The Characteristics of Stock Market Volatility

By Daniel R Wessels

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1. Introduction

Stock market volatility is synonymous with the uncertainty how macro-economic events and trends will affect the future profitability (dividends, cash flows) of listed companies and hence their market valuations. Typical examples of such variables in the current environment are: geo-political tensions, energy prices, inflation expectations, interest rate policies and the stability of exchange rates. But then again, these uncertainties in some form or another are always present; yet we find that stock market volatility is some times much higher than in other periods.

Many research studies, such as Schwert (1989)[1], have explained the variance of stock market volatility with the time-varying volatility of a variety of economic variables. For example, changes in inflation, money growth, industrial production and other measures of economic activity are related to changes in stock market volatility. Furthermore, volatility increases with the financial leverage (debt) of companies. In addition, volatility is correlated with interest rate movements and increases during economic recessions.

Stock markets in general have treated investors well over the past couple of years with no major setbacks (until the beginning of May 2006). A prominent feature has been the absence of volatility on stock markets and in general markets followed one direction only, namely upwards. However, during the year to date (May 2006) volatility once again has come to the fore as more investors were piling into the investment markets (daily trade volumes of R8-10bn) and stock prices soared to record levels[2].

My main objective with this study is to analyse the typical characteristics of stock market volatility on our local bourse (JSE). In this paper I endeavour to answer questions such as: How did stock market volatility behave in the past? Are there any identifiable patterns? Is there any meaningful link between volatility and returns? How could one use this information to develop some insight how to manage future volatility?

Monthly stock market data from 1960 until March 2006 (more than 46 years) were used in this analysis. First, I provide some general background on the meaning and implications of the volatility concept for investors. Second, I analyse the typical characteristics of stock market volatility – its distribution, movement patterns and duration intervals. Finally, I investigate the general relationship between volatility and stock market returns with specific focus on the correlation between changes in volatility and investment returns.

2. The Concept of Volatility: Back to Basics

Most investors perceive investment risk primarily as the risk of losing capital, but it may also include the risk of not achieving a certain minimum return. In short, investment risk can be defined as the possibility of being disenchanted with your investment plan in not meeting your investment objectives.

Understandably, it is immensely difficult to develop a universal accepted definition of investment risk since investors apply different time frames to the outcome of their investing efforts. For example, some investors do not want any capital losses over any period; another group might tolerate some short-term losses in the hope of doing well in the long run, while others realise that exceptional gains are not likely without exposing oneself to some real risk.

In order to gauge this likelihood of “disappointment”, the professional investment industry uses a common indicator, namely the volatility of investment returns. The volatility of stock market investments can be defined

as the dispersion of investment returns below and above the mean, otherwise known as the standard deviation of returns.

The concept of volatility is widely used in the investment industry. Typically, the allocation of investment strategies and fund selections to an investment plan are based on their respective volatilities and whether it fits the risk profile of the prospective investor. Therefore, it is important for investors to understand the limitations and uses of volatility as a barometer of investment risk.

First, it is important to understand how volatility is estimated. Typically, the volatility of investments spanning over different intervals is standardised, for example annualised volatility, to compare the riskiness of investment portfolios. The following annualization rule applies:

Standard deviation over an interval x Square root of the number of intervals per annum

For example, if the standard deviation measured on a weekly basis is equal to 2.5% and one wants to express the deviation on an annual basis, the following formula will apply: 2.5% x SQRT(52) = 18%.

Note, it is not merely volatility on a weekly basis times the number of weeks in a year, because such practice would have led to a gross overestimation of volatility. In essence, the volatility of stock prices exhibits a mean-reverting pattern.

Table 1 illustrates the various annualised rates over different measurement periods.

Table 1: Converting different volatility measures to a standard basis

	Measured Volatility	Annualised Volatility
Std Deviation (daily)	1.2%	19.0%
Std Deviation (weekly)	2.5%	18.0%
Std Deviation (monthly)	5.5%	19.1%
Std Deviation (annually)		18.0%

Second, and in accordance with the first principle illustrated above, the passing of time reduces volatility.

