A Close Examination of Canadian Stock Market Volatility

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Abstract

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This paper examines stock market volatility using daily returns from the Toronto Stock Exchange 300 Price Index, for the time period of January 1st, 1977 through December 31st, 1997. More specifically, the dates on which volatility shifts occurred during this sample period are identified, using the methodology of Haugen, Talmor & Torous (1991). Furthermore, I investigate the extent to which extraordinary macro-economic events are associated with the identified shifts in volatility. Next, I examine how stock prices react immediately following the volatility shifts. In addition, I examine how future realized returns behave due to these same volatility shifts.

My findings are as follows. First, I find that the majority of Canadian volatility shifts are associated with macro-economic events. Also, I find that an increase in volatility is more likely to be followed by another increase in volatility than a decrease in volatility and vice versa. Second, I find that an increase (decrease) in volatility causes stock prices to drop (rise). Third, I find that both an increase and a decrease in volatility cause future realized returns to rise. This last finding contradicts the theory and demands further research.

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I. Introduction

Stock market volatility has been a vital research topic in finance for many years. A great number of studies have been published on various aspects of stock volatility using US data. However, research on Canadian stock market volatility is surprisingly limited. In particular, the study of Calvet & Rahman (1995) on Canadian stock return volatility, is the *only* one I was able to identify throughout my literature exploration. Researchers might assume that US volatility results hold for Canadian data as well, since the two countries are highly integrated economically. It is extremely important to realize that Canada and the US possess major differences, which are very likely to affect their corresponding stock market volatility in distinct ways.

First, Canada's economy relies heavily on natural resources while the US economy relies mostly on manufacturing and technology. Second, the political environment in Canada and the US are very different. Canada experiences great levels of political uncertainty due to the separation issue of Quebec. Third, Canadian taxes are a lot higher than those of the US, which reduces Canadian disposable income severely. As a result, Canadian citizens are likely to have different savings, investment and consumption patterns as compared to American citizens. Fourth, the Canadian stock market is a rather "young" market as compared to the US stock markets. In addition, the recent Asian crisis has greatly affected the Canadian economy however, the US economy was not affected to the same extent. In summary, it is clear that the two countries are not similar enough in order for their stock markets to be moving in like manners. In other words, the volatility patterns and the volatility effects of the Canadian stock market could be different from those of the US. The present study examines Canadian stock market volatility in great detail. Daily data are used from the Toronto Stock Exchange 300 Price Index (TSE 300 Index) for the time period of January 1977 through December 1997. By closely following the work of Haugen, Talmor & Torous (1991) (HTT henceforth), the present study identifies the volatility shifts that occurred during this sample period as well as how subsequent prices and realized returns were affected by those shifts. It is important to emphasize that to this date, the HTT methodology has not been used in studying Canadian stock market volatility. I provide a detailed review of HTT's paper in section II.b. since it is the foundation of this thesis.

The choice to follow HTT, rather than other volatility studies lies in the advantages of their methodology. The first advantage is that the researcher is able to identify the exact date on which a volatility increase and/or decrease took place. The second advantage is that using these dates, the researcher can examine whether volatility shifts are associated with particular macro-economic events. Third and most important, the methodology allows one to examine how stock returns react immediately after the volatility shifts as well as, how future realized returns behave due to those same shifts. Another advantage of using the HTT methodology is that it has not yet been used to test Canadian stock market volatility.

HTT perform their study using daily returns from the Dow Jones Industrial Average (DJIA), for the time period of 1897 through 1988. First, HTT identify the dates on which volatility shifts occurred. Moreover, they attempt to explain these variance shifts with macro-economic events. For the most part, HTT argue that volatility shifts cannot be associated with such events. Second, HTT hypothesize that volatility increases (decreases) will cause immediately following returns to drop (rise). This is because investors revise their discount rates due to volatility. An increase (decrease) in volatility causes investors to increase (decrease) the discount rates. Keeping cash flows constant, this revision in discount rates causes stock prices to drop (rise). Since prices have dropped (risen), stock returns will also drop (rise). The results of HTT support this hypothesis. Third, HTT hypothesize that an increase (decrease) in volatility will cause future stock returns to increase (decrease). The reason is that investors will require higher (lower) returns for higher (lower) levels of risk, as quantified by volatility. The results of HTT provide supporting evidence for this hypothesis as well.

In the present study, I identify 39 statistically significant volatility increases and 36 significant volatility decreases. I find that the majority of volatility shifts can be associated with macro-economic events. Further, I find support for the second HTT hypothesis but not for the third HTT hypothesis. The results are discussed in more detail later in the paper.

In reading this paper, the reader must always keep in mind that it covers 20-years of data, while the HTT study covers 92-years of data. Therefore, direct comparisons cannot be made among the results of the two studies. Moreover, the present study includes data from the 1990s which are not included in the HTT paper. This difference is important since during the 1990s stock market dynamics have drastically changed, especially in the North American markets. This signifies the fact that comparisons between the two studies must be avoided or made with caution.

The paper is organized as follows. Section II reviews the finance literature on volatility in detail. Section III analyzes the methodology used to identify volatility increases and volatility decreases. Section IV unveils the characteristics of the identified volatility shifts. Section V shows how volatility shifts relate to important news releases. In Section VI, presents the results of how stock price returns behave immediately after changes in volatility. Section VII, reveals how future realized returns react to volatility shifts. Finally, Section VIII concludes the paper and Section IX presents ideas for future research.

II. Literature Review

Stock price volatility is an extremely important concept in the finance field for numerous reasons. Just to mention a few, accurate volatility forecasts are essential in portfolio selection, asset management and for the pricing of futures, options and other derivatives. Moreover, the pricing of the latter financial instruments is essential in forming effective hedging strategies.

More precisely, understanding stock market volatility will enable us to evaluate options and other derivatives, more accurately. Merville & Pieptea (1989) argue that since the Black & Scholes (1973) option pricing formula assumes constant variances and since such an assumption does not hold completely, models that allow for changes in volatility can enhance the option pricing methodology. Moreover, it is clear that the finance field is incorporating the concept of options in a growing number of ways, as time elapses. That is, their usefulness is growing very rapidly. As a result, the continuous improvement of option-pricing models will become even more vital in the future. Rendleman & O'Brien (1990) reveal the importance of misestimating volatility in insuring one's assets with the purchase of put options. Their result reinforces the need for us to build models, which do not assume constant variance.

Second, as put by Schwert (1989), movements in the stock market influence several economic factors, such as consumption, as well as capital investment. Therefore, understanding volatility is extremely important for a nation's economy.

Third, once we are able to understand volatility in our domestic market, then we will be ready to comprehend whether volatility spillovers exist between markets. As shown by Hamao, Masulis & Ng (1990), the Japanese stock market is rather sensitive to volatility shifts in the Standard & Poors 500 Composite (S&P) Index, as well as in the Financial Times-Stock Exchange 100 Share (FTSE) Index. Therefore, investors who seek to benefit from international diversification must be careful of such volatility associations.

Last but certainly not least, erroneous assumptions about stock market volatility can lead to misleading and inaccurate empirical results. Schwert & Seguin (1990) examine heteroskedasticity in stock returns and how it affects financial empirical testing. They find that assuming homosketasticity can lead to inaccurate results and conclusions.

The literature on stock price volatility agrees on one key phenomenon. There is evidence of severe movements in stock prices, and the sources of this have not been explained completely. Several researchers attempt to explain the stock price volatility phenomenon. These include: LeRoy & Porter (1981), Shiller (1981a,b), Grossman & Shiller (1981), Long (1981), Pindyck (1984), Poterba & Summers (1986), Schwert (1989, 1990), Bulkley & Tonks (1992) and many more. Consequently, a great number of explanations for stock volatility have been proposed in the literature. I have created eleven groups of such explanations:

1. This group of studies deals with changing future dividends, non-stationary discount rates and changing risk-premia.
2. The second group deals with the effects of macro-economic news on volatility.
3. This group connects trading volume to stock volatility.
4. The fourth group examines the volatility effects of trading structure.

5. Financial leverage and personal leverage are investigated as potential factors.
6. Micro-variables such as: acquisition announcements, stock-splits, as well as dividends & earnings announcements and firm-size effects are reviewed.
7. Market characteristics, such as market thinness are investigated.
8. Fads and bubbles in asset prices are offered as potential volatility explanations.
9. This group includes studies of how volatility in one market affects volatility in other markets.
10. This group includes volatility studies which concentrate on options and futures markets.
11. Finally, the last group contains several miscellaneous studies that do not fit into the above ten groups.

