Serge Jeanneau
+41 61 280 8416
serge.jeanneau@bis.org

Marian Micu
+41 61 280 9279
marian.micu@bis.org

Volatility and derivatives turnover: a tenuous relationship[1]

It is often presumed that higher market volatility begets more active trading in derivatives markets. A number of empirical studies have confirmed that such a positive relationship between volatility and activity exists. However, those studies have usually drawn on analyses that apply mainly to daily or intraday data. Very few studies have considered the existence of a possible relationship between volatility and volume from one month to the next. Moreover, the nature of the trading that could give rise to such a relationship is generally left unexplained.

In this special feature, we examine the relationship between volatility and monthly activity in exchange-traded derivatives contracts. First, we discuss the various trading motives that would lead to such a relationship. We distinguish between hedging motives and information-based motives. Moreover, we distinguish between motives that tend to generate a relationship between volatility and volume on a day-to-day basis from those that would create a relationship on a month-to-month basis.

We then examine the issue empirically. We look at two different markets, that for S&P 500 stock index contracts and that for 10-year US Treasury note contracts. We further look at two types of contract for each market, futures and options, and two measures of activity, turnover and open interest. We also use two conceptually distinct measures of market uncertainty, namely actual (or historical) and implied volatility.

Our results generally show a tenuous relationship between volatility and monthly activity in our selected contracts. More specifically, there is no statistically significant relationship between volatility and turnover in 10-year US Treasury note futures and options contracts. However, there does seem to be a negative relationship between volatility and turnover in S&P 500 stock index contracts. Such results stand in contrast to much of the earlier literature on the relationship between financial market volatility and activity. We suggest an interpretation of these results.

[1] The views expressed in this article are those of the authors and do not necessarily reflect those of the BIS. The authors would like to thank Dimitrios Karampatos and Maurizio Luisi for excellent research assistance.

Links between volatility and activity in derivatives markets

Other studies find a positive link between volatility and activity ...

Previous research has tended to find a positive relationship between volatility and activity in financial markets. Much of that research has focused on the behaviour of volume as volatility changes from one day to the next. In a detailed review of the early literature, Karpoff (1987) noted that most studies based on daily data had found a positive correlation between the volatility of prices in equity and futures markets and trading volume. In one of the few studies that considers a month-to-month relationship, Martell and Wolf (1987) show that volatility is the most significant explanatory variable of monthly turnover in futures markets. However, other macroeconomic factors such as interest rates and inflation also play an explanatory role.

... but the nature of the link remains unclear

The analysis of the factors that could potentially account for such a relationship is often set in highly general terms. Cornell (1981), for example, associates volatility with uncertainty and argues that such uncertainty should lead to an increase in both hedging and speculative trading in derivatives contracts. First, uncertainty may induce risk-averse economic agents to transfer risk to those better able to bear it, at least assuming that uncertainty will make some agents relatively more willing to bear that risk. Second, uncertainty is supposed to lead to differential or asymmetric information, thus greater uncertainty provides a speculative motive for trading. Although these two trading motives are intuitively appealing, the precise interaction between volatility and trading is not spelled out. In fact, one could think of several potential links between volatility and trading, each working in a different way. Moreover, these links could be of varying intensity or even work in opposite directions. We examine some of these links below.

Hedging-related transactions

Hedging creates a clear positive link

Hedging creates an unambiguously positive link between volatility and trading. Hedgers tend to use mechanical trading strategies, such as dynamic hedging to replicate the payoff of options or immunisation to fix the duration of fixed income portfolios. Here price changes automatically call for changes to the exposure to the risks of the underlying securities. Dynamic hedging, for example, involves purchases or sales of the underlying asset to maintain an exposure in proportion to the options' delta.[2] In the case of immunisation, financial institutions target the gap in duration of their assets and liabilities. A rise in interest rates shortens duration, and this forces them to take a position in longer-term assets to return to their duration target. These examples are sufficient to show that price changes will tend to be accompanied by corresponding transactions in the underlying assets and/or derivatives contracts.

