by G. William Schwert

Stock Market Volatility

Investors, regulators, brokers, dealers and the press have all expressed concern over the level of stock market volatility. But the perception that prices move a lot—and have been moving a lot more in recent years—is in part merely a reflection of the historically high levels of popular stock indexes. The drop in stock prices on October 13, 1989—while large in terms of point decline—was not even among the 25 worst days in NYSE history in terms of percentage changes. While a 6 per cent drop in prices is not inconsequential, neither is it a rare event when considered within the context of the behavior of stock returns over the 1802–1989 period.

Apart from October 1987 and October 1989, volatility was not particularly high in the 1980s. Moreover, the growth in stock index futures and options trading has not been associated with an upward trend in stock volatility. There is little evidence that computerized trading per se *increases volatility, except perhaps within the trading day.*

On October 13, 1989, all the major networks flashed reports on the market decline. The ability of investors and the press to track stock prices on a virtually continuous basis has heightened public perceptions of a volatility problem. What we do not know, because the intraday data on stock prices are simply unavailable, is whether the large but extremely brief price drops that have characterized recent market declines also occurred in the past, when daily and monthly volatility was higher than it is today.

The evidence so far is inconclusive as to whether trading halts or circuit-breakers can reduce volatility in a beneficial way. Even if circuit breakers can reduce volatility, are the benefits of stability greater than the cost of the inefficiency created by the trading halt?

THE STOCK MARKET CRASH of October 19, 1987, and the drop in stock prices that occurred on October 13, 1989, left many people wondering whether stock prices haven't become too volatile. Since the 1987 crash, numerous studies have looked at the effects of program trading, index arbitrage and other modern investment techniques on the volatility of stock prices. The Brady Commission, the stock and futures exchanges, securities industry regulatory bodies and Congress have all proposed various means of limiting volatility through trading halts, increases in margin requirements and limits on automated trading systems. In short, there has been a large demand for remedies to fix a perceived problem.[1]

This article surveys the academic evidence on stock market volatility in an attempt to put the current policy debates in perspective. The evidence so far indicates that the volatility of rates of return to broad portfolios of New York Stock Exchange common stocks has not been unusually high in the 1980s, except during very brief periods such as October 1987. Volatility has

G. William Schwert is Gleason Professor of Finance and Statistics at the William E. Simon Graduate School of Business Administration of the University of Rochester and a Research Associate of the National Bureau of Economic Research.

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1. Footnotes appear at end of article.

seemed high to many people because the level of stock prices is much higher than it has ever been. Thus, while we have experienced large *absolute* changes in the level of the Dow Jones Industrial Average, these changes in percentage terms are only moderate.

There is little evidence that the level of stock return volatility has increased since the start of index futures and options trading in the early 1980s. Although high volatility has been associated with high levels of trading in stocks, futures and options, it is unclear whether the large volume of trading *causes* high volatility, or whether the high volatility and trading volume both reflect the arrival of important information.

The remarkable technological advances in the computer and communication industries have made it much easier for large numbers of people to learn about and react to information very quickly. They have also made it possible for financial markets to provide liquidity for investors around the world. These changes have had two by-products. First, there are large incentives for investors to get and act on new information. Second, because new information spreads more quickly, the rate at which prices change in response to information has also accelerated. The liquidity of organized securities markets plays an important part in supporting the value of traded securities, but it also means that prices can change quickly. From this perspective, volatility is a symptom of a highly liquid securities market.

What Is Volatility?

On October 19, 1987, the Dow Jones Industrial Average (DJIA) fell from 2246.7 to 1738.4, over 508 points. This was the largest one-day drop since Dow Jones began computing index numbers in 1885. It was also the largest percentage drop—about 22.5 per cent. Nevertheless, most public attention focused on the absolute size of the drop. The 190-point drop on October 13, 1989 also caused a large public reaction, although it represented only a 6.9 per cent drop in value. (The broader-based Standard & Poor's 500 dropped 6.1 per cent on October 13, 1989.)

Finance academicians widely agree that volatility should be measured in *percentage* changes in prices, or *rates of return*.[2] If you invest $1,000 in a portfolio of common stocks, its rate of return tells you the proportional change in the value of your investment over the period. A 10 per cent rate of return would mean an increase in value of $100, whether the DJIA was at 100, 1000 or 2500.

By focusing on the absolute level of the DJIA, the press and the public exaggerate the severity of recent volatility. For example, the DJIA reached 509.76 for the first time on March 19, 1956; prior to that date, it would have been impossible for the index to drop 508 points. Alternatively, the DJIA fell by "only" 38 and 31 points on October 28 and 29, 1929, yet these are the second and third largest daily percentage drops in the history of the New York Stock Exchange to date.

I have suggested (in jest) that the volatility problem could be solved if Dow Jones (the publisher of the *Wall Street Journal*) would simply do what the Bureau of Labor Statistics does periodically with the Consumer Price Index—rescale the index, setting its value during some recent period at 100. Absolute changes in the price index would then approximate percentage changes, and the press and the public would not be fooled when the index drops from a level that is higher than it has been in the past. Given the reaction to the decline on October 13, 1989—which is not even among the 25 largest percentage drops in stock prices, although it is the second largest absolute drop in the DJIA—perhaps my suggestion should be taken more seriously.