All in all, I summarize volatility studies from 1976 through 1999, in order to provide the reader with as much of a complete story on volatility as possible. I organize these studies based on the above eleven groups. Next, I thoroughly review the study of HTT (1991) in a separate section, since as indicated previously, their work is the foundation of this thesis.

II.a.i. Review of the 1st Group of Studies

The first group of studies attempts to explain stock price volatility with changing future dividends, non-stationary interest rates and/or changing risk-premia. Present Value is one of the fundamental concepts in finance. It states that the value of an asset should be equal to its discounted future expected cash flows where a constant discount rate is used. Therefore, it makes sense to suggest that news that may alter the distribution of future dividends might explain stock price volatility. Shiller (1981b) states that this is a "reasonable story to tell, when people ask what accounts for a sudden movement in stock price indexes" (p.421).

A number of well-known studies examine whether the volatility of stock prices can be explained by the volatility in the future dividends. These studies include LeRoy & Porter (1981) and Shiller (1981a,b). Specifically, LeRoy & Porter (1981) are the first to report that stock prices move to a much greater extent than would be anticipated by the present value model. Shiller (1981a,b), confirms the above conclusion. He claims that the movements in stock prices are "too big" to be attributed to the changes in the present value of expected dividends. Particularly, he suggests that stock price volatility is "five to thirteen times too high—to be attributed to new information about future real dividends" (p.433). In addition, Shiller highlights the stock market decline during the period of 1929 through 1932. The author emphasizes that these declines could not possibly be explained by subsequent dividends, earnings, variations in future discount rates.

Two explanations are provided by Shiller in response to these results. One possibility is that ex-ante interest rates experience large movements, hence the discount rates are not constant through time. A second possibility is the presence of fads in the stock markets. For one, Shiller strongly dismisses the possibility that data errors, forecasting errors and/or price index problems are to blame for the movements in stock returns. Therefore, the question remains; what causes stock price volatility?

As suggested by Shiller (1981), Long (1981) also claims that unstable discount rates might explain the high volatilities. In like manner, Grossman & Shiller (1981) argue that the volatility of stock prices can be due to information releases on discount factors. On the other hand, Pindyck (1984) suggests that the volatility in stock prices is due to changes in risk, which in turn, cause changes in risk premia. However, Poterba & Summers (1986) state that they doubt that volatility fluctuations, and the movements in equity risk premia which they induce, can explain a large fraction of the variation in the stock market's level. In addition, they report that volatility shocks disappear fast; therefore, their effects on stock prices will exist only for short time intervals, (one to six months). In short, Poterba & Summers (1986) claim that their results intensify the mystery underlying the extensive volatility of stock prices. That is, they argue against the possibility that changing discount rates and/or risk premia cause stock price volatility.

Further, French, Schwert & Stambaugh (FSS), (1987) argue that none of the above studies presents a direct test for the relation between expected risk premiums and volatility. As a result, their study aims to eliminate this gap. Specifically, FSS investigate the link between market volatility and stock returns by exploring the intertemporal relationship between the volatility of the stock market (risk) and the expected market risk premium. The latter variable is used in calculating expected returns. Therefore, the underlying relationship the authors aim for is how market volatility and expected returns are connected. More specifically, they question whether the expected risk premium is positively related to the risk measured through the volatility of the stock market. FSS use ARIMA and GARCH-M statistical models to separate market volatility into two parts: expected and unexpected. Their goal is to understand the extent to which monthly stock returns react to each type of volatility during the period of 1928 through 1984. They find a significant negative relationship between stock returns and unexpected volatility changes. On the other hand, they find a significant positive relationship between stock returns and the expected component of volatility. They conclude that stock market volatility is very persistent; and that there is a positive relationship between ex-ante volatility and expected risk. FSS argue, however, that their results are rather uncertain due to the fact that risk premia are very likely to be affected by more factors than those used in their study.

II.a.ii. Review of the 2nd Group of Studies

In the second group of volatility studies, researchers investigate whether stock price volatility can be attributed to macroeconomic variables. Cutler, Poterba & Summers (1989) analyze monthly stock returns for the 1923-1985 period, and annual returns for the 1871- 1986 period. The authors estimate the proportion of variation in aggregate stock returns that can be explained with economic news, such as, macroeconomic variables and world news. They find that news can explain only one-third of total volatility in stock returns for both periods studied. They state that "it is difficult to link major market moves to the release of economic or other information" (p.9). This conclusion is consistent with Roll (1988), who reports that readily available measures of news can justify only a small portion of total volatility in stock returns. More specifically, Roll (1988) uses individual stocks in an attempt to see how stock price changes relate to the flow of news. He conducts a contemporaneous regression and reports that fewer than 40% of price changes can be explained by regressing stock price changes to news releases.

Furthermore, Fama (1990) conducts a similar regression, but on the aggregate stock market movements. He finds that production growth rates can explain 43% of return volatility.

Similarly, Schwert (1989) concentrates on the possible association of stock market volatility with: (1) macroeconomic volatility and (2) economic activity. Monthly data are used from the S&P 500 composite portfolio for the period of January 1857 through December 1987. In addition, daily data are used from the DJIA, for the period of February 1885 through December 1927. Back then, no study had attempted to explain "why volatility is higher at some times than in others" (p.1116), hence Schwert attempts to do so. Consistent with the pre-mentioned studies, Schwert concludes that overall, news on macroeconomic activity cannot explicate stock market volatility. Nevertheless, the results indicate that stock market volatility is higher during recessions. More specifically, variables such as monthly and daily stock returns, industrial production, PPI inflation rates and short-term interest rates are more volatile during recessions. An explanation is that during recessions financial leverage increases, therefore the volatility of leveraged stocks rises.

Schwert (1990) re-confirms that volatility increases during recessions. For this study, Schwert uses monthly, daily, as well as 15-minute returns in the S&P 500 index, for the period of February 1, 1983 through October 19, 1989. The results hold for all three data samples. First, the results show that volatility in the 1980s was normal overall, with the exception of the 1987 crash. Second, Schwert observes that large increases in prices are followed by eventual large drops and vice versa. Third, he concludes that extreme returns appeared at the same time as high volatility. Fourth, the prices of futures contracts react more severely to high volatility as compared to the prices of stocks. One explanation is that lower transaction costs are associated with futures contracts, hence prices adjust faster to new information.

Another study that examines whether fundamental economic factors can help explain volatility is that of Spiro (1990). In particular, this study explores the aftereffect of interest rate shifts to stock price volatility. Using actual values of GNP and actual real interest rates, Spiro is able to obtain a good forecast of changes in volatility direction. In addition, interest rates are mostly responsible for the excess short-term volatility of stock prices.

Ederington & Lee (1993) investigate the effects of scheduled macroeconomic news on two markets: (1) the interest rate and (2) the foreign exchange futures markets. Some of the macroeconomic variables examined are the Consumer Price Index (CPI), employment, GNP, Federal Budget, Industrial Production, Producer Price Index (PPI), and Personal Income. Ederington & Lee find that the prices of these two markets are most volatile in the five minute interval of 8:30 – 8:35 Easter Time of each trading morning. Moreover, the first minute incorporates the largest price movement. It is important to note that these markets open at 8:20, hence high volatility is observed ten minutes later. In addition, they emphasize that news on most of the above macroeconomic variables are released at exactly 8:30 each morning. Consequently, they hypothesize that a relationship might be present between volatility and the news releases of these macroeconomic variables. The authors examine the intraday five minute-segment prices in these markets and find support for this hypothesis. In addition, they find that volatility is higher on Fridays, as compared to the remaining days of the week. Further research demonstrates that macroeconomic announcements usually occur on Fridays. Ederington & Lee separate Fridays with such announcements and Fridays with no such announcements. They find that on Fridays with no macroeconomic news releases the volatility from 8:30 to 8:35 is flat. However, Fridays with news releases reveal high volatility between 8:30 and 8:35. The macroeconomic variables with the greatest volatility effect are: CPI, PPI and employment, the latter being the most important. The authors claim that volatility declines sharply after about fifteen minutes. However, it is still much higher than normal. A few hours later, volatility is still present where as on a day with no announcements this volatility does not even appear. There are two explanations for this: (1) either the market is slow in incorporating new information, thus there are profit opportunities, or (2) information is released slowly and the market is efficient in adjusting the prices as more detailed news become available. In the latter case, the market is efficient hence no profits can be made.