Consider the following two examples, a five-year investment and a ten-year investment, shown in table 2 below:

Table 2: The passing of time reduces volatility

Period	Capital Value	Annual Return
Year 0	100	
Year 1	115	15.0%
Year 2	106	-8.0%
Year 3	129	22.0%
Year 4	154	19.0%
Year 5	174	13.0%

Std Deviation	**11.8%**
Average Return	**12.2%**
Geometric return	**11.7%**

Table 2 (continued…)

Period	Capital Value	Annual Return
Year 0	100	
Year 1	115	15.0%
Year 2	106	-8.0%
Year 3	129	22.0%
Year 4	154	19.0%
Year 5	174	13.0%
Year 6	200	15.0%
Year 7	184	-8.0%
Year 8	224	22.0%
Year 9	267	19.0%
Year 10	301	13.0%

Std Deviation	**11.1%**
Average Return	**12.2%**
Geometric return	**11.7%**

In the above example both investments yielded the same return; in fact the five-year investment is identical to the ten-year investment, except for the term. Note that the standard deviation in the latter is lower than in the former investment (11.1% versus 11.8%).

From table 2 two other important inferences are made, first the average return is higher than the geometric or annualised return and second, if the ten-year investment is identical to the five-year investment, then one would have expected the capital value after ten years to be exactly double the capital value after five years (174 x 2 = 348), but it is not!

A third principle is hereby installed. Time reduces volatility, but not the value at risk. This phenomenon is explained by the degenerating effect of volatility on returns which lead to actual returns (geometric or annualised) being lower

than the average return. This difference is compounded with the passing of time and leads to lower returns than it would have been predicted otherwise (as illustrated in table 2).

In general the following rule applies:

Degeneration of returns = average return minus 50% of portfolio variance (standard deviation squared).

A fourth principle is that volatility measures both the upside and downside deviations from the mean. Nobody would mind the upside (higher returns), but definitely the downside. Thus, one can identify both "good" and "bad" volatilities. Examples of such investments are depicted in table 3 below.

Table 3: Same volatilities, different outcomes

Period	Capital Value	Annual Return
Year 0	100	
Year 1	95	-5.0%
Year 2	112	17.9%
Year 3	125	11.6%
Year 4	139	11.2%
Year 5	150	7.9%

Std Deviation	**8.5%**
Average Return	8.7%
Geometric return	**8.4%**

Table 3 (continued…)

Period	Capital Value	Annual Return
Year 0	100	
Year 1	100	0.0%
Year 2	122	22.0%
Year 3	143	17.0%
Year 4	154	8.0%
Year 5	174	13.0%

Std Deviation	**8.5%**
Average Return	12.0%
Geometric return	**11.7%**

From table 3 it is obvious that volatility must never be seen in isolation. Investment return is the flipside of investment risk and should always be the criterion upon which your investment decision is based.

Furthermore, although we know that high volatility leads to the degeneration of investment returns it does not mean that volatility altogether should be avoided. In fact, low volatility investments (like cash) generally lead to low returns. Therefore, we should seek volatility to have any chance of making real gains. However, when we evaluate two similar risky investments one can compare their volatilities and respective returns. In essence, we want to invest in those investments or assets that yield the highest return per unit risk (volatility).

3. The Characteristics of Stock Market Volatility

3.1 The Distribution of Stock Market Volatility

The standard deviations of the JSE All Share Index (ALSI) monthly returns from January 1960 to the end of March 2006 (in total 543 periods) were computed and presented on an annualised basis.

Figure 1 and table 4 display the frequency distribution and statistical description of the annualised volatilities recorded over time.

