_{(x\%)}$ is defined as follows: $D_{(50\%)}$ is 0 if the absolute change in spot return ($\lvert R_t - R_{t-1}\rvert$) falls below the 50th percentile, and is 1 if $\lvert R_t - R_{t-1}\rvert$ falls above the 50th percentile; $D_{(75\%)}$ is 0 if $\lvert R_t - R_{t-1}\rvert$ falls below the 50th percentile, 1 if between the 50th and 75th percentile, and 2 if above the 75th percentile, etc.

Hence, there are indications that employing the traditional measures to describe volatility in exchange rates may provide different results than when employing volatility measures from ARCH-type specifications. Nonetheless, all measures of volatility are positively correlated with the conditional variance measure employed in the study.

As pointed out by Becketti and Roberts (1990), regulators may be especially concerned with the possibility that derivative trading contributes to the generation of extreme turbulence in cash markets. Thus, conditional variance is evaluated as to whether it reflects the non-normal/extreme-jumps in the exchange rates of the currencies under study. For this purpose, a set of dummy variables are formulated to represent various percentile of "jump" in the return of the five spot rates. The measure is in the same spirit as Becketti and Robert's (1990) and Schwert (1990)'s measures. Jump is defined as $J = \lvert R_t - R_{t-1}\rvert$, and the jump level corresponding to the 50th, 75th, 90th, 95th, and 99th percentile are computed for each currency. Next, five sets of dummy variables, $D_{(50\%)}$, $D_{(75\%)}$, $D_{(90\%)}$, $D_{(95\%)}$, and $D_{(99\%)}$ are defined to reflect an increasingly higher spectrum of volatility. For instance, for each currency's sample period, $D_{(50\%)}$ is given the value of 0 if J falls below the 50th percentile (relatively low volatility), and is 1 if J falls above the 50th percentile (relatively high volatility); $D_{(75\%)}$, is 0 if J falls below the 50th percentile (relatively low volatility), 1 if J falls between the 50th and 75th percentile, and 2 if J falls above the 75th percentile (relatively high volatility), etc.[16] If conditional variance reflects extreme volatility, it should be most closely related to $D_{(99\%)}$, and least related to $D_{(50\%)}$. Panel B of Table III presents the correlation coefficients pertaining to this exercise. In all but one of the cases, the correlation coefficients are the highest for the 99th percentile, and lowest for the 50th percentile. Only for the DM is h_t more closely related to $D_{(95\%)}$ than to $D_{(99\%)}$. The results, in general, indicate that h_t is more closely related to the jump volatility measures that better account for the extreme changes in exchange rates. Hence, it can suggest that conditional variance reflects or captures extreme volatility.

The Lead–Lag Relationship Between Futures Trading and Exchange Rate Volatility

Table IV reports the results from the VAR estimation of the relationship between conditional variance of exchange rates and futures trading activity for each of the five currencies. The set of VAR coefficients for each currency is followed by the Granger causality test statistics. It is clear from these statistics that futures trading activity impacts conditional variance of each of the five exchange rates. On the other hand, the feedback effect from conditional volatility to futures trading activity is somewhat weaker: the test statistic fails to reject the null hypothesis that trading activity is caused by h_t in the case of the Canadian dollar. However, the $t = -1$ coefficients do indicate that trading activity drops on the day following a rise in spot market variability.

The other striking pattern that emerges is that for all currencies, the futures trading activity of day, $t = -1$, has a significant and positive impact on h_t, while the futures trading activity of day, $t = -2$, has a significant and negative impact on h_t (albeit this coefficient is consistently lower than that for day $t = -1$). The opposite sign on the day, $t = -1$ and $t = -2$, coefficients could indicate that exchange rate volatility rises (falls) on the day following a rise (fall) in trading activity, and falls (rises) subsequently. Further, the negative trading activity coefficients on day, $t = -3$, 4 or 5, for the BP, CD, and JY supports the notion that volatility

[16]The five sets of dummy variables thus take on the values (0 or 1), (0,1 or 2), (0,1,2 or 3), (0,1,2,3 or 4), and (0,1,2,3,4 or 5).