Table I gives the 25 highest and lowest daily returns to broad stock market indexes such as the Standard & Poor's 500 between February 1885 and October 1989.[3] As noted, October 19, 1987 was the largest one-day percentage change in stock prices (−20.4 per cent) out of more than 29,000 observations.[4] The next-largest change in stock prices occurred on March 15, 1933, when stock prices *rose* 16.6 per cent following the Federal banking holiday. Several patterns emerge from this list. First, there are many reversals, large drops in stock prices being followed by large increases. The 1929 stock market crash, for example, represents the second and third largest drops in stock prices— −12.3 and −10.2 per cent, on October 28 and 29. The market rebounded on October 30, however, with the second largest one-day gain in the sample—12.5 per cent. An increase in stock market volatility brings an increased chance of large stock price changes of *either* sign. Most of the market's highest returns occurred during the Great Depression, from 1929 to 1939. This is

Table I The 25 Highest and Lowest Daily Percentage Returns to Market Portfolios, 1885–1989*

	Lowest		*Highest*	
1	October 19, 1987	−20.39	March 15, 1933	16.61
2	October 28, 1929	−12.34	October 30, 1929	12.53
3	October 29, 1929	−10.16	October 6, 1931	12.36
4	November 6, 1929	−9.92	September 21, 1932	11.81
5	October 18, 1937	−9.27	September 5, 1939	9.63
6	July 20, 1933	−8.88	April 20, 1933	9.52
7	July 21, 1933	−8.70	October 21, 1987	9.10
8	December 20, 1895	−8.52	November 14, 1929	8.95
9	October 26, 1987	−8.28	August 3, 1932	8.86
10	October 5, 1932	−8.20	October 8, 1931	8.59
11	August 12, 1932	−8.02	February 13, 1932	8.37
12	May 31, 1932	−7.84	December 18, 1931	8.29
13	July 26, 1934	−7.83	February 11, 1932	8.27
14	March 14, 1907	−7.59	July 24, 1933	8.14
15	May 14, 1940	−7.47	June 10, 1932	7.66
16	July 26, 1893	−7.39	June 3, 1931	7.54
17	September 24, 1931	−7.29	November 10, 1932	7.51
18	September 12, 1932	−7.18	October 20, 1937	7.48
19	May 9, 1901	−7.02	June 19, 1933	7.23
20	June 15, 1933	−6.97	May 6, 1932	7.22
21	October 16, 1933	−6.78	April 19, 1933	7.21
22	January 8, 1988	−6.76	August 15, 1932	7.20
23	September 3, 1946	−6.73	October 11, 1932	7.17
24	May 28, 1962	−6.68	January 6, 1932	7.02
25	May 21, 1940	−6.64	October 14, 1932	6.90

* Based on the Dow Jones industrial and railroad indexes from 1885 to 1927, the Standard & Poor's composite from 1928 to 1962 and 1988 to 1989, and the CRSP value-weighted index of New York Stock Exchange and American Stock Exchange stocks from 1962 to 1987, all including dividends.

a simple way to show there were high levels of stock market volatility.

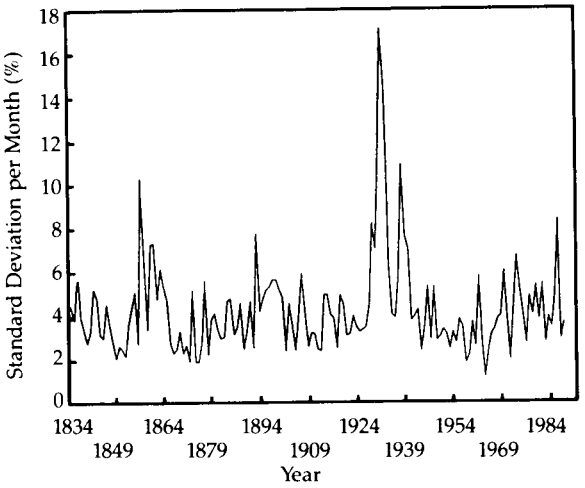
Table II gives the 25 highest and lowest monthly returns from February 1802 through October 1989. As with the daily returns in Table I, many of these extreme monthly returns oc-

Table II The 25 Highest and Lowest Monthly Percentage Returns, 1802–1989*

	Lowest		*Highest*	
1	September 1931	−28.79	April 1933	37.68
2	October 1857	−24.37	August 1932	36.19
3	March 1938	−23.46	July 1932	32.68
4	May 1940	−22.02	June 1938	23.49
5	October 1987	−21.64	May 1933	21.10
6	May 1861	−20.29	March 1858	17.59
7	May 1932	−20.21	December 1857	17.24
8	October 1929	−19.56	October 1974	16.80
9	April 1932	−17.87	September 1939	15.95
10	July 1893	−17.81	January 1863	15.72
11	June 1930	−15.66	October 1862	15.43
12	September 1857	−14.31	April 1938	14.36
13	October 1907	−14.00	July 1837	14.10
14	January 1842	−13.84	May 1898	13.88
15	September 1937	−13.45	June 1931	13.75
16	December 1931	−13.34	May 1843	13.64
17	May 1931	−13.27	April 1834	13.53
18	February 1933	−13.19	January 1975	13.48
19	December 1860	−13.08	August 1891	13.40
20	October 1932	−12.89	June 1933	13.38
21	September 1930	−12.32	January 1934	12.96
22	November 1929	−12.04	January 1987	12.82
23	March 1939	−11.86	December 1873	12.81
24	July 1914	−11.70	October 1879	12.79
25	November 1855	−11.64	October 1885	12.60

* Based on the index of monthly New York Stock Exchange stock returns for 1802–1987, and on the Standard & Poor's composite for 1988–89, including dividends.

Figure A Volatility of Monthly Returns to a Market Index, Based on Monthly Returns within the Year



curred during the Great Depression. October 1987 is only the fifth lowest return in the 1802–1989 sample. The return for the month is similar to the return on October 19, implying that the large positive and negative returns for the rest of the month net to zero. The return for October 1989 was −2.5 per cent, far smaller than the extreme values in Table II. The high and low returns tend to be clustered in brief subperiods over the 1802–1989 period, indicating an increase in stock volatility during these periods.