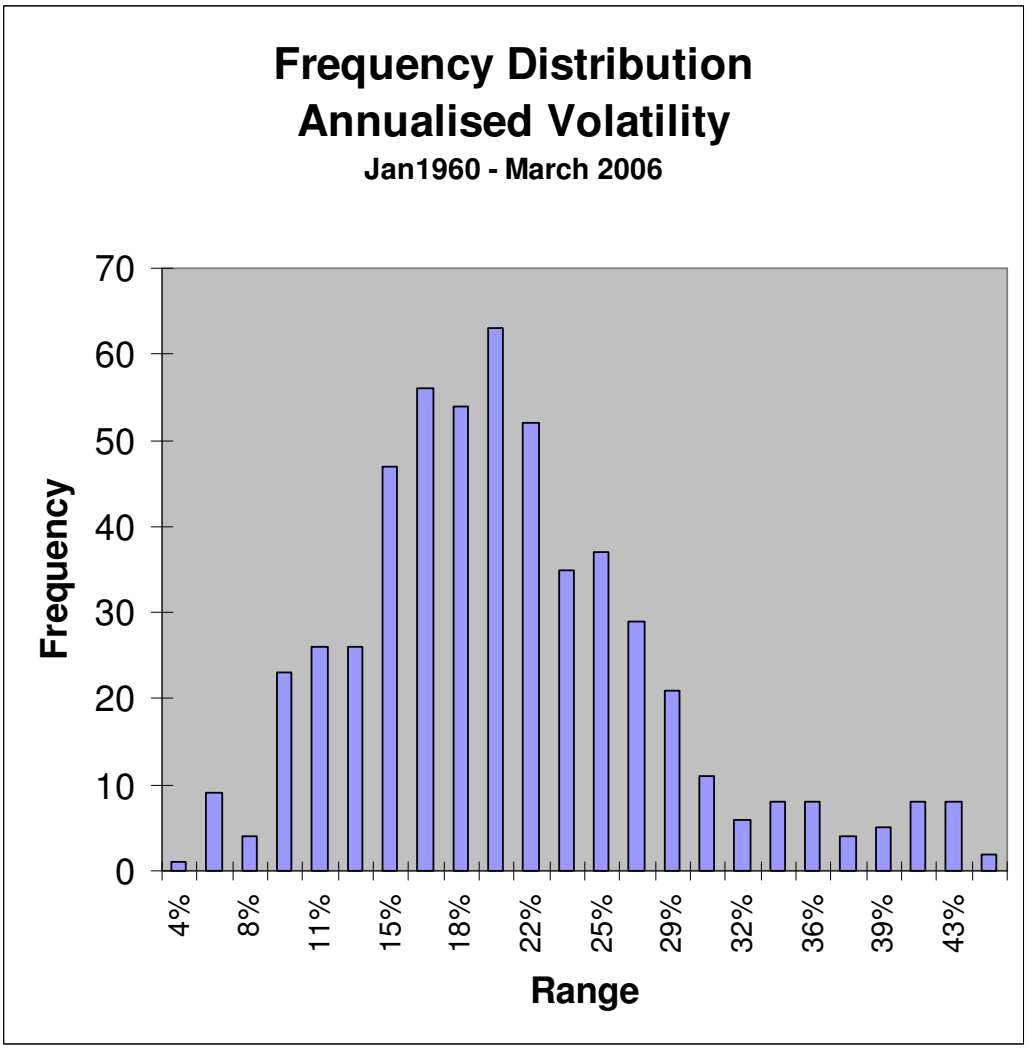

Figure 1: A graphical presentation of the frequency distribution of annualised volatilities in the monthly return of the JSE All Share Index

Table 4: A statistical description of annualised stock market volatility (monthly ALSI returns)

Mean	20.04%
Standard Error	0.33%
Median	19.14%
Standard Deviation	7.76%
Kurtosis	0.61
Skewness	0.75
Minimum	4.3%
Maximum	44.7%

The distribution of the monthly volatilities is asymmetrical and positively skewed, meaning the occurrence of large volatilities to the right of the mean (20%) with a maximum observed annualised volatility of near 45%.

3.2 The Clustering of Volatility

An important characteristic of stock market volatility is the tendency of clustering, in other words volatility tends to stay more or less the same for some time before it moves to a new level.

Figure 2 illustrates the clustering effect of volatility by means of an autocorrelation analysis, which found that a positive autocorrelation is statistically significant in 33 out of 36 consecutive months. This indicates that the volatility in the preceding months have a profound affect on the volatility in the following month – the so-called momentum effect.