A few years later, Ederington & Lee (1996) re-examine the effect of news on market volatility. This time they measure volatility with implied standard deviation (ISD) in three option markets: the T-Bond, Eurodollar and the Deutschemark options markets. News are separated into two groups: scheduled and unscheduled announcements. Scheduled announcements include the PPI as well as the employment report. Unscheduled announcements are any type of news that the market does not know of ex-ante. The authors test two hypotheses. First, they hypothesize that volatility will be high prior to the release of a scheduled announcement since the market already anticipates this information. However, volatility will decline to normal levels, once this announcement is actually made because the market has already incorporated the information in its prices ahead of time. Second, they hypothesize that an unscheduled announcement will increase volatility, as measured by ISD, and that this high level of volatility will last for the remaining life of the option. The results support both of these hypotheses. In addition, Ederington and Lee find that volatility is higher on Mondays and lower on Fridays. This is in agreement with their earlier study, in which they report that scheduled news such as PPI are made on Friday. Thus, based on the results of the present study it is implied that on Mondays unexpected announcements usually take place. Moreover, this result is in agreement with Harvey & Whaley (1992) who use stock options (S&P100) in measuring ISDs. At the time, Harvey & Whaley explained their result as a pattern created by the buying and selling activity of traders. Finally, the authors reveal that no profits can be made using these findings, which is also in agreement with Harvey & Whaley (1992).

Calvet and Rahman (1995) use a generalized autoregressive conditional heteroscedasticity (GARCH) model to investigate the volatility of the daily stock returns in the Toronto Stock Exchange from 1976 to 1991. Moreover, they consider how changes in US monetary regimes affect Canadian conditional volatility. The authors suggest that changes in US monetary regime influence US interest rates, which in turn are very highly correlated with Canadian interest rates. As a result, US regime changes are hypothesized to affect conditional volatility in the Canadian market. In addition, they state that most severe price changes experienced by the Toronto Stock Exchange can be attributed to either movements on the New York Stock Exchange (NYSE) or to interest rate policy changes in the US. The authors divide their sample period into three sub-periods, each corresponding to a different monetary regime. They find that changes in monetary regime influence the mean and variance of stock returns.

They then turn to the effects of (1) outliers and (2) seasonal anomalies on the conditional mean and variance of stocks. Once the outliers are removed, the duration of volatility is reduced. As a result, the authors question whether shifts in monetary regimes or outliers are more responsible for stock return volatility. They research for macroeconomic news that are associated with the outliers and find that most of them are connected to the arrival of economic or political news. More importantly, a good proportion of these news are from the US. In all, the authors claim that when using GARCH models to measure conditional variances, researchers must account for changes in monetary regimes. If not, conditional variances will seem to be more persistent than in reality. Furthermore, when eliminating outliers, the volatility persistence is reduced further. However, seasonal anomalies do not help reduce the persistence of volatilities beyond the reduction achieved with the elimination of outliers. The authors promote future researchers to further examine their relation between stock price changes and outliers.

II.a.iii. Review of the 3rd Group of Studies

The third group of studies examines whether stock return volatility is related to trading volume. In particular, French & Roll (1986) report that stock volatility is higher during trading hours than during non-trading hours. Their study tests three hypotheses that could explain this phenomenon. The first hypothesis states that volatility is higher when the exchange is open, because public information is more likely to be communicated during regular business hours. The second hypothesis suggests that volatility is higher when the exchange is open, because private information is incorporated in the prices through active trading. Finally, the third hypothesis states that large movements in prices occur due to pricing errors that take place only during trading hours. French & Roll conclude that 4% to 12% of daily return variance is due to mispricing. In addition, they find that the behavior of returns during non-trading hours suggests that private information is the predominant factor behind the high trading variances.

Schwert (1989) explores how stock market volatility relates to stock trading activity. He confirms the results of French & Roll (1986), in that trading activity and stock volatility are positively related. However, he is not able to explain the cause of this relationship. He suggests that trading volume and high volatility could just as well be due to the arrival of big news. Moreover, Schwert (1990) explores whether automated trading increases volatility, but does not provide a conclusive answer. Nevertheless, his advice is that past data on intraday volatility is needed in order to test whether such volatility has increased through the years. Unfortunately, such historical data is not available.

Lockwood & Linn (1990) study hourly DJIA stock returns and compare the levels of intraday return volatility with overnight volatility, for the years of 1964 to 1989. The results indicate that hourly stock return variances follow a U shape. That is, they keep declining from the opening hour and start rising later in the trading day. In addition, stock market return variance is significantly greater during the day, as compared to overnight variance. This is in agreement with French and Roll (1986) and Schwert (1989).

In the study of Amihud & Mendelson (1991), Japanese data are used to examine the volatility behavior of stock returns based on the trading mechanism. This is also an indirect test of the effect of trading volume on volatility. The authors define the two mechanisms of trading, the first being the *continuous dealership market* and second, *the periodic clearing procedure*. In a continuous dealership market traders buy/sell based on the quoted bid-ask prices of the market makers. The periodic clearing procedure gathers all the buy and sell orders over a specific time period. Then, a price is determined at which supply equals demand. Stock markets are debating on which trading mechanism is more efficient. Hence if the authors find higher levels of stock volatility for one trading mechanism, stock markets ought to consider such trends in their decision making. Amihud & Mendelson decide to use the Tokyo Stock Exchange, since both types of transactions occur each day. The first clearing transaction opens the new trading day in the morning and is then followed by continuous dealership trading. The second opens the afternoon trading section of that same day and is then followed by continuous dealership trading. The difference between the two clearing transactions is that the first follows the long overnight non-trading period, while the second follows only a few hours of no trading in the middle of the day. This enables the authors to determine whether higher levels of stock return volatility are due to the length of non-trading periods or due to the trading mechanism. Such an experiment would not be possible using North American markets, since the clearing process follows the overnight long period of non-trading. In addition, the authors use return autocorrelations in order to test for market efficiency. Amihud & Mendelson find that trading volume does indeed influence the level of volatility. Their results are in agreement with French & Roll (1986) and Schwert (1989). Also, they find that the high volatility observed at the beginning of the trading day, as well as the negative autocorrelations (inefficient market), are associated with the number of elapsed non-trading hours, not with the type of trading mechanism. In other words, the authors conclude that volatility is related with trading and the "private information it reveals" (p.1779), as suggested by French & Roll (1986). Furthermore, the authors suggest that "noise" also might be influencing volatility. They find that stocks that trade on the Tokyo Stock Exchange and on the NYSE reflect less noise induced volatility. Hence, they suggest that active stocks that are traded globally, can help reduce noise. In all, the authors conclude that stock markets that incorporate both types of mechanisms alternative during the trading day, will experience less volatility and more efficiency.

Foster & Viswanathan (1993) examine trading costs and how they relate to trading volume and stock return volatility. The models of two older studies are basically tested. The following table provides the major points of each of these earlier studies.

Admati & Pfleiderer (1988)	**Foster & Viswanathan (1990)**
➢ Intraday data are used.	➢ Interday data are used.
➢ Trading costs are low when volume is high.	➢ Trading costs are low when volume is high.
➢ Trading costs are low when prices are more volatile.	➢ Trading costs are low when prices are less volatile.
	➢ Find a weekend effect in volume and volatility. Therefore, volume is lower on Monday and trading costs are high on Monday.

The study at hand tests the null hypothesis that trading volume is invariant through time. Particularly, this hypothesis is tested for both interday and intraday trading. The results reveal that trading volume varies significantly from day to day, only for the most actively traded stocks.

On the other hand, when examining intraday trading volume, all types of stocks, have the highest volume during the very first half-hour and the lowest, in the middle of the day. In all, these results are consistent with both the earlier studies.

Next, the authors examine how changes in stock return volatility and trading costs are related to trading volume changes. They claim that stock return volatility represents the degree of information flow. In other words, high volatility in stock returns suggests that more information is entering the prices. As a result, investors form their trading strategies accordingly. The results reveal interday stock return variations only for the most widely traded stocks. Moreover, such volatility is not significant. On the contrary, intraday stock return volatility is significant for the majority of stocks. This is consistent with the finding for trading volume.

In summary, the authors find that trading costs do not vary significantly neither within the day nor across days. However, trading volume jumps high in the first half-hour of the trading day and reaches the lowest point in the middle of the day. This is inconsistent with the Admati & Pfleiderer model. In addition, trading volume is low on Mondays as compared to the rest of the weekdays, only for actively traded stocks. This is consistent with the Foster & Viswanathan model. Also, intraday trading volume is the highest when returns are most volatile. No significant relation is found for interday trading volume and stock return volatility. Finally, the authors are unable to explain why high trading costs appear when trading volume is high. They urge future researchers to try and find such an explanation.

Foster & Viswanathan (1995) built upon the results of Foster & Viswanathan (1993). They examine the effect of speculative trading on the volume-volatility relation. The stock of IBM is used in this study, in particular half-hour data on IBM's volume and prices are collected for the year of 1988. The authors report that speculative trading does not help understand the volatility-volume relationship.

