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Stock Market Volatility: Measures and Results

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Introduction

Virtually everyone who is interested in financial markets seems to agree on two things: that markets are now more volatile than ever, and that volatility causes many problems. Let's look at some recent and not-so-recent articles concerning volatility.

This week turned out to be slower than expected on the IPO market, as intense volatility on U.S. exchanges prompted many companies to put off much-anticipated debuts.

I am writing to you today to address my concerns about trading in a fast market, a current issue of extreme importance to me. I want to give you my perspective and let you know the steps we at Schwab are taking to support investors during this time of market volatility.

In recent months, there has been a marked increase in price volatility and volume in many stocks, particularly of companies that sell products or services via the Internet (Internet issuers).

In the above quotes, there are two implicit assumptions: that volatility is higher now than it has been in the past, and that this volatility is somehow bad. In the first article, it assumes that (obviously) increased volatility has caused firms to delay their Initial Public Offerings (IPO's). Next, Schwab believes that investors need special support because of the high volatility inherent in today's market. Finally, Barrett appears to be more concerned about volatility for Internet stocks even though the volatility has

(obviously) increased in the market as a whole as well.

These articles ignore some important questions. Is stock market volatility greater now than it has been in the past? Is stock market volatility a bad thing? How does it impact the markets? This paper will look at these issues and try to answer as many as possible.

Volatility

Volatility is difficult to analyze because it means different things to different people. People are rarely precise when they talk about volatility. Also, there is a lot of misinformation about volatility. In this section we will take a closer look at volatility what it is, and what causes it. We will also look at some important things to remember about the subject, and explode some myths about volatility.

What Is Volatility?

People speak of volatility without defining what they mean by the term. In financial terms, volatility is:

The degree to which the price of a security, commodity, or market rises or falls within a short-term period.
There are several things to note about this definition. Most importantly, the definition specifically mentions price increases and decreases. People are usually most concerned about volatility during periods when prices decrease or go through a "correction." During an extreme bull market, no one (with the possible exception of investors with short positions) seems to care that the markets are exhibiting volatility. Also, most people use volatility and risk interchangeably. However, volatility has to do with variability while risk has to do with variability that is unpredictable or uncertain.

Different investors in different market sectors may have different characteristics with respect to risk. Because of this, different sectors may have different volatilities. Therefore, looking at the volatility of a market really means looking at the volatility of the indices of the securities within the market. For each individual security, its beta measures the security's volatility relative to the market as a whole, but if beta stays the same, and the market's risk increases, then the risk associated with a given security will increase.

What Causes Volatility?

There are a number of things that cause volatility. Arbitrage causes volatility. Arbitrage is the simultaneous or almost simultaneous buying and selling of an asset to profit from price discrepancies. Arbitrage causes markets to adjust prices quickly. This has the effect of causing information to be more quickly assimilated into market prices. This is a curious result because arbitrage requires no more information than

the existence of a price discrepancy.

Another obvious reason for market volatility is technology. This includes more timely information dissemination, improved technology to make trades and more kinds of financial instruments. The faster information is disseminated, the quicker markets can react to both negative and positive news. Improved trading technology makes it easier to take advantage of arbitrage opportunities, and the resulting price alignment arbitrage causes. Finally, more kinds of financial instruments allow investors more opportunity to move their money to more kinds of investment positions when conditions change.

Most people would say that new information in general causes volatility. News digests of the day's market performance almost always include a reason the market is up or down. Often, different writers give different reasons for market changes. For example, on November 15, 1991, the Dow fell over 120 points. The article in Investors Business Daily had the title, "Dow plunges 120 in a Scary Stock Sell-off: Biotech, Programs, Expiration and Congress Get the Blame." On the same day, the New York correspondent for the London Financial Times titled its article: "Wall Street Drops 120 Points on Concern at Russian Moves." The information that the Russian government had suspended oil licenses and taken over foreign gold supplies was not mentioned once in the US article.