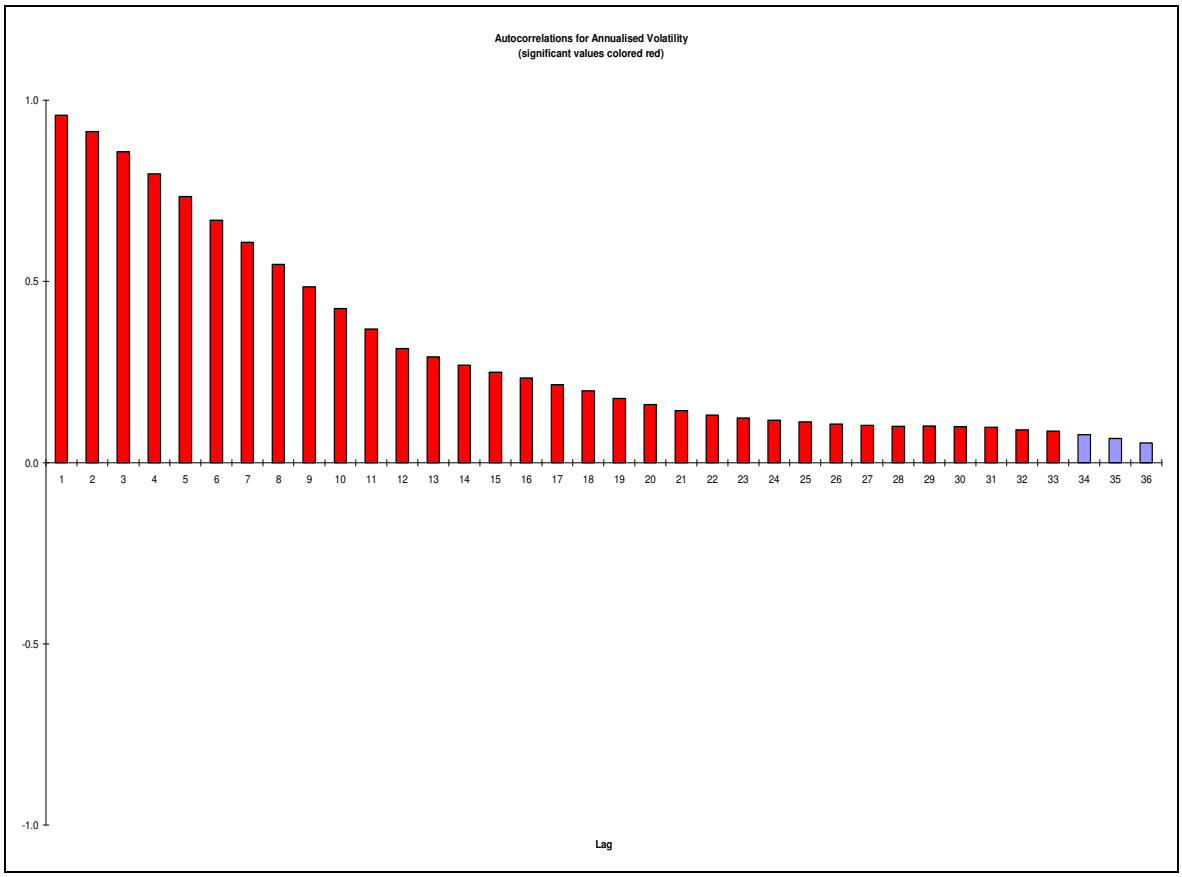

Figure 2: Autocorrelations for annualised volatility, significant values coloured red (lag = 36 months)

3.3 Volatility Patterns

Figure 3 presents the absolute level of annualised stock market volatility on the JSE ALSI since 1960 to date.

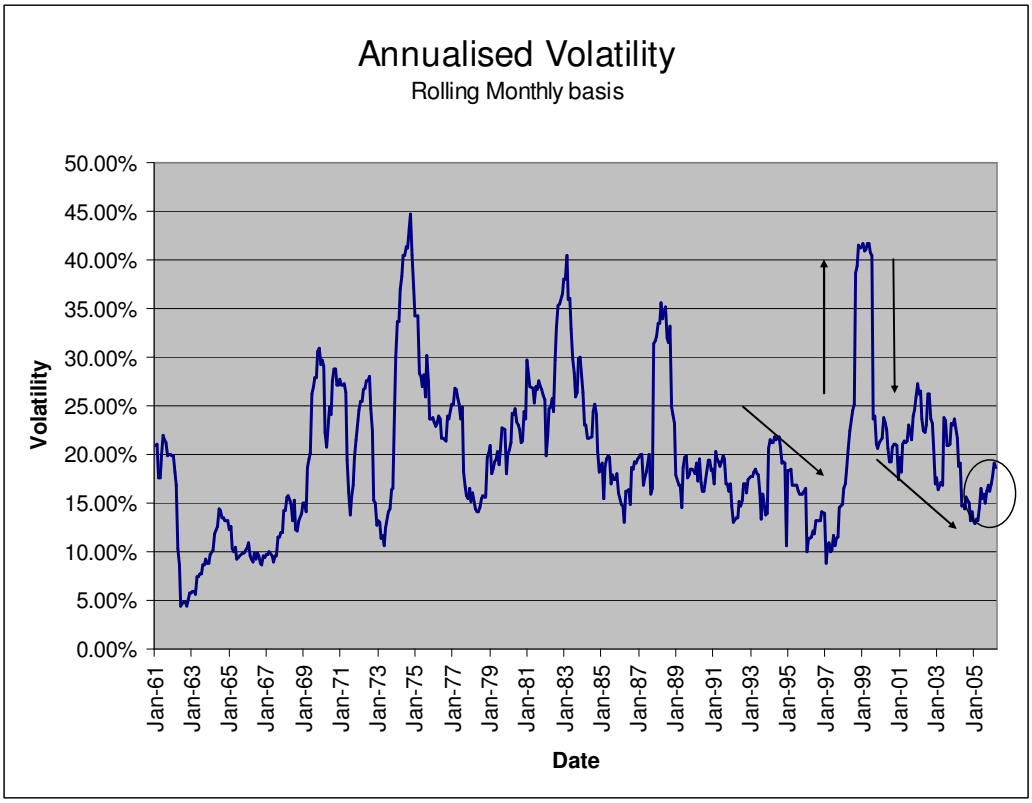

Figure 3: The JSE stock market volatility (1960-2006)