TABLE IV

Futures Trading Versus Condition Variance (h_t) in Currencies—VAR Results[a]

Dependent Series	Independent Series	lag	Lagged h_t	T	Lagged V_t/OI_t	T	DW
British Pound							
h_t	V_t/OI_t	−1	0.937[d]	61.843	0.197[d]	27.004	2.000
		−2	0.051[c]	2.464	−0.077[d]	−9.089	
		−3	−0.007	−0.336	−0.018[c]	−2.100	
		−4	0.017	0.814	−0.010	−1.217	
		−5	−0.029	−1.395	−0.001	−1.115	
		−6	−0.003	−0.197	−0.022[d]	−2.811	
V_t/OI_t	h_t	−1	−0.117[d]	−3.692	0.463[d]	30.538	2.001
		−2	0.024	0.564	0.087[d]	4.920	
		−3	−0.044	−1.007	0.052[d]	2.947	
		−4	0.072[b]	1.657	0.105[d]	5.871	
		−5	0.062	1.447	0.059[d]	3.313	
		−6	0.015	0.477	0.011	0.708	
H_o: h_t is not Granger caused by V_t/OI_t: F-value = 122.5906[d]							
H_o: V_t/OI_t is not Granger caused by h_t: F-value = 9.1401[d]							
Deutsche Mark							
h_t	V_t/OI_t	−1	0.970[d]	64.012	0.156[d]	22.207	1.999
		−2	0.032[d]	1.509	−0.088[d]	−10.788	
		−3	−0.063[d]	−2.971	−0.008	−0.982	
		−4	0.020	0.935	0.011	1.349	
		−5	0.001	0.050	−0.013	−1.543	
		−6	−0.001	−0.096	−0.012	−1.605	
V_t/OI_t	h_t	−1	−0.131[d]	−4.019	0.497[d]	32.760	2.003
		−2	0.109[c]	2.392	0.091[d]	5.166	
		−3	−0.050	−1.097	0.070[d]	3.913	
		−4	0.057	1.253	0.086[d]	4.830	
		−5	0.022	0.489	0.041[c]	2.285	
		−6	0.020	0.645	0.031[c]	1.983	
H_o: h_t is not Granger caused by V_t/OI_t: F-value = 85.0314[d]							
H_o: V_t/OI_t is not Granger caused by h_t: F-value = 6.7477[d]							
Swiss Franc							
h_t	V_t/OI_t	−1	1.011[d]	66.502	0.087[d]	18.934	2.000
		−2	−0.015	−0.706	−0.052[d]	−10.072	
		−3	−0.030	−1.375	−0.008	−1.583	
		−4	0.004	0.170	0.004	0.848	
		−5	0.004	0.165	−0.007	−1.434	
		−6	0.005	0.346	−0.063	−1.317	
V_t/OI_t	h_t	−1	−0.129[d]	−2.585	0.425[d]	27.992	2.006
		−2	0.124[b]	1.741	0.122[d]	7.193	
		−3	−0.108	−1.522	0.090[d]	5.233	
		−4	0.118[b]	1.650	0.073[d]	4.221	
		−5	−0.008	−0.107	0.069[d]	4.029	
		−6	0.023	0.479	0.044[d]	2.831	
H_o: h_t is not Granger caused by V_t/OI_t: F-value = 62.4807[d]							
H_o: V_t/OI_t is not Granger caused by h_t: F-value = 3.1028[d]							
Canadian Dollar							

TABLE IV (Continued)

Futures Trading Versus Condition Variance (h_t) in Currencies—VAR Results[a]

			Lagged		Lagged		
Dependent Series	*Independent Series*	*lag*	h_t	T	V_t/OI_t	T	*DW*
h_t	V_t/OI_t	−1	0.967[d]	59.806	0.038[d]	24.314	1.999
		−2	0.017	0.761	−0.014[d]	−7.816	
		−3	0.027	1.193	−0.001	−0.485	
		−4	−0.066[c]	−2.951	−0.004[c]	−2.416	
		−5	0.042[b]	1.868	0.010	0.548	
		−6	−0.027[b]	−1.736	−0.005[c]	−2.869	
V_t/OI_t	h_t	−1	−0.304[b]	−1.837	0.443[d]	27.350	2.001
		−2	0.362	1.570	0.050[d]	2.684	
		−3	−0.031	−0.132	0.023	1.219	
		−4	−0.016	−0.071	0.070[d]	3.761	
		−5	−0.115	−0.504	0.034[b]	1.804	
		−6	0.174	1.088	0.031[b]	1.815	
H_o: h_t is not Granger caused by V_t/OI_t: F-value = 100.0768[d]							
H_o: V_t/OI_t is not Granger caused by h_t: F-value = 1.3659							
Japanese Yen							
h_t	V_t/OI_t	−1	0.862[d]	44.938	0.198[d]	21.090	2.000
		−2	0.033	1.315	−0.079[d]	−7.221	
		−3	0.026	1.038	−0.016	−1.473	
		−4	−0.038	−1.491	−0.018[b]	−1.663	
		−5	0.008	0.301	−0.020[b]	−1.898	
		−6	−0.002	−0.110	0.002	0.247	
V_t/OI_t	h_t	−1	−0.116[d]	−2.950	0.450[d]	23.474	2.000
		−2	0.156[d]	2.998	0.083[d]	3.707	
		−3	−0.109[c]	−2.091	0.048[d]	2.154	
		−4	0.111[c]	2.137	0.065[d]	2.900	
		−5	0.009	0.173	0.016	0.713	
		−6	−0.039	−1.062	0.024	1.178	
H_o: h_t is not Granger caused by V_t/OI_t: F-value = 74.4674[d]							
H_o: V_t/OI_t is not Granger caused by h_t: F-value = 3.0251[d]							