Standard Deviations of Return

The most commonly used measure of stock return volatility is standard deviation. This statistic measures the dispersion of returns.[5] Financial economists find the standard deviation to be useful because it summarizes the probability of seeing extreme values of return. When the standard deviation is large, the chance of a large positive or negative return is large.

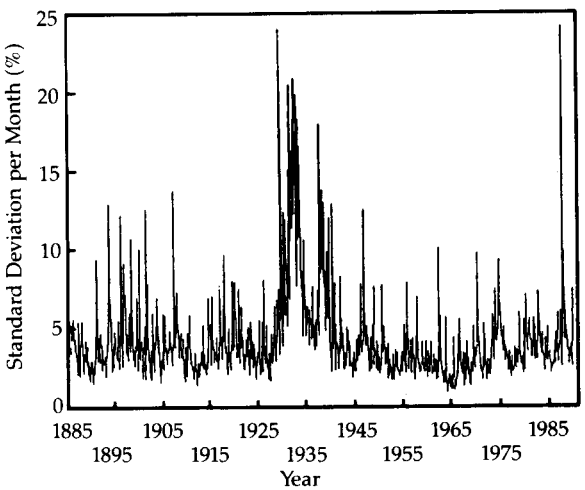
Figure A plots the standard deviations of monthly returns to an index of New York Stock Exchange-listed stocks from 1834 to 1989. Each year, the 12 monthly returns are used to calculate the standard deviation, so there is one point per year in the plot. This plot shows that stock return standard deviations are about 4 per cent per month. This means that most monthly returns were between 8 and −8 per cent per month.[6] During the Great Depression, the standard deviation was around 10 per cent per month, so most monthly returns were between 20 and −20 per cent per month.

Comparing Figure A with the extreme monthly returns in Table II, we can see that years with extreme returns also had high standard deviations. It is also clear from this perspective that the 1980s, except for 1987, have not been a period of unusually high volatility.

Figure B plots the standard deviations of monthly returns to an index of New York Stock Exchange-listed stocks from 1885 to 1989. Here, daily returns are used to calculate the standard deviation for each month. Because returns are not highly correlated over time, the standard deviation of monthly returns is about equal to the standard deviation of daily returns times the square root of the number of trading days in the month. This transformation was used to create the plot in Figure B.

There are over 1,200 standard deviation estimates in Figure B, each based on about 21 trading days per month. In contrast, Figure A contains about 150 standard deviation estimates, each based on 12 months per year. Figure B thus contains much more information about volatility. Months like October 1929 and October 1987 also show up more clearly in Figure B, because their intramonth volatilities are not diluted by the monthly volatilities of the rest of the year. Otherwise, the results in Fig-

Figure B Volatility of Monthly Returns to a Market Index, Based on Daily Returns within the Month, February 1885–October 1989



ures A and B reinforce each other. The typical level of the monthly standard deviation is about 4 per cent. Except for the last three months of 1987, the 1980s do not stand out as being a period of unusually high volatility. October 1989 has a lower standard deviation than the 1973–74 bear market, for example.

These long historical series of standard deviations help put recent events in perspective by showing that the general level of stock return volatility has not risen recently. Nevertheless, the very high volatilities of October 1987 and, to a lesser extent, October 1989 have focused attention on volatility in the last decade. The rapid growth of trading in financial futures and options contracts since 1982, and the belief that computerized trading systems have somehow destabilized the market for common stocks, have undoubtedly exacerbated investors' concerns.

Figure C plots the standard deviations of monthly returns to the S&P 500 and to the futures contract on the S&P 500 from 1982 to 1989. (The procedure used was the same as for Figure B.) Figure C shows that the level of stock volatility has not increased during the 1980s, but it highlights the dramatic increase in volatility in the last three months of 1987. It also shows that the standard deviation of futures returns is usually higher than that of stock returns, most noticeably in October 1987 and October 1989.

Figure C Volatility of Monthly Standard & Poor's Stock Returns and S&P Futures Returns, Based on Daily Returns within the Month, January 1982–October 1989

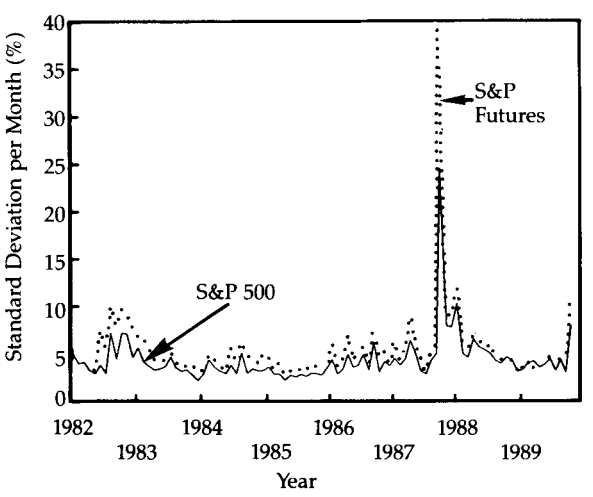
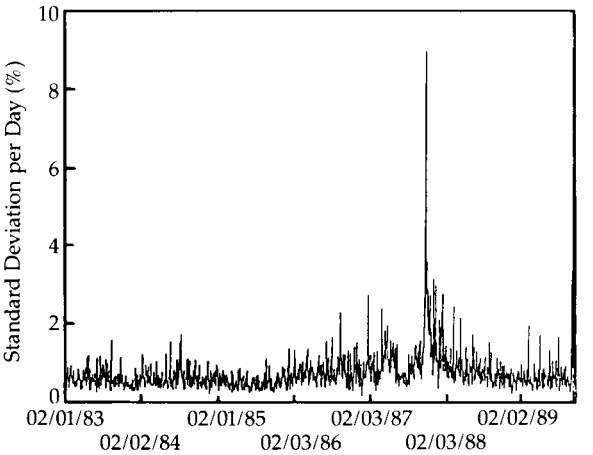