Unfortunately, when analyzing major market changes, it is often very difficult to associate specific market moves with specific news events. There have been 120 days since 1885 when the Dow has changed by more than 5 percent. Of these, only 28, or less than one in four, can be clearly connected with specific events. Further, of the 10 largest changes, only two can be attributed to specific news stories: the 6.62% drop on September 26, 1955, when President Eisenhower suffered a heart attack, and the 6.12 percent drop on October 13, 1989, when a UAL leveraged buyout failed. Neither of the two worst market declines (in 1929 or in 1987) were ever definitively connected to any news event.

Volatility: Points Versus Percentage?

When talking about volatility, it is difficult to know whether to talk about volatility in terms of points or percentages. Percentage volatility reflects percentage changes in the value of the amount invested. It is therefore useful to talk about percentage changes to discuss the change in a given investor's wealth or in the change in wealth invested in the market, or in the economy as a whole. As a market's base level increases, the point volatility could increase while the percentage volatility could decrease. Economists, business professors, and market gurus often forget that people care more about dollars than percents.

Is Volatility a Bad Thing?

The two primary complaints about volatility are that it delays IPO's and that it decreases value. The research presented in my dissertation indicates that there is no statistical evidence that the number of IPO's decline during periods of increased volatility. Further, increases in volatility actually increase values of financial assets. This is because volatility increases the option value of waiting to invest. That is, during times of high volatility, there is value in being able to "time" your investment.

To see this, let's look at two countries: Safe and Risky.

In Safe, the government strictly limits all returns on investment (ROI's) to 10 percent. If an investment pays more than 10 percent, the government taxes away all "excess" returns. If an investment pays less than 10 percent, the government subsidizes "substandard" returns. Suppose a firm wishes to issue its preferred stock with an annual dividend of $3 per share. The value of such an issue would be $30 if we issued the preferred stock in Safe:

$$\begin{aligned} \textit{Preferred Stock} &= \$3/10\% \\ &= \$30 \end{aligned}$$

In Risky, the government guarantees that while the average ROI will be 10 percent, it will be allowed to vary. It could go as high as 15% or as low as 5% with equal probability (50 percent). For Risky, the expected value of our preferred stock offering would be $40.

$$\textit{Preferred Stock} = \begin{cases} \$3/5\% = \$60, \textit{if rates are low} \\ \$3/15\% = \$20, \textit{if rates are high} \end{cases}$$

We calculate the expected value by multiplying the probabilities of each outcome times the value of that outcome:

$$\begin{aligned} \text{Expected Preferred Stock Value} &= (\$60 \times 0.5) + (\$20 \times 0.5) \\ &= \$40 \end{aligned}$$

Therefore, all other things being equal, increasing volatility increases value. In Safe, there is no value to waiting for times to be good, but in Risky, timing your investment properly increases the value of your outcome. This view is long-term investor's perspective.

What About Limits on Volatility?

Many people suggest that there should be limits on volatility. They suggest that trading should be suspended if markets change "too much" over a certain period of time. Such limits on trading already exist on commodity markets. Most analysts are unsure whether this is a good or bad thing. During 1980, I knew an investor who had purchased wheat contracts on the Friday before the Sunday that President Carter announced the grain embargo against the Soviet Union. This announcement caused the market to open "down the limit" for seven business days. It was therefore impossible for my friend to get out of his position for a week and a half! Furthermore, each day he had to pay his margin call. Reasonable people may disagree over whether it is better to get a swift severe beating, or to get beaten less severely each day for a longer period of time.

Measuring Volatility

Measuring volatility presents some problems. Even simple measures of volatility are relatively complex. Further, any measurement of volatility requires a lot of information. Consequently, using any measure of volatility has both advantages and disadvantages. This part of the paper will address the two most common (and most useful) measures of volatility: standard deviation and implied volatility. It will also discuss the proper index to measure market volatility.