[a]*T* and DW represent the *t*-statistic and Durbin Watson statistic, respectively.
[b,c,d]Represent significance levels of 10, 5, and 1%, respectively.

continues to decline subsequent to the initial reaction to futures trading activity may persist over several trading days. Thus, the VAR coefficients provide some evidence that spot markets "overreact" to futures trading activity.[17]

To obtain further insight into these patterns, the responses of volatility and trading-activity to innovations in trading-activity and volatility are simulated.[18] Figure 1 presents the patterns of impulse responses of

[17]Exchange rates have been known to "overreact" or "overshoot" following shocks in macro variables such as money supply, e.g., Dornbusch (1976).

[18]The simulated "impulse responses" are generated from the VAR model (1a, 1b).

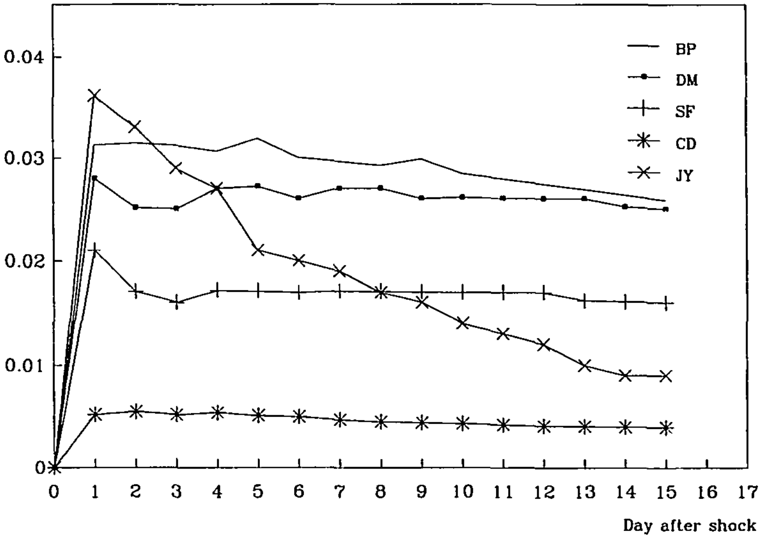

FIGURE 1
Response of conditional variance to 1 standard deviation shock in futures activity.

conditional variances to 1 standard deviation shocks in the futures trading activity on the five currencies. The responses across the five currencies are strikingly similar. All the responses of conditional variances indicate a positive and lagged impact of futures trading. While all the responses rise on the day following the shock, they persist (remain significant and positive) over several trading days.[19] Thus, there are signs that exchange rates overreact to shocks in futures trading activity. Figure 2 presents the responses of the trading-activity to shocks in the conditional variances. Consistent with the results in Table IV, the responses of futures trading activity to shocks in exchange rate volatility are relatively weaker. However, in all cases, trading activity drops on the day following the shocks in spot volatility.

Some Robustness Tests

Three sets of tests are conducted to evaluate the robustness of the above documented relationships.[20] The first test is based on the concern that

[19]The significance of each response is evaluated employing a 2 standard-deviation upper and lower limit.
[20]The VAR model is run employing futures trading data that include the delivery month. The causal patterns between futures trading activity and spot volatility as well as the impulse response patterns remain unchanged.