Jones, Kaul & Lipson (1994) is another study that examines how stock return volatility is affected based on trading and/or new information. This study concentrates on the short-run volatility behavior of stock prices. One <u>key</u> difference in this study is the definition of non-trading periods. That is, businesses and stock markets are open, however, traders choose <u>not</u> to trade.

There are two advantages in using this unique non-trade period definition. First, there is no way of predicting when such non-trading will occur. Second, the information flow is continuous through these non-trading periods, since businesses and stock exchanges function regularly. In the past, researchers[1] defined non-trading as a time-period when the stock markets and business were closed. That is, overnight or on holidays, which makes such periods predictable. Also, no information was flowing in the stock markets during such of non-trading periods. As a result, researchers were unable to detect what is really moving stock prices: Is it the fact that no trades take place or that no new information is incorporated into the prices? Surprisingly, the authors find that a considerable amount of volatility in stock prices, (20-30%), occurs when the stock markets are open, but no trading takes place. In all, the authors claim that public information is the key ingredient of short-term stock price volatility, not private information. This is opposite to the conclusions of French & Roll (1986) and Amihud & Mendelson (1991).

Yet another study that explores the relationship between trading volume and return volatility is that of Andersen (1996). He focuses his study on interday data instead of intraday, which has been widely used by other authors. The "Mixture of Distribution Hypothesis" (MDH) suggests that returns and volume both depend on a specific informative variable. MDH assumes that the information flow makes volatility stochastic. Andersen tests for the MDH using five heavily traded stocks on the NYSE in the period of 1973 through 1991. These stocks include: IBM, Coca Cola, Kodak, Alcoa and Amoco. The author suggests that by making the test bivariate, that is, include both volume and returns, instead of just returns, volatility persistence can be substantially reduced. This is consistent with Foster & Viswanathan (1995), who use both return and volume in measuring volatility for IBM. Andersen is able to show that the modified MDH fits the data better. Hence, when measuring daily return volatility, one can achieve more accurate estimates by utilizing trading volume in combination with returns, instead of using returns alone. Thus, even if Andersen rejects the standard MDH, he suggests that a simple modification makes the MDH a more accurate tool to use, as compared to ARCH techniques. Future researchers are advised to take these results into consideration. In summary, the author

[1] An example being French & Roll (1986)

suggests that volatility persistence can be biased downward and in order to minimize such bias researchers must: (1) test as to whether different information flows affect trading volume as compared to returns and (2) test how intraday volatility relates and affects interday volatility.

II.a.iv. Review of the 4^{rth} Group of Studies

The fourth group of studies concentrates on whether market structure affects market volatility. For instance, Schwert (1990) examines the effects of trading halts in stock market volatility. The purpose of circuit breakers is to halt trading once volatility is moving beyond a certain upper bound. Finally, the author suggests that in the past trading halts end up increasing volatility instead of decreasing it. He promotes future research to examine this topic more closely.

Subrahmanyam (1994) also inquires the true effects of circuit breakers on market volatility. He empirically shows that circuit breakers end up having the exact opposite effect on market volatility; that is, they increase it, causing stock prices to move more than before. This is in agreement with Schwert (1990). Moreover, when a circuit breaker is introduced in one market, traders shift their actions in other markets where there is no such halting. As a result, high volatility levels are transmitted into other markets as well. The author advises policy makers to recognize that the current regulations have the opposite result of what they intended, hence improve or eliminate them in the future.

Lockwood & Linn (1990) test the effect of specific changes in the structure of financial markets on market return volatility. These structure changes include (1) the opening of NASDAQ in 1971, (2) the standardization of stock options in 1973, (3) the negotiable commissions in 1975, (4) the beginning of stock index futures in 1982 and (5) the increased margin requirements for stock index futures in 1988. They report that the level of stock market volatility changes through time. They are able to connect shifts in volatility levels to the financial structural changes mentioned above. More specifically, the market variance is found to increase after the introduction of NASDAQ in 1971, after the options are standardized in 1973 and in 1982 after the beginning of stock index futures. A general decline in the market variance is reported after the commission period and after the increase in margin requirements.

II.a.v. Review of the 5th Group of Studies

The fifth group of studies uses financial and/or personal leverage as an explanation of stock price volatility. Schwert (1990) explains that when a firm replaces equity with debt, its risk increases, thus the volatility of its returns rises. High personal leverage seems to be affecting volatility in a positive manner as well. That is, as people borrow in order to invest in the stock market, the volatility of stock returns rises. Black (1976) and Christie (1982) suggest that such leverage is related to the dramatic movement of stock prices. Schwert (1989) tests the relationship of stock volatility and financial leverage. He finds that financial leverage explains only a small fraction of stock market volatility through the time period studied. Furthermore, FSS (1987) suggest that changes in volatility are "too large" to be fully explained by firm leverage alone.

Engle & Ng (1993) aim to enhance the work of Black (1976), Christie (1982), FSS (1987), Schwert (1990) and Pagan & Schwert (1989). They measure the impact of bad and good news on volatility and report an asymmetry in stock market volatility towards good news as compared to bad news. More specifically, market volatility is assumed to be associated with the arrival of news. A sudden drop in price is associated with bad news. On the other hand, a sudden increase in price is said to be due to good news. Engle & Ng find that bad news create more volatility than good news of equal importance. This asymmetric characteristic of market volatility has come to be known as the "leverage effect". The studies of Black (1976), Christie (1982), FSS (1987), Schwert (1990) and Pagan & Schwert (1989) also explain this volatility asymmetry with the "leverage effect". However, their models do not capture this asymmetry. Engle & Ng (1993) provide new diagnostic tests and models, which incorporate the asymmetry between the type of news and volatility. They advise researchers to use such enhanced models when studying volatility.

II.a.vi. Review of the 6th Group of Studies

The sixth group of studies examines how firm micro-news affect stock price volatility. For instance, do earnings and dividends news affect volatility? Does the size of the firm relate to volatility? Do acquisition announcements affect volatility? How about stock splits?

Schwert (1989) examines how dividends and earnings relate to stock returns five years into the future. He concludes that there is no particular relationship between either of these two variables and stock price volatility. Furthermore, Fama (1990) reports that only about 30% of the volatility in stock prices can be explained by variables such as the cash flows of the firms and the discount rates of investors.

Schwert & Seguin (1990) argue that certain firms are more susceptible to market volatility than others. More precisely, small more volatile firms are "four times more sensitive" (p.1137) to market volatility than large firms. However, Jones, Kaul and Lipson (1994) argue that large firms experience more volatility when no trades occur.

Conrad, Gultekin & Kaul (1991) explore the differences between the volatility predictability of the conditional variances of (a) large firms and (b) small firms. They use weekly returns to form three-size based portfolios with (1) NYSE stocks and (2) AMEX stocks. The twenty-six year period studied is from 1962 through 1988. In order to model the conditional mean and variance of stock returns, the authors use univariate and multivariate ARMA-GARCH-M techniques. The results indicate that volatility shocks in large firms can very well predict future returns for both large and small firms. However, volatility shocks in small firms are "never" useful in predicting such future returns in large firms. The authors divide their sample period in two groups to verify the robustness of their results. They confirm that the asymmetry they found is not specific to the time period examined. In addition, they find that large changes in stock prices are followed by subsequent large changes of either positive or negative direction. Similarly, small changes in stock prices are more likely to be followed by small changes of either sign. In all, the authors are not able to explain their asymmetric findings. Nevertheless, they urge future researchers to consider this firm-size-predictability asymmetry.

Copeland & Copeland (1999) use changes in the Market Volatility Index of the Chicago Board Options Exchange. They find that after volatility increases, portfolios of large-capitalization stocks perform better than portfolios of small-capitalization stocks. Moreover, following volatility increases, value-based portfolios perform better than growth-based portfolios. On the other hand, after volatility decreases, small-cap portfolios outperform large-cap portfolios. In like manner, growth-based portfolios outperform value-based portfolios after volatility decreases.

Jennings & Mazzeo (1991) conduct an interesting study on stock price volatility near acquisition announcements. The purpose of their study is to identify a potential relationship between stock price volatility around such announcements and the actual result of the acquisition. That is, was the acquisition cancelled or not? Was this decision related to the way prices moved around the announcement date? If the answer to the latter question is yes, the authors believe that managers wait to see how their firm's stock reacted to the announcement in order to decide whether to go for the acquisition or not. The results provide little support. That is, managers do not seem to learn from the way stock-prices react to the announcement. In other words, their decision about the acquisition is not related to such information.