[2] Delta measures the change in an option's price relative to the change in the price of the underlying.

Speculative transactions

Type of information has an impact on speculative trading

Speculative or "information-based" transactions also create a link between volatility and activity in asset and derivatives markets. This link depends in part on whether the new information is private or public and on the type of asset traded. In theory, the arrival of new private information should be reflected in a rise in both the volatility of returns and trading volumes in single equity and equity-related futures and options. The price of individual stocks tends to be influenced by firm-specific rather than economy-wide information. Such firm-specific information is often private in nature (perhaps arising from stock research or investors' "hunches" about a firm's prospects) and is conveyed to the market through trading. The incorporation of new private information will therefore tend to generate a relationship between price volatility and trading. Indeed, this is one of the main links found by empirical studies of activity in stock markets at a daily or intraday level.

Trading with public information

Impact of public information on our two derivatives contracts

In the case of the contracts we look at – namely on 10-year US Treasury notes and the S&P 500 stock index – price movements in the underlying asset would tend to be driven by information on the economy, which is by and large public in nature. Such public information comes primarily in the form of regular macroeconomic data releases, which become available to the market as a whole at scheduled release times. Significant US releases include non-farm payrolls, the producer price index and the consumer price index. Each of these numbers is released once a month and tends to be associated with both unusual volatility and unusual trading volume in government bonds and related derivatives markets during the day of the announcement.

Macro announcements generate unusually high volatility and trading

The arrival of public information tends to be associated with a degree of disagreement over what the information precisely means, leading to a rise in trading and thus an association between volatility and turnover. Fleming and Remolona (1999) show with intraday data that the arrival of public information in the US Treasury market sets off a two-stage adjustment process for prices and trading volumes. In a brief first stage, the release of major macroeconomic announcements induces a sharp and nearly instantaneous price change with a reduction in trading volume. In a prolonged second stage, price volatility persists and trading volume surges as investors trade, seemingly to reconcile residual differences in their views. Hence at the daily level, new market-wide information will be associated with price volatility and an increase in activity arising from disagreement over the new information.

Day-to-day versus month-to-month effects

The above discussion of the links between volatility and trading suggests that the uncovering of a relationship may depend on the time frame used for analysis. Daily data will tend to show a positive link since trading volumes will tend to be substantially higher on announcement days than on days for which no announcements are released.[3] Monthly data will probably show less of a relationship because the main macroeconomic announcements tend to be repeated every month. Their impact is also likely to dissipate fairly quickly. However, if announcement surprises happen to be bigger in one month than in another, then market prices and activity may fluctuate more strongly and for longer periods, creating a relationship that is observable at monthly levels. Moreover, such a relationship is more likely to be induced by surprising events that do not take place according to regular monthly schedules. These events may include important political developments or significant market disruption.

Link may depend on time frame for analysis

The remainder of this article will look at two main issues. First, we will look at whether the positive relationship found in earlier studies between volatility and daily activity is also present using month-to-month data. Second, we will look at whether there are differences in the behaviour of the two contracts we selected, both for futures and options and for turnover and open interest.

Empirical approach and key market variables

We use regression analysis to quantify the relationship between volatility and activity in exchange-traded derivatives contracts (see the box on page 62). The focus of our analysis is on volatility but we also attempt to account for the particular characteristics of our data sets, such as seasonal patterns. We use two concepts of market volatility and two standard measures of activity in exchange-traded markets.

Regression analysis is used ...

Two concepts of market volatility

We look at two rather distinct types of volatility commonly used by market participants: actual and implied volatility. Actual volatility is generally measured by the annualised standard deviation of changes in asset prices. It often presents a time-varying pattern, which has prompted the development of models, such as GARCH-type estimators (Engel (1982)), accounting for this pattern. In contrast, implied volatility is based on options prices, which incorporate a premium reflecting the time-varying nature of risk aversion.[4] As shown in Graph 1, the two series can show sizeable short-term deviations.

... on actual and implied volatility ...