Figure D Volatility of Daily Returns to Standard & Poor's 500, Based on 15-Minute Returns within the Day, February 1, 1983–October 19, 1989

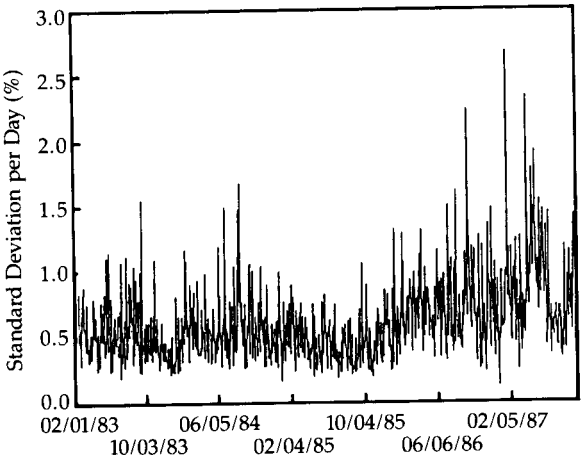


There are two common interpretations of this result. One is that "noise traders" are more active in the futures markets, so temporary price swings are exaggerated. (The term "noise traders" refers to people who do not have correct information about the value of the securities they trade.[7]) The alternative is that futures contract prices react more quickly to new information because the contracts have lower transaction costs and because they price the bundle of underlying stocks simultaneously.[8] We will return to the question of the relation between futures and options trading and stock volatility later.

Volatility of Intraday Returns

For recent years, it is possible to measure volatility using prices measured within the day. Figure D plots the standard deviations of daily returns to the S&P 500 from 1983 to 1989, based on returns measured every 15 minutes within the day. Each daily standard deviation is thus based on 27 intraday returns. (To measure the daily standard deviation, I multiplied the 15-minute standard deviation by the square root of 27, a similar procedure to the one used in Figures B and C.) The typical level of the daily standard deviation is about 0.75 per cent (which corresponds to about 3.5 per cent per month, if there are 21 trading days per month). The period from October 19 through the end of 1987

Figure E Volatility of Daily Returns to S&P 500, Based on 15-Minute Returns within the Day, February 1, 1983–September 30, 1987



and October 13, 1989 stand out.

Figure E plots daily standard deviations based on 15-minute returns within the day from February 1983 to September 1987. Prices were volatile during some individual days, but the daily standard deviations were below 1 per cent for most of this period. Figure F plots daily standard deviations based on 15-minute S&P 500 and futures returns within the day from October 1, 1987 to December 31, 1987. For the two weeks following October 19, 1987, the standard deviations of futures returns were higher than those for S&P 500 returns. By early November, however, the volatilities of both futures and index returns had returned to low levels.

Figure G plots daily standard deviations based on 15-minute S&P 500 and futures returns within the day from January 1988 to October 1989. Futures and index returns had similar standard deviations throughout this period, except on October 13, 1989, when futures volatility was well above the S&P 500 volatility. Thus October 13, 1989 was similar in several ways to the crash of October 19, 1987: Volatility rose for a brief period, and it was larger in the futures market than in the stock market. Of course, the size of the volatility shock was much smaller.

What do all these plots of standard deviations tell us? They show that volatility as measured using the standard deviation of rates of return has been stable since the mid-19th century in the United States. The major exception was the Great Depression period from 1929 to 1939. The plots also show that the high levels of volatility following Black Monday (October 19, 1987) were short-lived; the burst of volatility on Friday the 13th (October 13, 1989) was even more temporary. These conclusions are the same whether volatility is measured from monthly returns, daily returns or 15-minute returns. Finally, the evidence indicates that futures returns are more volatile than stock index returns when there are big price movements.

Explanations for Long-Term Volatility

Several economic factors may lie behind slow changes in stock market volatility—that is, changes that become noticeable over many months or years. These factors include financial leverage, operating leverage, personal leverage and the condition of the economy.

Corporate Leverage

Financial and operating leverage affect the volatility of the returns to common stocks. Consider the simple example of an all-equity firm. The standard deviation of its stock returns simply equals the standard deviation of the returns to its assets. Now, suppose that the firm issues debt to buy back half its stock. The volatility of its stock returns will increase, because the stockholders still have to bear most of the risk of the assets, but the value of their investment is only

Figure F Volatility of Daily Returns to S&P 500 and S&P Futures Contract, Based on 15-Minute Returns within the Day, October 1, 1987–December 31, 1987