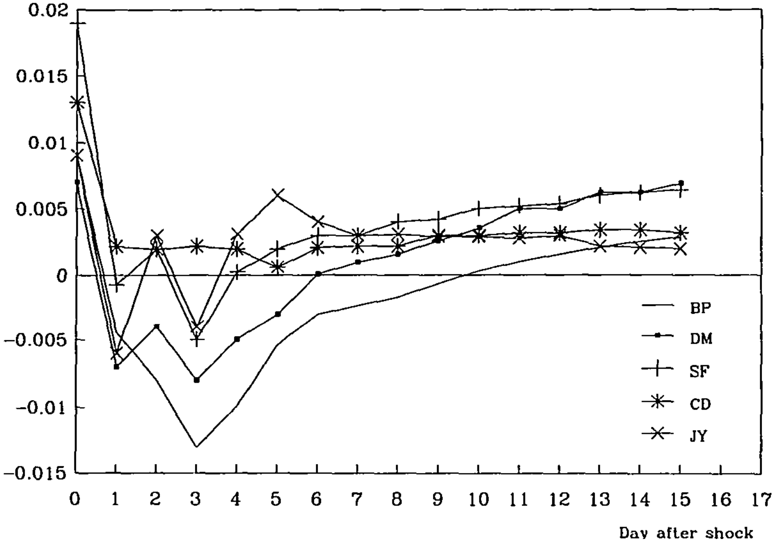

FIGURE 2
Response of futures activity to 1 standard deviation shock in currency conditional variance.

the step-estimation procedure in the VAR model employed in 1a and 1b may be inefficient. Namely, h_t could be a deterministic function of lagged ε term in the GARCH model, and the significance of V_{t-1}/OI_{t-1} in (1a) may simply reflect the fact that ε_{t-1}^2 is excluded in the VAR estimation. An alternate model is employed which entails refitting the GARCH (1,1) model with V_{t-1}/OI_{t-1} as an explanatory ("mixing") variable in the conditional variance equation. In all cases, the V_{t-1}/OI_{t-1} coefficients are very similar to those provided by (1a), suggesting that the model does not suffer this problem.

Second, a test is conducted to determine whether the relationships are robust across an alternate measure of trading activity. The alternate proxy to gauge the change in the number of futures contracts outstanding is given by $|OI_t - OI_{t-1}|/OI_{t-1}$. The focus on the change in open interest is partially motivated by Clifton (1985) who notes that the strength of the futures market's impact on the interbank foreign exchange market is related to the trading strategies employed by the futures market participants. Since open interest represents the sum of contracts made that are not liquidated by delivery or offset, this measure is relatively free from day-trading and scalping activities. The results from a VAR estimation continue to indicate the patterns found earlier: the futures trading activity of day, $t = -1$, has a significant and positive impact on h_t for all the five currencies, while the futures trading activity of day, $t = -2$, has a significant and negative impact on h_t. For major shocks in the level of futures trading activity, exchange rate volatility is found to persist for several trading days. These results are illustrated in Figure 3 which presents the impulse responses of exchange rates returns to one standard deviation shocks in open interest changes.

Finally, a test is conducted to determine whether the documented relationships between spot volatility and futures trading activity remain intact when employing more traditional measures of volatility. For this purpose, the VAR model is fitted to trading activity and the jump measure of volatility defined earlier.[21] As before, the results for each of the currencies indicate a positive impact of futures activity on exchange rate volatility, and a negative impact of exchange rate volatility on trading activity. The impulse responses presented in Figure 4 continue to indicate that the positive impact on volatility persists over several days after the shock in futures trading activity.[22]

SUMMARY AND CONCLUSIONS

This article examines the relationship between futures trading activity and the volatility in five spot exchange rates, namely the British Pound, Deutsche Mark, Swiss Franc, Canadian dollar, and the Japanese Yen. The measure of volatility is consistent with the return distribution of the exchange rates, and generally captures extreme volatility. Vector Autoregressive tests are conducted on daily data on exchange rates and futures trading for the flexible rate era.

The evidence indicates a positive relationship between the level of futures trading activity and the volatility in exchange rate changes. The evidence also indicates that futures activity has a positive impact on the conditional volatility in the exchange rate changes, with a weaker feedback from exchange rate volatility to futures activity. The patterns that emerge are also symptomatic of overreaction in exchange rate changes to shocks in futures trading activity. The positive impact of shocks in futures trading activity on exchange rate volatility is found to persist over several trading days. On the other hand, futures trading activity is found to de-

[21]The measure has obvious similarities with other commonly employed measures of interday volatility.
[22]Whether traders can benefit from certain trading rules based on the evidence of the persistence of volatility (in Figs. 1, 3, and 4) remains to be tested.