Standard Deviation

The most common measure of volatility is standard deviation. To calculate the standard deviation, you first determine a time frame for returns you wish to measure. That is, you must determine whether you wish to measure the volatility of hourly returns, daily returns, monthly returns, etc. For purposes of explanation, let's assume we are interested in the standard deviation for daily returns over the past month. Then, you calculate the daily returns for the month, and compute the standard deviation using the formula you learned in statistics class, or that is available on your spreadsheet:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(r_i - \bar{r})^2}{n-1}}$$

Where r_i = *the rate of return for the* i^{th} *day*

$\bar{r}$ = *the average rate of return for the month*

i = *the day identifier for the month (i.e., for a month,* i *goes from* 1 *to* 30 *or* 31.

The primary advantage with standard deviation is that everybody is familiar with and understands it. It is easy to calculate, and is readily available from a number of sources (e.g., spreadsheets, calculators, etc.). However, there are a number of problems with this measure. As the time frame decreases, the measure's validity is less certain. You must also calculate the mean return for the period analyzed. Further, you must specify a time frame for the returns, and the relevant time period. Consequently, it is historical in nature. Therefore, it homogenizes the information. If you are interested in what the volatility is this instant, the standard deviation measure is of little use.

Implied Volatility

A less well-known, but more valuable measure is implied volatility. This measure is the result of an important fact about derivatives: the price of the derivative along with the price of the underlying security produces two observations of the security's price. Arbitrageurs have used this fact to profit by determining whether a security is improperly priced relative to its derivative. Students of the financial markets can use

the information provided by a security's observed prices along with the security's observed derivative prices to generate important information.

The mathematics of implied volatility is rather complex, and I will not discuss them here. Implied volatility uses the stock's current value, the option's current value and the particulars of the option to calculate an instantaneous measure of the underlying volatility for any security or index with a call or put option.

There are problems with implied volatility. First, It is sensitive to dividend payments. Also, there are some technical details to be examined. The analyst must select the appropriate time frame and strike price. Also, the New York Stock Exchange (NYSE) and the Chicago Board Options Exchange (CBOE) close at different times. Finally, this approach produces, in a way, too much information. An analyst can determine the market volatility at virtually any instant in time.

There are a number of financial software packages that can be used to compute implied volatility. The most useful I have found is DerivaGem. I used DerivaGem for many of the computations in this paper. I have also found a Web site that measures and keeps track of implied volatility. The URL for this site is:

http://www.ivolatility.com/

What Index to Use?

Another problem when measuring volatility is choosing an index. The most widely reported index is the Dow. It has a number of problems. First, it uses very few stocks in its calculation. Thirty stocks is hardly representative of an entire financial market. Also, it tends to be most affected by high-value stocks. Often, such high-value stocks tend to be small in total capitalization. The S&P 500 index is perhaps the most useful measure of the NYSE as a whole. It is weighted by the market capitalization, and it includes many more securities than the Dow does. Further, it is more heavily traded than other indices with more stocks. However, the S&P 500 index has a number of drawbacks. It does not include many high-value stocks in the high-tech sector. It also ignores the NASDAQ. Because other market indices are too infrequently traded to reflect properly how the market as a whole is doing, they are not as useful as the S&P 500. Consequently, I have focused on the S&P 500 and the NASD 100 index for this paper.

Results

Past versus Current

Are the markets more volatile than they have been in the past? The answer is sometimes yes and sometimes no. A former colleague of mine, G. William Schwert, generated the following graphs. They show past volatility measures up to September

of 1999. The first graph measures the monthly volatility of the Dow from 1885, while the second graph measures the volatility of the S&P 500 from 1928. In both graphs, there are extreme spikes during the worst downturns (1929 and 1987), but there is no evidence of markets getting more volatile recently. There are also clear, but less pronounced spikes in volatility throughout the range of the graph.