Patell & Wolfson (1984) explore how dividend and earnings announcements affect intraday stock price volatility. They find that such announcements very quickly increase stock price volatility for about five to ten minutes. Volatility remains high until the next day; however, any potential profits dissolve within the first ten minutes after the announcement(s). The authors also report that, for intraday stock volatility, a price increase is most likely to be followed by another price increase, and almost half as often by a decrease. Similarly, a price decrease is most likely to be followed by another price decrease. Moreover, they find that earnings announcements create greater movements in prices, as compared to dividend announcements. In all, the authors conclude that the market adjusts very quickly to public information.

Koski (1998) looks for patterns in the variance of returns after stock splits. In the past researchers have shown that after stock splits, stock return volatility increases (see Ohlson & Penman, 1985; Dravid, 1987). Also, he examines how stock returns are related to the bid-ask spread and price discreteness. By price discreteness the authors are referring to the rounding of stock price returns, which are used to calculate volatility. In other words, prices are reported in 1/8 increments. However, in calculating stock return volatility, researchers round off, causing the volatility to seem larger than it really is. The current study explores how such measurement techniques affect stock split volatility changes. He finds that, after stock splits, the volatility of daily stock returns increases, even after controlling for the remaining changes of the market. In addition, he finds that bid-ask spreads do increase volatility and this is not due to measurement errors. Bid-ask spreads, however, are significant only for large splits. Moreover, price discreteness does not have a significant effect on stock return volatility. When using weekly returns, the author still finds increased volatility after all types of stock splits. However, measurement errors, price discreteness and bid-ask spreads are not related to those volatility increases. The author concludes by saying that future research is needed in order to understand why volatility increases after stock splits.

II.a.vii. Review of the 7th Group of Studies

The seventh group of studies evaluates market thinness and its effect on volatility. Pagano (1989) researches how market thinness affects stock price volatility. Based on past studies, it appears that thin markets face higher levels of volatility as compared to deep markets. (Pagano, 1986; Tauchen & Pitts, 1983). That is, in a thin market there are fewer transactions taking place; hence, prices are very sensible to the actions of a few traders. Such price sensitivity is not present in deep markets. Pagano shows that thinness affects stock market volatility independent from the volatility of asset fundamentals. He suggests that such volatility can be reduced as more transactions are made per unit time. Moreover, Calvet & Rahman (1995) and Jorion & Schwartz (1986) suggest that the thin market problem is present in Canadian stocks. Therefore, authors researching Canadian stock market volatility must keep this "problem" in mind.

II.a.viii. Review of the 8th Group of Studies

The eight group attempts to explicate stock market volatility through fads and/or bubbles. In particular, Schwert (1989) suggests that the presence of "fads" or "bubbles" might be augmenting volatility. This is in agreement with Shiller (1981). However, West (1988) reports that stock price volatility cannot be explained by "bubbles" or small sample biases. Nevertheless, West suggests that maybe "fads" are related to stock price volatility, even though such evidence is rather weak. Finally, Spiro (1990) concludes that "fads" are not the predominant cause of stock price volatility. This provides an answer to the question posed by Shiller (1981), Schwert (1989) and West (1988).

II.a.ix. Review of the 9th Group of Studies

The next group investigates how stock volatility in one market relates to the volatility in other markets. These studies are important for investors who try to diversify their stock holdings internationally. Hamao, Masulis & Ng (1990), use an autoregressive conditionally heteroskedastic ARCH model to look at how stock price changes and stock market volatility, correlate across international markets. The stock indices used are: (1) Tokyo Nikkei, (2) FTSE and (3) S&P. The authors obtain daily and intraday stock prices for the period of April 1st, 1985 through March 31st, 1988. They concentrate on the pre-crash period separately in order to separate the effects of the crash from the correlations between these three markets. When the 1987 crash is removed, there is a significant volatility spillover from the United States to Japan. When the crash is included, the results indicate volatility spillovers from the American and British markets to the Japanese market. Also, there is a weaker volatility spillover from the American market to the FTSE. These results demonstrate that markets are correlated in terms of volatility;

hence, investors who try to diversify their portfolios internationally ought to pay attention to such volatilty correlation.

In a similar manner, King & Wadhwani (1990) examine the spillover of volatility across the following markets: (1) the FT 30, (2) the Nikkei and (3) the DJIA. Strong emphasis is placed on the crash of 1987 and how the volatility of the above markets was influenced. These stock markets fell almost simultaneously and approximately to the same extent, on October 19th, 1987. The authors find this astonishing, since each of these countries faced different economic conditions at the time. Their results suggest that volatility correlation between foreign markets, rose significantly during and after the crash. The authors offer what they call a "contagion" model. This means rational traders use information from one market to trade in another. Hence, the volatility of the home market is transmitted to other markets. The authors suggest that the 1987 crash can be seen as a possible "mistake" that occurred in one market and was transported to other markets, through such trading.

Moreover, Bekaert & Harvey (1997) examine stock market volatility in emerging markets. These authors re-emphasize the importance of understanding the volatility of foreign markets in diversifying one's holdings. It is important to remember that this study focuses only on emerging stock markets and how their volatilities compare to those of developed markets. Twenty emerging markets are examined, some include: Brazil, Greece, Mexico, Portugal, Taiwan, Thailand, Turkey, Venezuela and more. The time period examined is January 1976 to December 1992. The authors report that emerging markets on average experience higher and more predictable returns than developed markets and higher volatility. Moreover, such markets are not highly correlated with developed markets. The primary purpose of this study is to examine why volatility in such emerging markets is so high. The results suggest that countries which are more integrated with the world experience lower market volatility. On the other hand, isolated countries experience higher market volatility. Also, capital market liberalizations tend to decrease the degree of local volatility in the emerging market, while increasing its correlation with the world market.

II.a.x. Review of the 10th Group of Studies

The studies in the tenth group use futures and options, instead of stocks in trying to understand market volatility. Schwert (1990) suggests that trading in futures and options contracts does not create increases in volatility. In other words, the increased volatility observed in later years is not due to the introduction of derivative-trading.

Another interesting study worth mentioning is that of Merville & Pieptea (1989). These authors use call options and futures to find that "*ex ante* volatility follows both a mean-reverting diffusion process and a noise process" (p.193). Moreover, they argue that these findings can be used in developing new option pricing models. Specifically, they argue that since the Black & Scholes option pricing formula assumes constant variances and since such an assumption does not hold completely, models that allow for changes in volatility can enhance the option pricing methodology.

Rendleman & O'Brien (1990) reveal the effects of misestimating volatility in insuring one's assets with the purchase of put options. Specifically, if a manager hedges a portfolio after having underestimated volatility, the hedge will not be strong enough. Hence, the portfolio is at risk even if the manager believes it is insured. On the other hand, if the volatility is overestimated, the hedge will be unnecessarily too high. In both cases, there are avoidable costs involved. The study shows, that during the 1987 crash, the portfolios with the lowest insurance, experienced the worse outcomes. All insured portfolios fell below their insured value during this crash, however, some fell significantly more than others. Rendleman & O'Brien (1990) suggest that the estimation of volatility is crucial in determining the best hedge possible for portfolios.

Sheikh (1993) uses call option prices to determine the relationship between implied volatilities and: (1) their own lagged value, (2) the prices of the underlying stocks, (3) interest rates, (4) forecasts of implied volatility for the market portfolio and (5) their own recent actual stock volatility, as well as that of the market. In summary, the author finds that implied volatilities are positively related with their own lagged value. This implies that the risk-return relationship is strongly revealed in these results. The higher the risk in individual stocks the higher the return expected. Also, he finds that implied volatility is negatively related to the prices of the underlying stocks, positively related with interest rates, positively related with the forecasted implied volatility of the market portfolio and their own actual stock volatility and that of the market.

II.a.xi. Review of the 11th Group of Studies

Finally, I review studies that are each unique in nature. For example, Schwert (1990b)[2] concentrates on the effects of the 1987 crash on stock volatility by examining daily stock returns prior to, during and after the crash. He studies stock return volatility using daily data from the S&P 500 Index during the period of 1885 through 1988. Specifically, his sample consists of 29,137 days. Schwert concludes that the October 19th, 1987 crash was the largest percentage change observed during those 29,137 days. In addition, the author uses call option prices and futures contracts to verify the pre-mentioned result. Furthermore, Schwert reports that stock market volatility rose severely during and after the 1987 crash; however, he emphasizes that stock market volatility quickly returned to its normal levels much faster than expected. This finding is again supported by the analysis of the contingent claims. In addition, he concludes that negative stock returns result to larger volatility shifts than do positive stock returns. The author reports three facts concerning stock return volatility. First, he argues that stock return volatility is "persistent". This implies that an increase in volatility will last for a number of periods. This is consistent with FSS (1987). Second, he reports that a stock volatility increase follows a decrease in stock prices. Last, he suggests that volatility is associated to recessions, and banking crises. However, the causes of the October 1987 crash cannot be matched to either of these explanations.