From the above chart the following volatility pattern can be identified: Once volatility has peaked in the 30% – 40% range, it moves down rapidly to some normal level (around 15% - 20% volatility) from where it move sideways or slow down even further to about 5% -10% volatility. At these benign levels volatility starts to gain momentum and exhibits some cyclical movement patterns. At some point volatility will break out of its cyclical mode and spike to extreme volatility levels again.

When studying the most recent period it is noticeable that volatility has started to gain momentum and is heading upwards after reaching a low in the beginning of 2005.

Although it is not within the realm of this study to investigate specifically why volatility exhibited the pattern of tranquillity and violent eruptions in the past, one generalisation can be put forward:

Changes in volatility reflect the changes in fundamental economic factors. Greater volatility leads to a perception of greater risk to the present and future value of assets. Increased volatility may simply reflect information and expectations of changes in fundamental economic factors. If volatility either exceeds or falls short of the level indicated by fundamental economic factors, the result is mispricing, and as a consequence the misallocation of resources[3].

For example, during periods of low volatility investors on the aggregate are prepared to pay too much for asset prices which lead to speculative bubbles and eventually give rise to dramatic collapses in inflated asset prices.

3.4 Volatility Intervals

In the previous section we have seen that stock market volatility over time exhibits a high-low pattern. In order to assess the average duration of volatility at specific levels, the annualised volatilities since 1960 were categorized into four quartiles. Table 5 displays the quartile ranges and the average duration in each quartile.

Table 5: Quartile Ranking of Annualised Volatility (rolling monthly basis)

Annualised Volatility Range	Lower Volatility	Upper Volatility	Observations (months)	Average Duration (months)	Maximum Duration (months)
Q1	4.3%	14.8%	136	21	70
Q2	14.8%	19.1%	136	4	13
Q3	19.1%	24.1%	135	4	16
Q4	24.1%	44.7%	136	8	23

The high average duration found in the first quartile is skewed by a long-lasting low volatility period from April 1962 to December 1967. When this period is excluded, the average duration in the first quartile drops to 6 months with a maximum duration period of 24 months.

Typically, it seems that volatility remains on average longer in the very low and high volatility ranges (quartile one and four) than in the middle categories (quartile two and three).

The rolling annualised volatility, expressed in quartiles, is graphically displayed in figure 5.