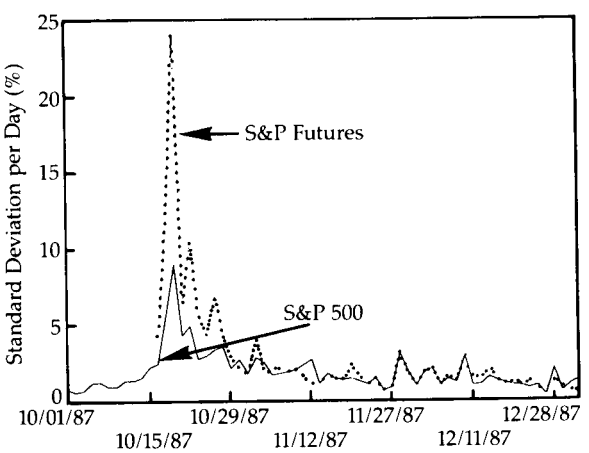
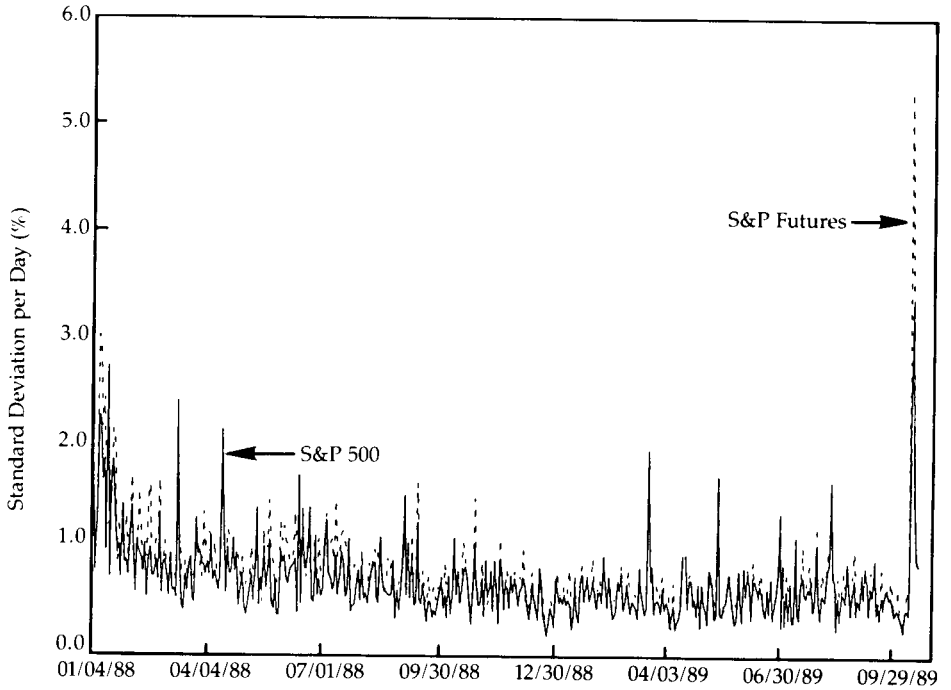


Figure G Volatility of Daily Returns to S&P 500 and S&P Futures Contract, Based on 15-Minute Returns within the Day, January 4, 1988–October 19, 1989



half as large. Thus, by increasing financial leverage, the firm has increased the volatility of its stock returns.

A similar case can be made for a firm that has large fixed costs. Large amounts of operating leverage will make the value of the firm more sensitive to economic conditions. If demand falls off unexpectedly, the profits of a firm with large fixed costs will fall more than the profits of a firm that avoids large capital investments or long-term supply contracts. Firms with large fixed costs will thus have higher stock return volatility.

In a previous paper, I have shown that aggregate financial leverage is correlated with stock return volatility, as financial leverage theory predicts. Moreover, I demonstrated that stock return volatility is higher during economic recessions than during expansions, just as operating leverage theory predicts.[9] Further evidence indicates that stock return volatility increases after a large drop in stock prices.[10] Because a drop in stock prices relative to bond prices increases financial leverage, this evidence also supports the theory that leverage affects stock volatility. Nevertheless, the effects of leverage do not explain much of the variation in volatility for broad market portfolios such as those depicted in Figures A through F. Aggregate leverage has not changed that much over time, and it does not change quickly.

Personal Leverage

Following the stock market crash in 1929, Congress and the public became concerned that personal debt used to finance purchases of common stock had caused or exacerbated the magnitude of the crash. The 1934 Securities and Exchange Act gave the Federal Reserve Board the responsibility to set minimum levels of margin for purchasing common stock. The Fed has not changed its minimum initial margin requirements since 1974. Nevertheless, much recent debate has focused on the effects of margin requirements on the volatility of aggregate stock prices. Gikas Hardouvelis, for example, has written several papers claiming that the Fed could have stifled volatility by raising margin requirements during the 1934–74 period.[11]

Other research, however, shows at best only a weak relation between margin regulations and stock return volatility.[12] Furthermore, the rela-

tional patterns that are evident show that the Fed raised margin limits after stock prices rose and lowered them after prices fell. Because volatility is lower after prices rise and higher after they fall (even before the initiation of margin regulations in 1934) the relationship is spurious.[13] In fact, my evidence indicates that volatility fell *before* the Fed raised margins and rose *before* it lowered them. The data thus suggest that the Fed was reacting to volatility (and the level of stock prices), rather than controlling volatility with margin regulations. The very absence of changes in margin limits in the last 15 years moreover suggests that the Fed itself may not believe that margin regulations have an important effect on volatility.

Business Conditions

There is strong evidence that stock volatility increases during economic recessions. A simple examination of Figures A and B shows that the Great Depression was a period of extremely high volatility. In recent years, the 1973–74 OPEC recession was a period of falling stock prices and high volatility. This relationship may in part reflect operating leverage, as recessions are typically associated with excess capacity and unemployment. Fixed costs for the economy would have the effect of increasing the volatility of stock returns during periods of low demand. Of course, periods of severe recession are usually associated with many other economic problems, so policy-makers and the press do not devote much attention to stock volatility.

Explanations for Short-Term Volatility

The recent interest in stock volatility has been spurred by several sharp drops in stock prices during the last few years. The crashes of October 1987 and, to a much lesser extent, October 1989 are prominent examples. These bursts of volatility are hard to relate to longer-term phenomena such as recessions or leverage. Instead, most people have tried to relate them to the structure of securities trading.

Trading Volume

There is much evidence that increased trading activity and stock return volatility occur together.[14] It is difficult, however, to determine what causes this association. Some observers conclude that trading volume directly causes volatility, but it is only when all traders want to buy (or sell) that prices change rapidly. Otherwise, large trading volume shows a very efficient market bringing together buyers and sellers in a centralized location (with potentially very little role for inventory managers such as specialists).