Schwert & Seguin (1990) examine the heteroskedasticity in stock returns and how it affects financial empirical testing. In addition, they examine the association of (1) aggregate volatility and (2) monthly return volatility with disaggregated portfolios of stocks. They use daily returns to the S&P Composite portfolio for the years of 1928 through 1986. The authors believe daily data is the best choice when studying volatility. Using these data, they calculate the monthly variance of returns, following FSS (1987). First, Schwert & Seguin find that stock market volatility changes over time due to a "serially correlated factor". This is in agreement with Black (1976). Second, they conclude that market volatility affects the volatility of particular stocks in the same direction. That is, if the market experiences a 2% increase in volatility, the firms whose stocks are listed in the market will also experience an increase in volatility. This is again in agreement with Black (1976). Finally, the authors suggest that many empirical tests must incorporate the heteroskedasticity of stock returns in order to lead to accurate results. For instance, the time-varying studies of FSS (1987) and Poterba & Summers (1986) are examples of financial work that need to embody heteroskedasticity. As a result, mean reversions in stock returns are likely to disappear. In addition, studies on options and other derivatives can greatly benefit from such an alteration.

Campbell and Ammer (1993) attempt to examine the behavior of volatility in a rather different way. That is, they study the volatility of stock returns in connection with the volatility of bond returns by taking into consideration the covariance between the two types of returns. They examine how stock and bond returns are affected with changes in future cash flows and discount rates. First, they find that stock return volatility can be greatly explained by expectations of future stock returns. Second, they find that stock return volatility is not related to the long-term forecasts of real interest rates. Third, they find that bond returns can be predicted using the same variables as used to forecast stock returns. Finally, the authors explain why the correlation between stock and bond returns is low. For one, the only common variable affecting both stock and bond returns is real interest rates. However, they show that real interest rates do not explain much of volatility. Secondly, inflation tends to increase the stock market, but decrease the bond market.

Fleming, Kirby & Ostdiek (1998) use daily data from the S&P 500 index futures, T-bond futures and T-bill futures. The time period covered starts in January 1983 and ends in August

[2] Schwert suggests that when measuring stock market volatility, we do not need to incorporate dividends in our data. The reason being that the ex-dividend date of each stock differs. Moreover, Schwert has tested volatility tests with and without dividends and finds no important differences.

1995. The primary goal of the authors is to test whether there are volatility linkages among the stock, bond and money markets. Such association between markets is essential in making risk management decisions. In particular, the authors suggest that volatility linkages probably occur due to two reasons: spillover information and common information. More specifically, investors hedge their holdings across markets thus influencing them all, this is referred to as information spillover. Second, macroeconomic information is likely to influence all of these markets as well, this is named common information. The results reveal that indeed these markets are linked and that volatility in one market spills over to the other markets. The correlations among these three markets are strong and positive, but not perfect as hypothesized. Moreover, after the 1987 crash, these markets have been more linked than prior to the crash. This is in agreement with King & Wadhwani (1990).

Bremer, Hiraki & Sweeney (1997) (BHS, henceforth) attempt to predict stock return patterns after large stock price increases and decreases in the Tokyo Stock Exchange for the time period of January 1981 through December 1991. They use daily data from the Nikkei 300 Index and find that after large price decreases, stock returns tend to rise, consistent with HTT. Moreover, this pattern is still present even after the 1987 crash is removed from the sample, which makes the results even more robust. BHS report that these findings are consistent with the results of American studies, particularly on the NYSE. They argue that these reversal patterns are not unique to certain countries, rather they appear to be due to the act of trading. However, after big price increases, no significant patterns in stock returns are found in the Japanese market, even if several American studies find significant patterns. For instance, HTT find that subsequent stock returns drop significantly after increases in stock prices. This is also in agreement with Lehman (1990) and Atkins & Dyl (1990). On the contrary, Park (1995) finds that stock returns following increases in prices are not statistically different from zero. Next, BHS calculate cumulative abnormal returns for twenty days prior to and twenty days after the large price change. In agreement with the DJIA results reported by HTT, BHS (1997) suggest that stock returns in the Nikkei 300 are also affected more severely after decreases in stock prices than after increases in stock prices.

II.b. Haugen, Talmor, Torous Review

The purpose of the present study is to closely examine Canadian stock market volatility. In doing so, I first identify the timing of the volatility increases and volatility decreases in the TSE 300 Index for the period of January 1st, 1977 through December 31st, 1997, following the methodology of HTT. Second, I investigate whether the timing of macroeconomic events is associated with the timing of these shifts. Third, I examine the immediate aftereffect of these identified volatility shifts on the level of stock price returns. Fourth, I analyze their effect on future realized returns. All four steps are achieved by faithfully following the procedures in the HTT paper. In this section, I therefore thoroughly review the data and findings of the HTT study. In the next section I review their methodology in more detail.

Using daily returns from the DJIA, HTT investigate stock market volatility for the 92-year period of 1897 to 1988. These authors got inspired from the work of Merton (1980), who introduced a "longitudinal" method that measures reward to risk ratios for a stock market index with stochastic volatility. In particular, HTT directly measure the movements of (1) stock prices (by examining returns) as well as (2) future realized returns to changes in volatility. Also, they attempt to link the identified volatility shifts to macroeconomic news. The HTT study is unique in the volatility literature in that it uses the moving block methodology of Wichern, Miller, and Hsu (1976) (WMH, henceforth) to identify the timing of volatility shifts. This methodology allows the authors to directly assess the effects of volatility shifts on stock prices, and subsequent realized returns. In addition, the authors are able to quantify whether increases and decreases in volatility have similar or different consequences on immediate stock prices and future realized returns.

HTT identify the set of statistically significant variance ratios between a 20-day block of stock returns and its adjacent 20-day block of returns. These significant ratios signal either a decline or an increase in the volatility of the DJIA stock returns. A two-step screening procedure is then employed in order to eliminate homogeneous occurrences. First, the statistically strongest volatility shift is kept from each sequence of volatility increases. Similarly, the most statistically significant decrease is kept from each sequence of significant volatility decreases. The first screening results in 217 volatility increases and 224 volatility decreases. Second, the authors investigate whether consecutive variance shifts, of the same direction, continue to exist after the first screening. When such a sequence is found, HTT trace the data entries that were used in calculating the variance ratios for each of the shifts that make up the particular sequence. For example, if there are three consecutive significant increases in volatility that passed the first screening, the authors examine if there is an overlap in the data used to obtain each of these three increases. If such an overlap exists, the most significant shift is kept. The same procedure holds for consecutive decreases in volatility. However, significant shifts of opposite directions are kept, even if overlapping data were used to obtain them. After the second screening is completed, 205 variance increases and 197 variance decreases prevail for the HTT study.

I will now summarize the major findings of the HTT study. First, the authors calculate the average **prior** and **subsequent** volatility for all the volatility increases.[3] This information is separately calculated for volatility decreases as well. Further, the authors obtain these data for the entire sample, as well as by decade. The results reveal that volatility increases occur when the level of volatility prior to the shift is low. Similarly, volatility decreases tend to occur when volatility is high prior to the shift. In either case, a rising shift approximately doubles volatility, as measured by the annualized standard deviation of returns to the DJIA. In like manner, a decrease in volatility approximately halves volatility.

Second, the authors attempt to explain the timing of volatility changes by linking them to the timing of the release of significant information. Overall, HTT find that only a small portion of volatility could be explained in this manner. In particular, only 11% of the volatility shifts can be associated to the release of exceptional news. The authors find that volatility increases tend to be linked to "acts of violence by individuals, countries or nature" (HTT, p.992). On the other hand, volatility decreases can be linked to statements made by politicians.

Third, using the second block, HTT estimate how stock returns react immediately after volatility shifts. They look at volatility increases and decreases separately in order to test for asymmetries in stock return reactions. For example, let us concentrate on increasing shifts, keeping in mind that the following procedure is repeated for decreasing shifts. The average holding-period returns and the average excess[4] holding-period returns are calculated for the 20-day blocks that are instantly **prior** to and **subsequent** to the identified increases. These averages are obtained for the overall time period as well as by decade. In addition, the authors perform the following statistical tests on the numbers obtained: (1) t-test, (2) non-parametric sign test and (3) the Behrens-Fisher non-parametric test.