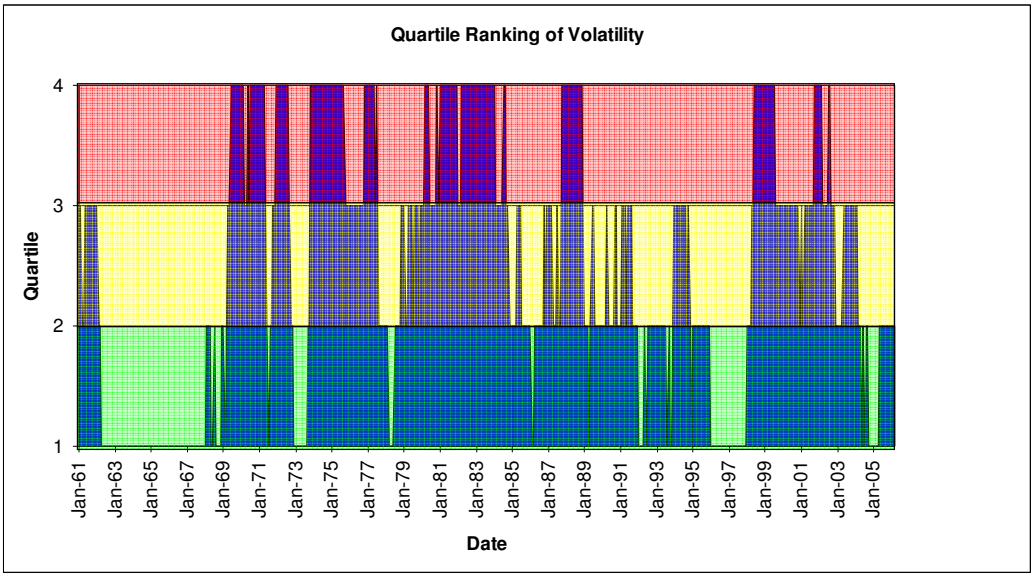

Figure 5: Annualised volatility grouped in quartiles from 1960 to date

4. Volatility and Returns

High stock market volatilities imply the rapid changes in stock prices, and thus returns, but do not explicitly imply whether stock market returns should be positive or negative. Therefore, I endeavour to establish which return profile can typically be expected for a certain level of stock market volatility.

Figure 6 portrays the annualised volatility plotted against the annual ALSI returns on a monthly rolling basis. In some instances it can be seen that high volatilities are accompanied by sharp stock market declines and *vice versa*, but a more unambiguous analysis is required to make some meaningful inferences.

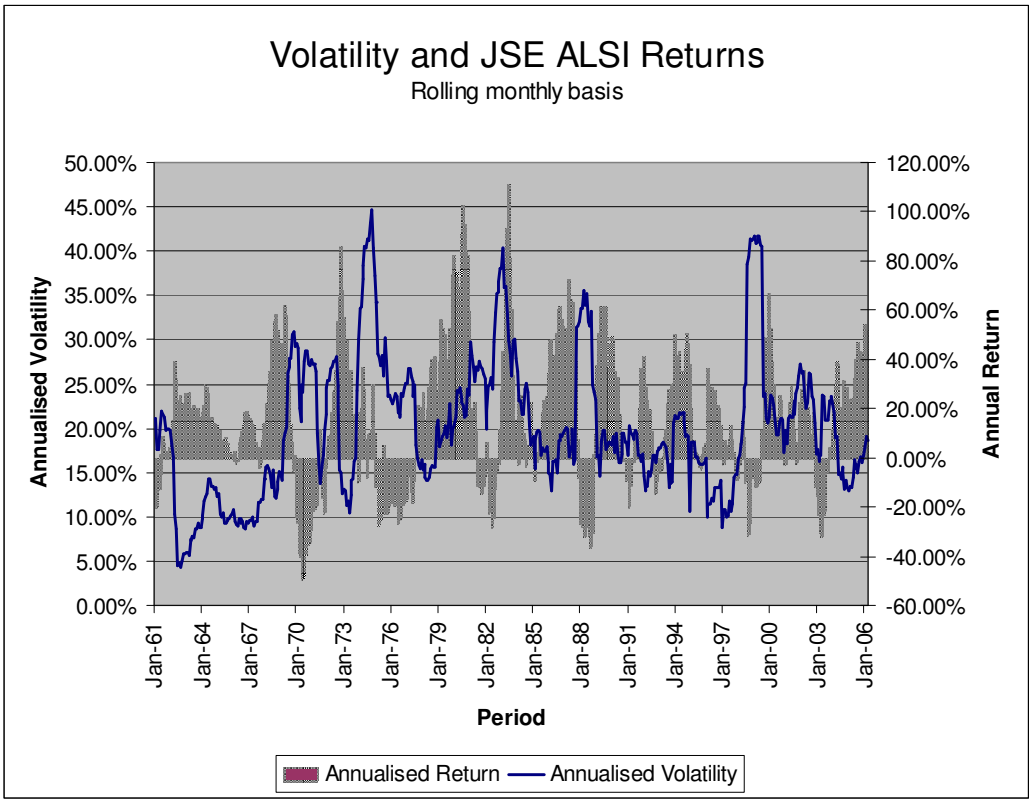

Figure 6: Annualised volatility and stock market return: 1960 – 2006

To this effect the volatility observations were grouped in quartiles, and the occurrence rate of positive and negative returns for each quartile, together with the average return for each occurrence, were determined.

Table 6 summarizes the findings. For example, observations in the first quartile are overwhelmingly accompanied by positive stock market returns with an average return of 19%, while the remaining observations recorded only a very slight negative return. In the following two quartiles (Quartile 2 and 3) between 20-25% of the observations meant negative returns, while the positive return periods yielded on average exceptional returns (30%). The majority of observations in the fourth quartile, which represents the extreme high volatilities, displayed negative returns averaging -17%, while the positive return observations averaged 26%.