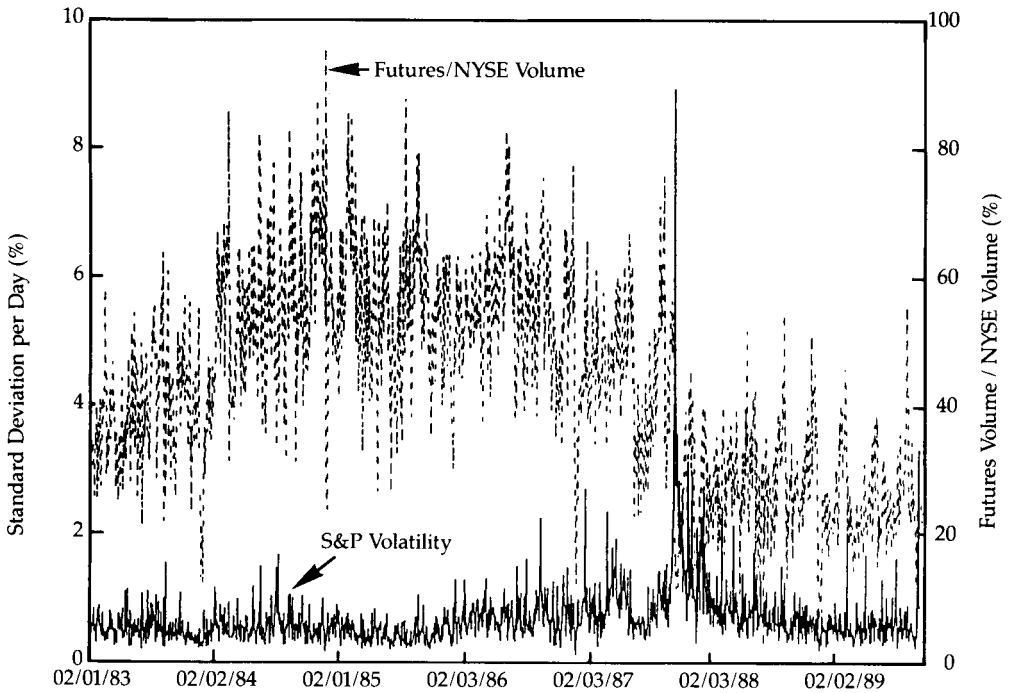
What would cause many people to want to trade simultaneously in the same direction? One possibility is the arrival of new information that leads investors to conclude that stock prices are too high (or too low). They will all then want to sell (or buy) at existing prices. If the information is correct, is there anything wrong with the large price changes that result? I would argue there is not. In fact, rules that would force the price to come down in small increments would force some buyers to pay too much for the stock. (This responsibility falls on the specialist, when no other buyers are willing to bid at existing prices.)

Another reason many investors might want to trade in the same direction is the use of stock price behavior as an important input to trading strategies. Suppose, for example, that some investors think there is persistence in the movement of stock prices. Once prices start to fall, these investors will want to sell, expecting prices to fall further. Without offsetting behavior by other investors, this scenario will lead to a continuing fall in prices. Of course, if prices fall too far, there will be profit opportunities in purchasing underpriced stocks. If "herd" investors follow the path of prices too long, they will lose money over time. Conversely, "contrarian" investors, who come in to buy when prices have fallen too low, will always make money. While every investor probably hopes that he or she is correctly timing the market, there is no conclusive evidence that many investors can successfully time market movements.

A variation of this explanation holds that volatility is high because many investors are revising their beliefs about stock value. No investor believes that he or she has all the information available to all other investors, so each learns something from watching the stock prices set by the trading of others. When prices fall, investors may conclude that there is negative information they did not know. As time passes, each investor revises his or her beliefs to incorporate information as it is revealed. If a price drop seems unwarranted, some investors will enter the market to take opposite positions.

This learning process seems a perfectly natural description of securities markets. Indeed,

Figure H Volatility of Daily Returns to S&P 500, based on 15-Minute Returns within the Day, and the Ratio of S&P Futures Volume to NYSE Share Trading Volume, February 1, 1983–October 19, 1989



looking at the large daily returns in Table I, one can see that many of the largest percentage increases in stock prices have followed large drops (for example, October 30, 1929 and October 21, 1987). But not all large price drops are followed by reversals; it is obviously difficult to pinpoint overreactions.

Finally, if there are frictions in the trading process, mechanistic trading strategies, such as portfolio insurance, that lead to selling after prices have fallen (and purchasing after prices have risen) could result in artificial price persistence. Among the many techniques that fall under the label of program trading, only portfolio insurance (dynamic hedging) strategies have the potential to be destabilizing. And even if portfolio insurance trading did cause prices to fall (or rise) too far, that would merely create incentives for other institutional investors to take the other sides of the trades and profit from the mistakes of portfolio insurers. Traders who, in effect, provide liquidity services to portfolio insurers would earn extraordinary rates of return.

Trading in Futures and Options

Futures trading on the S&P 500 began in April 1982, and it soon exceeded trading volume on the NYSE. Figure H shows the ratio of trading volume on the S&P 500 futures contract divided by NYSE trading volume from 1983 to 1989, along with the plot of daily stock return volatility from Figure D. Futures volume rose faster than NYSE volume until Black Monday, although the ratio seems to have peaked in early 1985. Since October 1987, futures volume has remained at a stable, but lower, ratio to NYSE share volume.

When I first looked at this plot I found it surprising that futures volume had not grown faster than it had. In relation to NYSE volume, futures volume remained at a fairly constant level over the whole period. It is also worth noting there are no obvious cases where unusually large futures trading activity is associated with unusual stock volatility. This may be surprising, given the scrutiny that was paid to the effects of "triple-witching days" in the mid-1980s. Those days were associated with large volume in both stock and futures markets.