It is important to emphasize that a change in volatility should cause returns to move in the opposite direction. As suggested by HTT, an increase (decrease) in volatility will cause risk to increase (decrease). As a result, investors will revise the discount rates upward (downward). Assuming that cash flows remain constant, such a revision in discount rates will cause prices to drop (rise). Hence such price adjustments cause stock returns to also drop (rise). In short, an increase (decrease) in volatility should cause stock returns to drop (rise).

The results reveal significant negative average returns and negative average excess returns following volatility increases. This is consistent for all the decades except for the 1970s. Similarly, significant positive average returns and average excess returns are found following volatility decreases. The only two decades that do not follow this pattern are the 1970s and the 1980s. In all, the authors conclude that the market reacts more severely to volatility increases as compared to volatility decreases. HTT emphasize that their results are in agreement with the changing discount rates hypothesis. This is in agreement with Long (1981). Moreover, HTT calculate cumulative average excess returns in order to further analyze the market reactions to volatility shifts. Once again, this is done separately for volatility increases and decreases. The results re-confirm the asymmetry of market reaction to volatility increases versus volatility decreases. In addition, HTT conclude that volatility effects remain present in the stock prices for the majority of the 20 days **following** the shift. However, the effects of volatility increases are longer lasting. Next, the authors continue their investigation on stock price movements through

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[3] Throughout this paper, the 1st **block** of daily returns is referred to as **prior** and the 2nd **block** of daily returns is referred to as **subsequent**. Also note that a shift in volatility occurs on the first day of the 2nd block.
[4] Excess returns are calculated by subtracting the appropriate risk-free rate from the daily return of the DJIA.

regression analysis[5]. The dependent variable captures the mean excess returns in the 2nd block (20 days subsequent to the shift). The independent variable is the ratio of variances in the corresponding 2nd block (leading) and the 1st block (lagging). HTT find this relationship to be significant for volatility increases, but not for volatility decreases.

Fourth, HTT estimate the effect of volatility shifts on future realized returns, following the immediate adjustments in stock prices (as quantified by studying 2nd block daily returns). Therefore, the third 20-day period is utilized for this inquisition. In particular, HTT calculate average returns for the block that immediately follows the 2nd block used in the previous set of tests. A Behrens-Fisher test is used to prove that "the 3rd block mean return for variance increases significantly exceeds the 3rd block mean return for variance decreases" (HTT, p. 998). This asymmetry is consistent with the previous results reported by HTT. Furthermore, volatility increases are associated with higher realized future returns, where as volatility decreases are associated with lower realized future returns. The explanation for this relationship stems from the notion that investors expect higher returns for higher levels of risk and vice versa. More specifically, an increase in volatility implies an increase in risk. Therefore since the risk is higher, investors demand higher expected returns to compensate for the risk. Similarly, a decrease in volatility implies a reduction in the level of risk. Hence, expected returns will drop. HTT find that these hypotheses are true by investigating the future realized returns.

In summary, the authors emphasize that their results support the notion that investors change their risk premia over time. This is in agreement with Pindyck (1984) and in contrast to Poterba & Summers (1986). Also, HTT report that "large and systematic" revisions in discount rates indeed occur as revealed by their results. This latter statement is again contrary to Poterba & Summers (1986), but in agreement with Long (1981) and Grossman & Shiller (1981). In addition, HTT report that stock price movements are caused mostly by changes in volatility and not by changes in expected future cash flows. HTT reach this conclusion because volatility increases are followed by "unusually large" future mean realized returns while volatility decreases are followed by "unusually small" future mean realized returns" (HTT, p. 1006). Moreover, HTT

[5] Once again, this regression is performed separately for volatility increases and volatility decreases.

suggest that stock market volatility might be due to the "the microstructure of the market", since they are not able to connect shifts to macro-economic events. In all, HTT suggest that changing risk premia partially explain stock price volatility. However, future research is encouraged for a more complete explanation.

As I identify in my literature review only one Canadian study has been conducted on stock market volatility. Thus, one of the aims of the present study is to fill some of this gap in the Canadian and international stock market volatility literature.

III. Research Methodology

The first step is to obtain the daily prices for the TSE 300 Index, for the period of January 1st, 1977 through December 31st, 1997 inclusive, using the Western Database. Then, the daily returns are calculated based on the following equation:

$$R_t = \ln(P_t / P_{t-1})$$

where P_t is the stock price on day *t*, and P_{t-1} is the stock price on the day immediately preceding *t*. We concentrate on the N-day sample $(r_1, \ldots r_N)$. In other words, this study will analyze 5,292 daily returns in order to identify volatility increases and decreases.

Following closely the methodology of HTT, I assume that these daily returns are independently and normally distributed with a mean of zero. Next, I form adjacent blocks of data, each consisting of 20 daily returns, corresponding to the number of trading days in a month. Also, the significance level utilized in this report will be 1%. The blocks will be formed in the following manner:

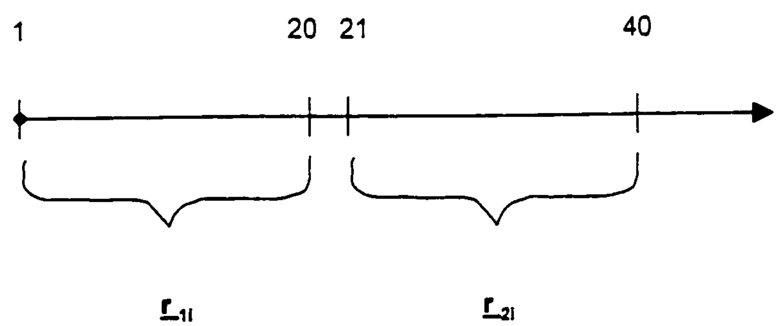
$$(\underline{r}_{1i}, \underline{r}_{2i}) \quad i = 0, 1, \quad N-2n$$

$$\underline{r}_{1i} = (r_{i+1}, \ldots\ldots r_{i+n})$$

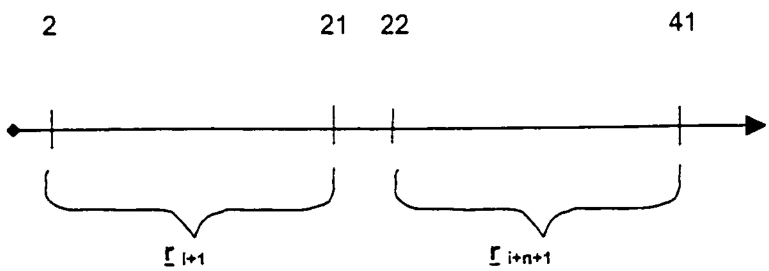
$$\underline{r}_{2i} = (r_{i+n+1}, \ldots\ldots r_{i+2n}).$$

For example, for i=0 and i=1, we have:

i=0



i=1



Thus, there is considerable overlap between i=0 and i=1. This is an AR(1) moving block (and therefore variance) process.

The variance for each "i" is then calculated as,

$$\mathrm{Var}(r_t) = \sigma_i^2 \quad t = i+1,\ldots,i+2n$$

The joint density of ($\underline{r}_{1i}$, $\underline{r}_{2i}$) is:

$$f(\underline{r}_{1i}, \underline{r}_{2i}) = (2\Pi\sigma_i^2)^{-n} \exp(-Q_i / 2\sigma_i^2)$$

where:

$$Q_i = \sum_{t=1}^{2n} r_{i+t}^2$$

Note that:

$$Q_i = Q_{1i} + Q_{2i} = \sum_{t=1}^{n} r_{i+t}^2 + \sum_{t=n+1}^{2n} r_{i+t}^2$$

and this joint density can be written as:

$$f(\underline{r}_{1i}, \underline{r}_{2i}) = (2\Pi\sigma_i^2)^{-n} \exp(-Q_{1i} / 2\sigma_i^2)\exp(-Q_{2i} / 2\sigma_i^2)$$

It is important to state that Q_{1i}/σ_i^2 and Q_{2i}/σ_i^2 are independently chi-squared distributed. The goal is to test for the null hypothesis that no variance change occurs within the i-th pair of adjacent blocks. This is accomplished with the statistic: $v_i = Q_{2i} / Q_{1i}$, which follows an F distribution with *n* and *n* degrees of freedom. In this study, this corresponds to $F_{0.01}$ (20, 20). According to WMH, we must obtain the series of $v_0, v_1, \ldots v_{N-2n}$ in order to test for the above hypothesis. In other words, by analyzing consecutive blocks of data, it is possible to identify the exact dates on which a statistical change in variance took place. That is, the null hypothesis of no variance changes will be rejected, if one of the following cases is observed:

a) if $v_i < F_{1-½(0.01)}$ (20,20), I conclude that a variance decrease has occurred. Specifically, if v_i < 0,3012, a variance decrease has occurred.

b) If $v_i > F_{½(0.01)}$ (20,20), I conclude that a variance increase has occurred. Specifically, if v_i > 3,32, a variance increase has occurred[6].