Table 6: Analysis of stock market volatility

Annualised Volatility Range	Lower Volatility	Upper Volatility	Obsv	Average Return	Positive Return Obsv	Average Positive Return	Negative Return Obsv	Average Negative Return
Q1	4.3%	14.8%	136	18.9%	92.6%	19.2%	7.4%	-0.3%
Q2	14.8%	19.1%	136	22.5%	79.4%	30.9%	20.6%	-9.9%
Q3	19.1%	24.1%	135	19.0%	75.6%	30.4%	24.4%	-16.2%
Q4	24.1%	44.7%	136	2.5%	45.6%	26.0%	54.4%	-17.1%
Total	4.3%	44.7%	543	15.7%	73.3%	26.8%	26.7%	-14.6%

Consequently, the following inferences are made: Very low volatility intervals (quartile 1) are synonymous with reasonable positive returns. Low to medium volatility intervals (quartile 2) are typically accompanied by strong positive returns and a low probability of negative returns. The same trend is evident in medium to above-average volatility intervals (quartile 3), but significant negative returns might occur in this quartile. Extreme high volatility intervals (quartile 4) are more than likely to be accompanied by large negative returns, although considerable positive returns are still possible.

In short, it seems that investors would achieve great results from stock market investing while volatilities are within the first two quartiles, but then should switch to more defensive positions/conservative strategies once volatility moves into the top two quartiles.

The validity of the above argument is reasonably confirmed when one compares the historical stock market returns with its volatility since 1960 to date (figure 7). Typically, sharp declines in annual returns very often occurred when volatilities peaked (quartile 4), while periods of lower volatilities (quartiles 1, 2 and 3) were accompanied by reasonable to exceptional stock market returns.

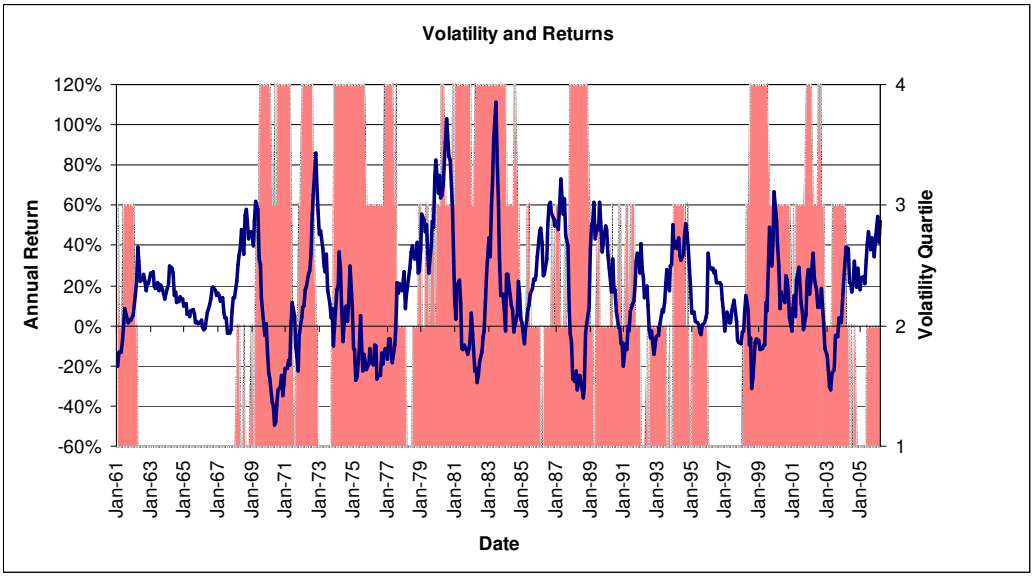

Figure 7: Stock market returns and volatility (quartiles): 1960 – 2006

5. Volatility Rate Changes

Thus far we have seen that periods of high volatilities are often associated with negative returns, and lower volatility intervals with positive returns. But this is not an infallible rule. Moreover, if volatility is currently at benign levels and is moving gradually upwards, what does that implicate for stock market returns? Alternatively, what if volatility increases/decreases rapidly from one period to another?

Therefore, the relationship between stock market returns and the direction (up or down) and velocity of volatility change from one period to another is analysed in tables 7, 8 and 9 for different time intervals.