The dramatic spikes for the downturns suggest that perhaps investors are right to be concerned about volatility during downturns. There are no corresponding extreme spikes in volatility that can be identified with market upturns. Perhaps there are mechanisms that prevent the market from going up as dramatically as it goes down.

Please see graphs at the following locations (must have adobe acrobat reader):

URL: http://schwert.ssb.rochester.edu/sd_day.pdf

URL: http://schwert.ssb.rochester.edu/spvol282k.pdf

Volatility Measures of Other Sectors

There is a general feeling among investors that NASDAQ stocks are more volatile than NYSE stocks. This appears to be true. The October 20, 2000 S&P 500 implied volatility is 25 percent. The 52-week high occurred on April 26, 2000 at 34 percent and the 52-week low occurred on September 1, 2000 at 9 percent. The NASD 100 index had a much more extreme range.

The NASD 100 index's October 20, 2000 implied volatility was 72 percent. Its 52-week high occurred on April 27, 2000 at 87 percent and the 52-week low occurred on September 1, 2000 at 21 percent. Note that the highs occurred at almost the same date while the lows occurred at exactly the same date. This suggests that market volatility may often be influenced by economy-wide factors.

Recent Volatility Measures

The week of October 6, 2000 to October 13, 2000 was a very tumultuous week. Problems occurred in the Middle East, including the attack on the USS Cole. An analyst might expect volatility to increase during such times. Interestingly enough, implied volatility declined throughout the week. The following table lists the implied volatility for the non-holiday trading days during the week. The highest volatility occurred on the Friday prior the USS Cole attack. The volatility declined from Friday to Tuesday, increased some on Wednesday, and reached a weekly low on Thursday. Volatility increased somewhat on the day of the attack, but not greatly. This suggests that the market had expected some kind of turmoil, and had built such expectations into security prices.

Date	Volatility
October 6, 2000	27.02%
October 10, 2000	22.45%
October 11, 2000	24.63%
October 12, 2000	15.05%
October 13, 2000	18.65%

The 52-week high for both the S&P 500 and the NASD 100 occurred during April of 2000. The highs occurred on April 26 for the S&P 500, and April 27, for the NASD 100. In both cases, the market performed some sort of seesaw action. On April 25, the S&P had increased into positive territory for the year, and it fell by 4.8% on April 26. For the NASDAQ, April 27 was a down-and-up day with a nearly 120 point fall, followed by a 144 point rise. Neither high volatility day could be connected to a specific news story.

The 52-week lows for both indices occurred the day prior to the Labor Day holiday. It was reported that both the unemployment rate and employment increased slightly. Further, both manufacturing and construction slowed. According to the news media, these economic indicators suggested that the economy was slowing gradually.

Conclusion

We have examined different ways of calculating volatility, and examined some of the empirical results of our calculations. Clearly, volatility is a very complex issue, but the evidence suggests that, in percentage terms markets appear to be no more volatile now than in the past. However, different markets and different sectors within the market can have different levels of volatility. We found that an increase in volatility actually increases the expected value of a financial security, and that is a counter-intuitive result. The one thing we can count on is that volatility is an inherent part of the financial markets, and investors must continue to deal with it.

1. Initial Public Offering (Author's note).
2. Wired News by Joanna Glasner May 26, 2000
3. Charles Schwab (2000)
4. Stock Market Volatility - A Psychological Phenomenon? David Barrett (1996)
5. The beta coefficient measures the risk of a security relative to the risk of the market. For example, if a stock has a beta of 2, the stock is twice as risky as the market, while a beta of 0.5 means that the stock is ½ as risky as the market.
6. The rule is, "buy cheap and sell dear." More properly stated, the rule is, "sell dear, then buy cheap to cover the sale."
7. My personal favorite reason is "profit taking."
8. Virginia Munger Kahn, Investors Business Daily, November 16, 1991, p. 1.
9. Jeremy J. Siegel, Stocks for the Long Run A Guide to Selecting Markets for Long-Term Growth, p.184.

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