Two measures of market activity

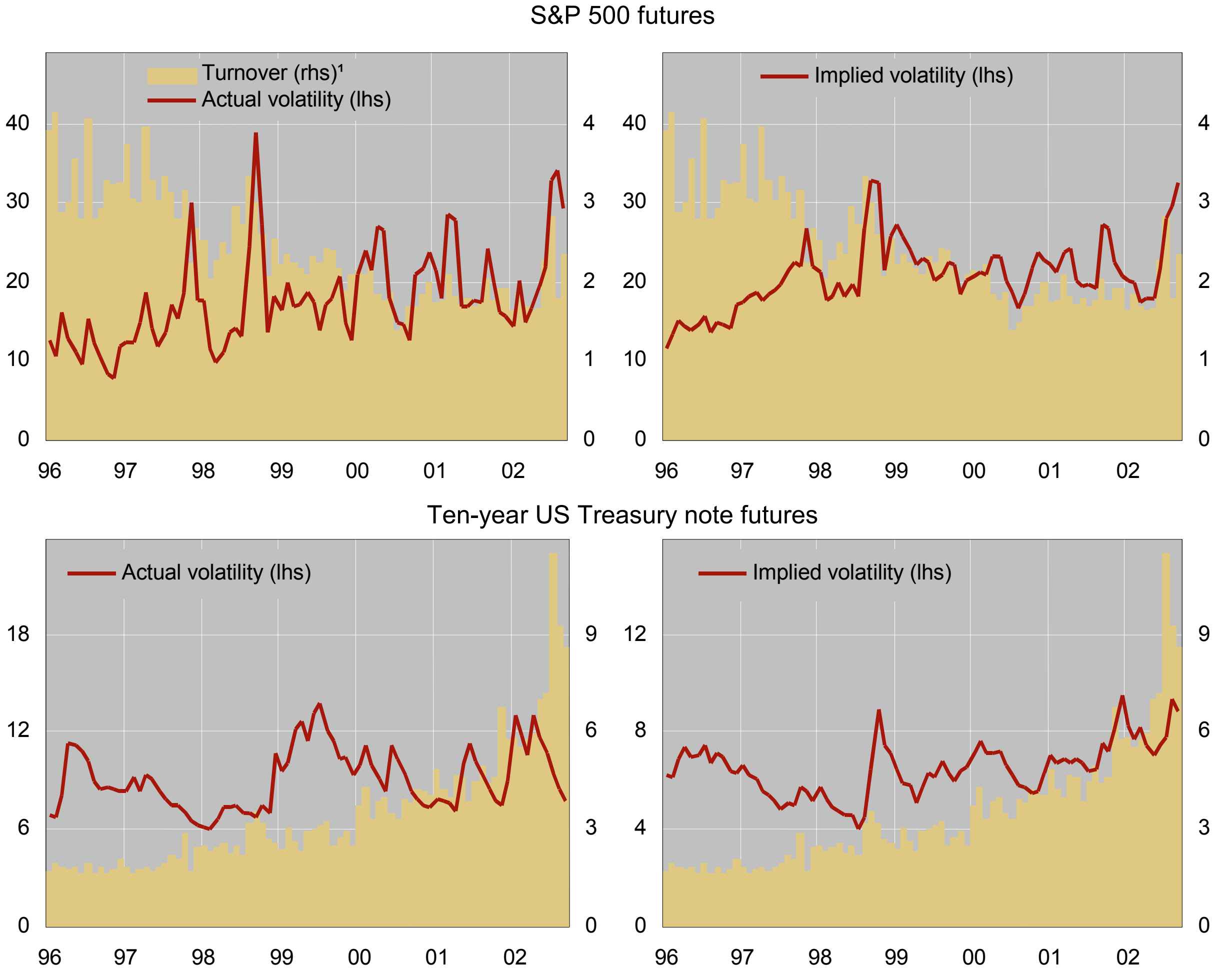
There are two main measures of activity on derivatives exchanges. *Turnover (or volume)* refers to the number of purchases/sales in the various contracts listed on an exchange during a given period of time. Since the exchange automatically matches a purchase with a corresponding sale, turnover gives an

[3] Very high frequency data, such as intraday series, would be useful in determining whether volatility emanates from trading itself since at high frequencies, the pressure and turbulences induced by trading are likely to be an important, if not the main source of volatility.