Has trading in options or futures contracts increased the volatility of stock returns? Franklin Edwards has shown that stock return volatility has not been higher, on average, since the advent of trading in futures and options (although his sample does not include October 1987).[15] His results are similar to the conclusions one would draw from Figures A and B. Edwards did find that the volatility of stock returns was higher, on average, for futures-expiration days than for non-expiration days from 1983 to 1986, particularly in the last hour of trading.

Similarly, Hans Stoll and Robert Whaley found that, on futures-expiration days from 1983 to 1985, share volume and volatility were higher during the last hour of trading.[16] Furthermore, prices tended to fall at the end of the day and to reverse at the opening of trading on the next day. Stoll and Whaley draw an analogy with block trades, where volume and volatility are temporarily high and followed by small price reversals. They argued that the effects of expiration of futures contracts are small and confined to brief periods of time, and reflect the costs of providing liquidity to futures traders.

Sanford Grossman has demonstrated that program trading, which involves simultaneous trading in futures or options and the underlying stocks, was not associated with higher-than-average daily return volatility from January through October 1987.[17] A recent study by the Securities and Exchange Commission, however, found a positive relation between hourly stock volatility and the volume of index arbitrage program trading from October 1988 to April 1989.[18] Preliminary work by the NYSE, using data from June 1989, also found a strong relation between program trading volume and volatility, except on June 16, 1989, a triple-witching day when program trading volume was very high and volatility was not abnormally high.

Douglas Skinner analyzed the volatility of individual stock returns after options contracts began trading on these securities.[19] He found a small but significant *decrease* in volatility after options began to trade. This may be due to an increase in the liquidity of the stocks; option markets have low transaction costs. Whatever the cause, there is no evidence that stock volatility increased because standardized options contracts began to trade on organized exchanges.

Policy Implications

The relation between program trading and volatility is similar to the relation between stock trading volume and volatility. There are many possible explanations of this result. Because program trading is inexpensive, people with information might use this method to rebalance their portfolios to reflect new information.

As noted, even in the cases where large program trading volume coincides with high volatility, the duration of the volatility is usually brief and the price reversals that follow occur within about an hour, on average. In a sense, this is analogous to the effect of a large block trade in an individual stock. This analogy raises three interesting questions. First, which traders are affected by this disruption? Second, is there an alternative to the trading methods used to handle these large trades that would result in a smaller disruption? Third, is the growth in the use of computers, high-speed communications equipment and futures and options markets exacerbating this problem?

Because the duration of the volatility increase associated with program trading is usually brief, investors who do not trade frequently should not be much affected. And if the effects of program trading are reversed within an hour or two, investors who trade infrequently should not be much affected. It is really only the professional money managers, floor traders and specialists, who are constantly trading stocks, who are affected by intraday volatility. These frequent traders have at their disposal several methods for placing orders that would limit their exposure to intraday price swings.

Circuit Breakers or Trading Halts

The continuous auction market that occurs during regular trading hours on the NYSE is not the only method of trading securities. Indeed, stock exchanges around the world use a variety of alternative methods, including the process of collecting orders for a period of time and then clearing them simultaneously (a call market). In fact, the procedure used to set opening prices on the NYSE is a call market. Different types of trading mechanisms have different advantages and disadvantages, but there has been little work done on comparing them. One exception is a paper by Yakov Amihud and Haim Mendelson, which shows that daily returns to DJIA stocks have higher variances and a greater tendency for reversals when measured from open-

to-open than when measured from close-to-close.[20] This suggests that the process of halting trading to collect orders that will clear simultaneously does not reduce volatility.

The NYSE and the futures exchanges instituted a variety of circuit-breakers after the October 1987 crash. On October 13, 1989, trading was halted twice on the Chicago Mercantile Exchange and it was almost halted on the NYSE.[21] Since October 13, the NYSE has said that it will study additional methods for slowing down the process by which prices fall. Of course, the important question is whether circuit-breakers decrease or increase volatility.

If investors tend to panic and overreact, then a trading halt that allows information to become widely disseminated and processed would reduce volatility. The price rebounds following the sharp price declines on October 30, 1929 and October 21, 1987 suggest that the declines may have been too large. The price reversals following large program-trading volume also imply that volatility might have been lower if those trades could have been absorbed. Indeed, the new procedure of settling futures expirations at the opening of trading seems to have reduced the size of expiration-day effects (although I am not aware of a thorough study of this issue).

If investors value the ability to transact quickly, however, the prohibition of trading will reduce the perceived and actual liquidity of securities markets and perhaps increase volatility. It may also have the effect of lowering the prices of securities perceived to have less liquidity. The Hong Kong stock market halted trading for a week following the October 19, 1987 crash. Stock prices fell more in Hong Kong than in most other countries as of the end of October 1987.[22]

If some investors value liquidity very highly, and fear that a trading halt will occur as prices approach known limits, they will hurry to sell now to assure their ability to trade. Such behavior would speed up price declines and could lead to overreaction. This could lead to increased volatility.

Computerized Trading

Over the last few years, securities industry leaders, regulators and the press have become concerned about the intraday behavior of stock prices. The discussions of triple-witching days, program trading and circuit-breakers all reflect this concern. But is intraday volatility worse now than it was in earlier years? From Figures A, B and C, it is clear that daily or monthly volatility was not unusually high in the 1980s. I conjecture that intraday volatility was often quite high in the 1930s, but it may also have been high at other times since then. Because the data are not readily available in computer-readable form, it is difficult to compare previous experience with the current state of affairs. The lack of availability of intraday data also means that fewer people were aware of high intraday volatility when it was happening.