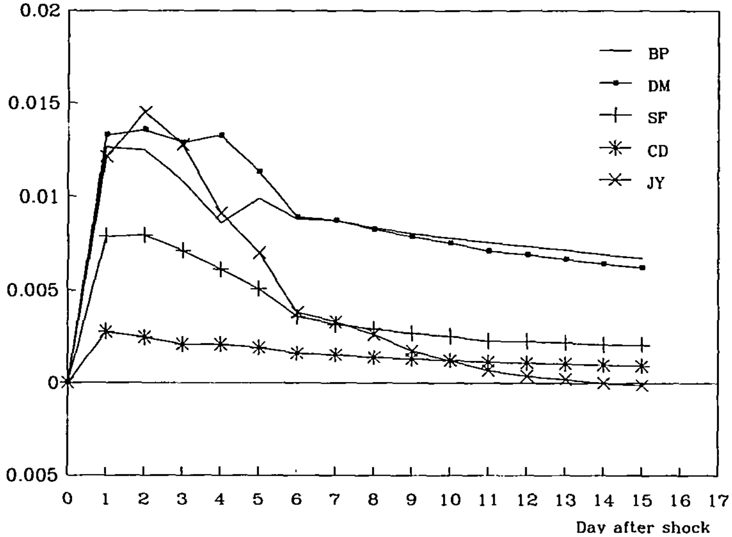

FIGURE 3
Response of conditional variance to 1 standard deviation shocks in open interest changes.

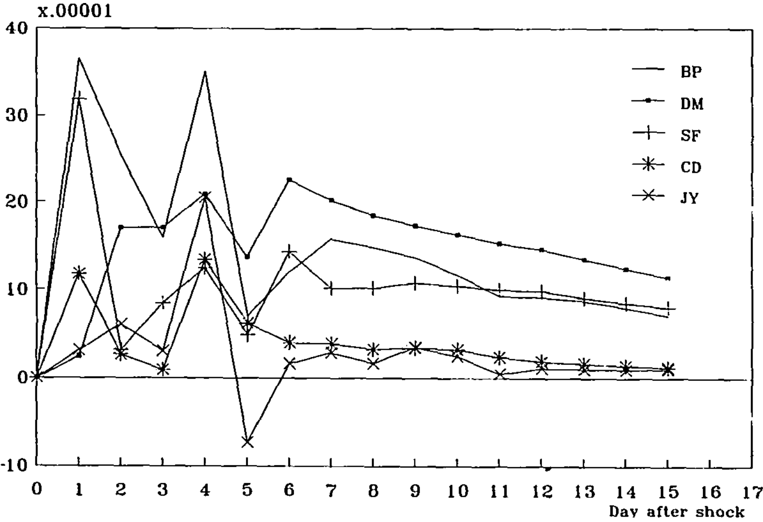

FIGURE 4
Response of jumps in exchange rate changes to 1 standard deviation shock in futures activity.

cline on the day following increased volatility in spot rates. These patterns remain when this relationship is examined in the context of changes in the stock of futures contracts outstanding or a more traditional measure of volatility.

The evidence presented is generally consistent with prior evidence on the impact of currency futures trading. Namely, the level of trading activity is positively related to exchange rate volatility. However, this evidence is generally not consistent with the prior evidence on the impact of futures trading activity associated with other commodities. Thus, it appears that there may be some uniqueness to the impact of currency futures trading. While the positive impact of futures trading on exchange rate volatility may be of concern to regulators, the persistent pattern of overreaction of exchange rate volatility to futures trading activity seems to suggest some inefficiency in the currency market. The indication of inefficiencies is not surprising, as several studies have documented patterns in exchange rate behavior that are not consistent with efficient markets. However, whether traders can make abnormal returns employing the information herein, remains to be answered.

Additional work is needed to obtain further insights into the role of futures trading in exchange rate behavior. The measure of futures trading employed in the present study is found to partially reflect the level of speculation in currency futures. In a market comprised of a variety of traders, ranging from day-traders, scalpers, speculators, and hedgers, the majority of concerns surrounding derivative trading are based around the role of the speculator. Studying the specific roles of speculators and hedgers, and small and large traders within the relationship between futures trading and spot volatility will serve to address such concerns. In the mean while, the present study indicates that an increase in the level of futures trading activity is followed by greater variability in the underlying exchange rates.

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