Table 7: The correlation between monthly changes in volatility and return

Volatility Change M-o-M	Observations (cumulative percentage)	Correlation
0.00%	100%	-0.27
0.50%	60%	-0.29
1.00%	40%	-0.33
1.50%	30%	-0.37
2.00%	21%	-0.43
2.50%	15%	-0.48
3.00%	11%	-0.48
3.50%	8%	-0.51
4.00%	6%	-0.57
4.50%	5%	-0.63
5.00%	4%	-0.63
5.50%	4%	-0.66
6.00%	3%	-0.72
6.50%	3%	-0.70
7.00%	1%	-0.85

Table 8: The correlation between quarterly changes in volatility and return

Volatility Change Q-t-Q	Observations (cumulative percentage)	Correlation
0.00%	100%	-0.25
0.50%	86%	-0.26
1.00%	71%	-0.27
1.50%	60%	-0.28
2.00%	49%	-0.29
2.50%	39%	-0.31
3.00%	32%	-0.32
3.50%	26%	-0.34
4.00%	20%	-0.38
4.50%	18%	-0.40
5.00%	15%	-0.42
5.50%	14%	-0.41
6.00%	13%	-0.45
6.50%	11%	-0.48
7.00%	9%	-0.55
7.50%	7%	-0.54
8.00%	5%	-0.55
8.50%	5%	-0.54
9.00%	5%	-0.66
9.50%	4%	-0.69
10.00%	3%	-0.69

Table 9: The correlation between yearly changes in volatility and return

Volatility Change Y-o-Y	Observations (cumulative percentage)	Correlation
0.00%	100%	-0.23
1.00%	88%	-0.24
2.00%	77%	-0.26
3.00%	66%	-0.27
4.00%	54%	-0.30
5.00%	47%	-0.31
6.00%	37%	-0.37
7.00%	33%	-0.38
8.00%	29%	-0.41
9.00%	26%	-0.43
10.00%	24%	-0.43
11.00%	22%	-0.47
12.00%	19%	-0.54
13.00%	16%	-0.53
14.00%	15%	-0.54
15.00%	13%	-0.56
16.00%	10%	-0.52
17.00%	8%	-0.57
18.00%	6%	-0.63
19.00%	6%	-0.66
20.00%	5%	-0.63

From the above tables: The majority of incremental changes (80-90%) are weak to moderate, but this is not too surprising; we have seen that volatilities tend to cluster around a certain level. In such instances, no statistically significant relationship is found between the change in volatility and investment returns.

However, when substantial changes in volatility do occur, a definite inverse relationship with investment returns does hold. For example, a substantial rise in volatility from one period to another is normally accompanied by large negative returns. Alternatively, a sharp decline in volatility goes together with considerable positive returns.

6. Conclusions

Stock market volatility tends to be sticky – meaning that the volatility level over a certain period remains more or less stable until some material changes in macro-economic variables are recognised, for example, increased uncertainty about future interest rate policies. The uncertainty will cause volatility to spike and a new pattern of volatility is established, which will continue until more certainty about future monetary policies are installed. At that stage volatility might calm down rapidly until it settles down at some normalised level.

The above pattern is fairly predictable[4] – although the underlying forces driving volatility are not – and has some important implications for stock market investors:

For example, in this study we found that investors on the aggregate should be doing well while volatility is benign and at below-average levels. However, some macro-economic shocks may cause volatility to spike, which normally leads to sharp negative returns. Thereafter, the continuous uncertainty will cause volatility to move within above-average and high volatility levels. Positive returns at this stage are still very much a possibility, although large negative returns can occur, especially when volatility reaches extreme levels. Eventually, favourable macro-economic news will lead to a sharp reduction in volatility, accompanied by strong positive returns, until volatility eases out at an average or below-average level and the cycle is repeated.

At present (June 2006) stock market volatility has shot up with the uncertainties surrounding future interest rate policies and we experienced the consequential sharp sell-off (negative returns) in our market. Going forward, I expect volatility to move in the third quartile range (above-average level) until macro-economic conditions turn favourable again. Thus, one can expect predominantly positive returns, but with some negative returns in between, from the stock market in the forthcoming months. Overall, expect a moderate to subdued stock market performance.

[1] G.W.Schwert, 1989. "Why Does Stock Market Volatility Change Over Time?" *The Journal of Finance*, 44(5), 1115-1153.

[2] When I started with the project early May 2006 I was of the opinion that the stock market volatility topic could soon be relevant for investors, yet little did I know that merely two weeks later it was a very hot topic indeed as some dramatic down- and upward movements in stock prices started to occur!

[3] Karmakar, M. 2006. "Stock Market Volatility in the Long Run, 1961-2005" *Economic and Political Weekly*, May 6, 1796-1802.

[4] I do not necessarily consider my findings about volatility patterns to be a "sharp predictive" tool, but rather a "blunt expectations" tool.