I suspect that the current debate about intraday volatility would take on a different tenor if it could be documented that recent events are not unusual, in much the same way that Figures A and B show that interday volatility in the 1980s was not that unusual. Clearly, if we are to understand the effects of new high-speed computer and communications technologies on the behavior of stock prices, it is important to understand how prices behaved before these changes occurred. ■

Footnotes

1. Presidential Task Force on Market Mechanisms, *Report of the Presidential Task Force on Market Mechanisms* (Washington: U.S. Government Printing Office, 1988).
2. The rate of return is the change in price plus the dividend received by stockholders during the period, all divided by the price of the investment at the beginning of the period.
3. G. W. Schwert, "Stock Volatility and the Crash of '87," *Review of Financial Studies*, forthcoming and "Indexes of United States Stock Prices from 1802 to 1987," *Journal of Business*, forthcoming, describe the construction of these daily returns in detail. C. P. Jones and J. W. Wilson, "Is Stock Price Volatility Increasing?" *Financial Analysts Journal*, December 1989, also address some of the issues discussed in this article.
4. The *Wall Street Journal*, in a story by C. Crossen on October 19, 1987, mistakenly reported that the DJIA fell by 24.4 per cent at the start of World War I, when trading on the NYSE was halted from July 31 to December 12, 1914. While it is plausible that a four-month trading halt accompanying the start of a war could cause stock prices to drop by large amounts, in fact they did not. Dow Jones redefined its industrial portfolio after the trading halt, and the *Wall Street Journal* made the mistake of splicing the two different indexes. Using a consistent definition of the portfolio, prices *rose* from July 31 to December 12, 1914, by 2.2 per cent.

5. The standard deviation σ of returns R_t from a sample of T observations is the square root of the average squared deviation of returns from the average return in the sample:

$$\sigma = \sqrt{\sum_{1}^{T}(R_t - \bar{R})^2/(T-1)},$$

where $\bar{R}$ is the sample average return, $\bar{R} = \Sigma R_t/T$.
6. If stock returns had a normal distribution, about one out of 20 returns would be more than two standard deviations away from the average return, which is less than 1 per cent per month.
7. For example, see F. Black, "Noise," *Journal of Finance*, July 1986.
8. Because not all stocks in the S&P 500 trade at the same time, the index, which is based on the last trade price for each stock, is likely to lag the movement in the futures price. Y. Amihud and H. Mendelson ("Index and Index-futures Returns," *Journal of Accounting, Auditing and Finance*, October 1989) conclude that both these explanations contribute to the higher volatility of futures returns.
9. G. W. Schwert, "Why Does Stock Market Volatility Change Over Time?" *Journal of Finance*, December 1989.
10. G. W. Schwert, "Stock Volatility and the Crash of '87," *op. cit.*
11. For example, G. Hardouvelis, "Margin Requirements and Stock Market Volatility," *Federal Reserve Bank of New York Quarterly*, Summer 1988.
12. See G. W. Schwert, "Business Cycles, Financial Crises and Stock Volatility," *Carnegie-Rochester Conference Series on Public Policy*, Fall 1989, and "Why Does Stock Market Volatility Change Over Time?" *op. cit.*, as well as R. Officer, "The Variability of the Market Factor of the New York Stock Exchange," *Journal of Business* 46 (1973), pp. 434–453, D. Hsieh and M. Miller, "Margin Regulation and Stock Market Variability," *Journal of Finance*, March 1990, P. Kupiec, "Initial Margin Requirements and Stock Returns Volatility: Another Look," *Journal of Financial Services Research*, December 1989, R. Roll, "Price Volatility, International Market Links, and Their Implications for Regulatory Policies," *Journal of Financial Services Research*, December 1989, and M. Salinger, "Stock Market Margin Requirements and Volatility: Implications for Regulation of Stock Index Futures," *Journal of Financial Services Research*, December 1989.
13. A. Pagan and G. W. Schwert ("Alternative Models for Conditional Stock Volatility," *Journal of Econometrics*, forthcoming) show that the tendency for volatility to rise after a drop in prices is strong even in the 1834–1925 stock return data.
14. J. M. Karpoff, "The Relation Between Price Changes and Trading Volume: A Survey," *Journal of Financial and Quantitative Analysis* 22 (1987), pp. 109–126.
15. F. R. Edwards, "Does Futures Trading Increase Stock Volatility?" *Financial Analysts Journal*, January/February 1988, and "Futures Trading and Cash Market Volatility: Stock Index and Interest Rate Futures," *Journal of Futures Markets* 8 (1988), pp. 421–439.
16. H. R. Stoll and R. E. Whaley, "Program Trading and Expiration-Day Effects," *Financial Analysts Journal*, March/April 1987.
17. S. J. Grossman, "Program Trading and Market Volatility: A Report on Interday Relationships," *Financial Analysts Journal*, July/August 1988.
18. Office of Economic Analysis, "Stock Price Volatility and Program Trading" (Securities and Exchange Commission, June 2, 1989).
19. D. J. Skinner, "Options Markets and Stock Return Volatility," *Journal of Financial Economics*, June 1989.
20. Y. Amihud and H. Mendelson, "Trading Mechanisms and Stock Returns: An Empirical Investigation," *Journal of Finance* 42 (1987), pp. 533–553.
21. *Wall Street Journal*, October 16, 1989.
22. See R. Roll, "The International Crash of October 1987," *Financial Analysts Journal*, September/October 1988, for detailed analysis of that crash.

Glossary

Volatility: A measure of the changeability or randomness of asset prices; usually the standard deviation or variance of the rate of return.

Standard Deviation: A measure of the dispersion of a frequency distribution; to arrive at mathematically, square the deviation of each observation from the arithmetic mean for the sample, find the arithmetic mean of the squares and take the square root of this.

Financial Leverage: The use of debt financing to increase the expected return to and risk of equity capital.

Operating Leverage: The use of fixed assets to increase the expected profitability and risk of production and marketing activities.

Personal Leverage: The use of personal debt to increase the expected return and risk of an individual's investment portfolio.

Circuit Breaker: A mechanism that automatically interrupts trading when large price changes occur (i.e., *volatility* is high).