[4] Traders generally calculate implied volatility in an iterative fashion through the use of an option pricing model along with the prices of actively traded options.

Turnover and volatility

In millions of contracts and percentages



[1] The series on turnover were seasonally adjusted for contract expiry effects and structural breaks.

Sources: Bloomberg; FOW TRADEdata; Futures Industry Association; national data; BIS calculations. Graph 1

... and turnover and open interest in derivatives

account of the total number of purchases or sales in the specified period. The basic unit of time on exchanges is the trading day, with the information on activity usually being reported in number of contracts traded. Turnover is a flow concept, which is generally used by market participants as an indicator of liquidity in a particular contract or as a measure of an exchange's success in attracting trading business.

Open interest refers to the total number of contracts that have not yet been offset by an opposite transaction or fulfilled by delivery of the asset underlying a contract. Although each transaction has both a buyer and a seller, only one side of the transaction is included in open interest statistics. Open interest is a stock concept reflecting the net outcome of transactions on a given date. It is often interpreted as an indicator of the hedging or "long-term" commitment of traders to a particular contract. Open interest is generally smaller than turnover because a large number of contracts that are bought or sold during the course of the day are reversed before the end of the trading session.

Empirical methodology and estimation results

We use regression analysis to quantify the relationship between market volatility and activity in exchange-traded derivatives. The regressions allow us to control for other factors such as a time trend and the effect of lagged volumes.

Dependent variables

We use as dependent variables two standard measures of activity in derivatives markets, namely turnover and open interest. Turnover is the total number of contracts traded in each month, while open interest is the number of contracts outstanding at the end of each month. We look at futures and options on the S&P 500 index and US 10-year Treasury notes. The series for the S&P 500 contracts are adjusted by incorporating activity in the S&P 500 E-mini contracts, retail-targeted instruments that have expanded rapidly since their launch in September 1997. They are also adjusted for the impact on turnover of the reduction in the contract's size in November 1997. The data on turnover and open interest are collected by the BIS from commercial databases (Futures Industry Association and FOW TRADEdata) and published on a quarterly basis in the *BIS Quarterly Review*. The sample period runs from January 1995 to September 2002.

The series were seasonally adjusted for contract expiry effects. Volume and open interest also follow a predictable pattern over the life cycle of a contract. Activity is minimal when the contract is far from its maturity date. It then rises gradually as maturity approaches, reaches a plateau two to three months before expiration and falls sharply as traders close out or roll over their positions to the next contract to avoid delivery. Delivery poses a number of practical problems to market participants and, for this reason, they prefer to avoid it by taking offsetting positions in the contracts to which they are exposed. This means that there is often a peak of turnover and open interest in the months when contracts come to the end of their maturity cycle, namely March, June, September and December.

Explanatory variables and estimation methodology

Our main explanatory variables are actual and implied volatility. For actual volatility, we use a GARCH specification initially developed by Glosten et al (1993).[①] Such a measure allows for the asymmetric impact on volatility of price increases and decreases. The underlying data used for the calculation of actual volatility are the returns on 10-year US Treasury notes and the S&P 500 index. For implied volatility, we use the price of at-the-money exchange-traded options.

Given that price volatility and exchange-traded volumes are jointly determined, we adopt an approach enabling us to deal with the problems created by endogeneity. Specifically, we use an instrumental variable approach and estimate a single equation of volume against implied volatility by two-stage least squares. In the case of actual volatility, we use price volatility predicted by our asymmetric GARCH model and estimate the equation by ordinary least squares.[②] In the case of implied volatility, we use the first lag of volatility as an instrument for the contemporaneous value of volatility. This should be a good approximation since there is evidence of persistence in volatility. The following equation, which relates price volatility and volume in a dynamic specification, is estimated:

$$Volume_t = \beta_0 + \beta_1 Volume_{t-1} + \beta_2 TREND_t + \beta_3 Volatility_t + \varepsilon_t$$

where:

- *Volume* is our measure of market activity (turnover and open interest).
- *TREND* is an exponential time trend to account for structural growth factors, such as financial innovation.
- *Volatility* is our measure of price volatility (predicted by GARCH in the case of actual and lagged in the case of implied).

Here β_i are the parameters to be estimated and ε_t are randomly distributed errors.

____

[①] Borio and McCauley (1996) discuss measures of volatility that account for this asymmetric response. [②] Such a specification is used because the GARCH measure of volatility is conditional on its past values.

Basic estimates

As shown by the table below, we find no statistically significant relationship between either of our two concepts of volatility and monthly activity in 10-year US Treasury note futures and options contracts. However, our results also show a negative relationship between volatility and turnover in S&P 500 futures and options. Our interpretation of those results is provided in the body of the text.

Volatility and activity in exchange-traded contracts

	Actual volatility[1]	Implied volatility[2]
Turnover		
Ten-year US Treasury note contracts		
Futures	–6.45 (43.28)	–103.49 (118.40)
Options	–24.24 (15.34)	–109.73 (52.49)*
S&P 500 contracts		
Futures	–53.29 (14.55)**	–41.10 (11.74)**
Options	–10.39 (4.35)**	–14.97 (3.69)**
Open interest		
Ten-year US Treasury note contracts		
Futures	1.13 (2.88)	2.05 (6.42)
Options	–5.18 (5.25)	–23.54 (14.98)
S&P 500 contracts		
Futures	–0.68 (1.08)	–0.01 (0.54)
Options	–2.00 (1.50)	–5.93 (1.38)**

Note: Standard errors in parentheses; * and ** denote significance at the 5% and 1% levels.

[1] Based on a GARCH specification developed by Glosten et al (1993). [2] Implied volatility of at-the-money options.

Estimation results: the impact of volatility

Our results show a tenuous link

Our estimation results are generally at odds with the results found by earlier empirical studies using daily data.[5] We generally find a tenuous relationship between volatility and monthly activity in our selected contracts. More specifically, there is no statistically significant relationship between either of our two concepts of volatility and monthly activity in 10-year US Treasury note futures and options contracts. However, our results also show a negative relationship between volatility and turnover in S&P 500 stock index futures and options.

Lack of relationship for Treasury note contracts

The lack of relationship for 10-year Treasury note contracts suggests that higher volatility in financial markets creates offsetting effects between speculative trading and hedging-related transactions. In fact, high monthly levels of volatility could lead to a sufficiently large retrenchment by information-based traders to offset the mechanical increase in hedging-related transactions. Such a reduction in activity could result from a desire by

[5] Early studies have found a significant autocorrelation of futures turnover at daily and intraday frequencies. Our empirical results confirm such persistence for monthly frequencies, with an important first-order autocorrelation of our measures of activity. This is a fairly frequent result in financial markets, as volatility and activity tend to cluster.

speculators to reduce their exposures during times when market developments are difficult to ascertain or when market liquidity dries up.

Negative link for S&P 500 contracts

In the case of the S&P 500 index contracts, the consistently negative relationship between volatility and turnover could imply that the reduction in speculative transactions is stronger than any possible increase resulting from mechanically determined transactions. It might also reflect the fact that variations in volatility tend to be more pronounced for S&P 500 contracts than for 10-year Treasury note contracts. Given this higher risk exposure in stock index contracts, market participants may react more strongly to significant market events. Such events appear to drive much of the negative and significant relationship found between volatility and activity in S&P 500 stock index contracts.

Market stress associated with weaker activity

Indeed, an analysis of the sharpest contractions in the turnover of S&P futures shows that they are associated with recent episodes of market stress. These episodes include the 1997 Asian crisis, the Russian debt default of 1998, the 2001 terrorist attacks in the United States and the restatement of WorldCom's accounts in 2002. In most cases, higher volatility is initially accompanied by an increase in the monthly turnover of futures contracts but it is also followed by an even more significant contraction.

In the case of the Asian crisis of June to December 1997, implied volatility of the S&P 500 index increased steadily from 19.7% in July to 26.9% in November, whereas seasonally adjusted futures turnover declined from a peak of 3.3 million contracts in July to 2.2 million in November. In the case of the Russian crisis, implied volatility jumped from 18.2% in July 1998 to 26.8% in August and remained high until October 1998, when it reached a level of 32.5%. However, after an initial surge in turnover in August 1998 to 3.3 million contracts, activity declined to 2.6 million in October. The terrorist attacks of September 2001 for their part led to an increase in volatility to about 27% for September and October but turnover only showed a significant increase in September, to 2.1 million contracts. Finally, the restatement of WorldCom's accounts in late June 2002 resulted in a prolonged period of high volatility in equity markets. However, turnover only rose for two months, June and July 2002, and then declined thereafter.

Consistently negative link for options

Another notable result is that there is a more consistently negative relationship between volatility and activity in options contracts. Given that exchange-traded options tend to be less actively traded than corresponding futures, higher volatility could affect their liquidity to a greater extent than that of futures and thus amplify any retrenchment by information-based traders.

Little difference between actual and implied volatility

Lastly, there is little difference in the impact of actual and implied volatility. This is somewhat surprising since they measure different things. Actual volatility is a measure of the past dispersion of returns, while implied volatility incorporates the market price of risk. This suggests that the risk premium is not an important factor in the volatility-turnover relationship, at least at the monthly level.

Conclusions

Previous empirical work has tended to find a positive relationship between the volatility of asset returns and the volume of transactions in exchange-traded derivatives markets. However, those studies have usually drawn on analyses that apply mainly to daily or intraday data. Very few studies have considered the existence of a possible relationship between volatility and volume from one month to the next. In this article, we examined the relationship between volatility and monthly activity in 10-year US Treasury note and S&P 500 futures and options contracts.

Our estimation results show a tenuous relationship between volatility and monthly activity in our selected contracts. More specifically, there is no statistically significant link between either of our two concepts of volatility and monthly activity in 10-year US Treasury note futures and options contracts. However, they also show a negative relationship between volatility and turnover in S&P 500 stock index futures and options. These results could be explained by the fact that mechanically determined hedging transactions are offset by a retrenchment of speculative trading in periods of heightened market turbulence and reduced liquidity. Moreover, in the case of the S&P 500 index contracts, significant market events seem to be associated with a major reduction in activity. This probably drives the negative relation between volatility and monthly volumes. Lastly, our two concepts of volatility, actual and implied, do not have a markedly different impact on market activity, which is also somewhat surprising given their different nature.

References

Borio, C E V and R N McCauley (1996): "The economics of recent bond yield volatility", *BIS Economic Papers*, no 45.

Cornell, B (1981): "The relationship between volume and price variability in futures markets", *Journal of Futures Markets*, vol 1, no 3, pp 303–16.

Engle, R (1982): "Autoregressive conditional heteroskedasticity with estimates of the variance of United Kingdom inflation", *Econometrica*, vol 50, pp 987–1007.

Fleming, M J and E M Remolona (1999): "Price formation and liquidity in the US Treasury market: the response to public information", *Journal of Finance*, vol LIV, no 5, pp 1901–3.

Glosten, L R, R Jagannathan and D E Runkle (1993): "On the relation between the expected value of the volatility and of the nominal excess return on stocks", *Journal of Finance*, vol 48, pp 1779–1801.

Karpoff, J M (1987): "The relationship between price changes and trading volume: a survey", *Journal of Financial and Quantitative Economics*, vol 22, no 1, pp 109–26.

Martell, T F and A S Wolf (1987): "Determinants of trading volume in futures markets", *Journal of Futures Markets*, vol 7, no 3, pp 233–44.