When a statistically significant shift in volatility is identified, one might wonder at which point in time it took place. The actual date on which a volatility shift occurred is the first date of the corresponding 2nd block.

Next, I look at the 20-day block following each and every volatility shift to see how stock prices reacted immediately after the shifts. Moreover, I analyze the third block as well, in order to see how future realized returns behave due to each volatility shift.

In order to obtain more robust results, I test the market's reaction to variance changes by calculating cumulative average excess returns for the overall sample period. Defining day +1 as the first date in the 2nd block, the cumulative average excess returns are obtained using the returns in the –20 through +30 interval for each volatility shift.

In addition, a regression is performed in order to further analyze how each type of volatility shift affects future stock prices. As previously mentioned, HTT regress mean excess returns in

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[6] HTT claim to have used a significance level of 1% in finding their significant shifts in volatility. However, they probably used a 5% significance level since the ratio of "variances ranges from 2,70 to 33,44" (HTT, p. 990) for volatility increases. However, the cut off point for a 1% significance level is 3,32. Therefore, HTT seem to have included several volatility increases which are not significant at the 1% level as they claim.

the second block "to the ratio of the variances in the corresponding" (HTT, p.998) prior and subsequent blocks. Finally, I examine the effects of volatility shifts on the third block's realized returns using a non-parametric Behrens-Fisher test. In all, this study faithfully follows the procedures of the HTT paper.

IV. Characteristics of Volatility Shifts

I originally identify 248 volatility increases and 269 volatility decreases. However, these transition points are severely reduced after the first screening. Specifically, 47 volatility increases and 43 volatility decreases remain. After the second screening, 39 volatility increases and 36 decreases survive. The screened volatility shifts can be viewed in Appendix 1.

Using these last transition dates, I examine the magnitude and frequency of volatility changes in the TSE 300 Index during the period of January 1st, 1977 to December 31st, 1997. The ratio of variances ($v_i = Q_{2i} / Q_{1i}$) for the 39 increases ranges from 3,34 to 74,21. The average is 6,9185. Similarly, the ratio of variances for the 36 decreases ranges from 0,1059 to 0,2991, the average being 0,2127. It is clear from these figures that volatility increases reveal a much wider range, as compared to volatility decreases. This is consistent with the HTT study. Appendix 2 reveals the actual date on which a volatility shift occurred, as well as the corresponding variance ratio after the two screening procedures are conducted. It is important to emphasize that the highest volatility ratio, 74,21, occurs around the time of the October 1987 crash. This can also be seen in Figure 1.

More specifically, Figure 1 plots the dates of volatility changes on the x-axis, along with the natural log of the significant variance ratios on the y-axis. In addition, a second y-axis is plotted, that of standard deviation of returns. This is obtained for each date in the sample period, "by the annualized market volatility in the 2-month period preceding that date" (HTT, p. 991). I first obtain the standard deviation for two months using the equation:

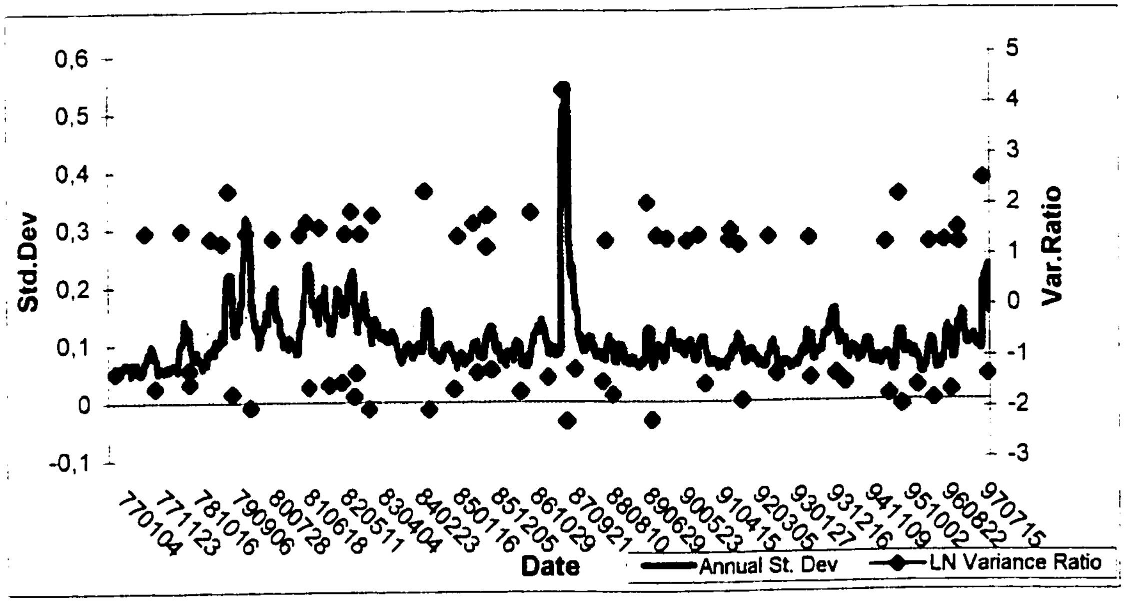
$$s_{2m} = \left[1/39 * \sum_{t=1}^{40} (r_i - \bar{r})^2 \right]^{1/2}$$

Second, I annualize these values under the assumption of independently distributed returns, using the equation:[7]

$$s_{annual} = S_{daily} * \sqrt{260}$$

As reported by HTT, there seems to be an asymmetry in the strength of volatility increases in comparison to that of volatility decreases. Figure 1 confirms that volatility increases are indeed wider than volatility decreases. Also, it demonstrates that volatility increases are observed more frequently than volatility decreases.

Figure 1: Characteristics of Volatility Shifts



Nevertheless, the number of increasing and decreasing shifts are well balanced through time. That is, approximately the same number of increases and decreases occurred during the entire sample period. A close examination of the logarithmic variance ratios reveals that in the 1980s there are more frequent shifts in volatility as compared to the 1990s. Especially the early 1980s demonstrate numerous important volatility shifts, as portrayed by the annualized standard deviations. This disagrees with the findings of Schwert (1990) which suggest that US stock

[7] I assume 260 days in 1 year. Obtained by calculating the number of days HTT use in annualizing their daily results.

market volatility in the 1980s was rather normal, if one excludes the 1987 crash. Figure 1 also displays the severe increase in volatility due to the 1987 crash. This shift is by far the largest shift in volatility during the time period studied. However, as revealed by the annual standard deviation the volatility prior to and after the crash is not "dramatically" high as suggested by Schwert (1990b). Rather, volatility is at normal levels prior to the crash, suddenly climbs up during the crash and rapidly drops back to normal levels subsequent to the crash.

The 1990s exhibit a continuation of the after-crash volatility patterns of the late 1980s. In other words, volatility in this decade portrays no surprises. The only severe shift in volatility is the increase observed in 1997, which can be associated to the Asian crisis. As mentioned in the introduction, the Asian crisis greatly affected the Canadian economy. Other than that, Canadian stock market volatility, for the years of 1990 through 1997, is rather smooth considering the drastic changes that the North American stock markets faced during the particular time period.

Furthermore, there seems to be a pattern in the direction of the volatility shifts. Specifically, a decrease in volatility is more likely to be followed by an increase in volatility than by another decrease in volatility and vice versa. Table I reveals the distribution of volatility transitions.

Table I: Distribution of Volatility Transactions

Volatility Transition	Number of Transitions	Percentage
Decrease to Decrease	11	14,66%
Decrease to Increase	24	32,00%
Increase to Decrease	24	32,00%
Increase to Increase	16	21,33%
Total	**75**	**100,00%**

Quantitatively, a volatility decrease is more likely to be followed by a volatility increase (32%) as compared by another volatility decrease (14,66%). In like manner, an increase in volatility is more likely to be followed by a decrease in volatility (32%), rather than another increase in volatility (21,33%). This pattern is in agreement with Schwert (1990).

Moreover, I analyze the behavior of stock market volatility before and after the identified transition points. It is important to emphasize that I examine volatility increases and decreases separately in order to test for asymmetries. In particular, I estimate the **average** volatility in the block **prior** (1st block) to the identified increases over the sample period. Then, I estimate the **average** volatility in the block **subsequent** (2nd block) to these identified increases. Following the procedure of HTT, average volatility is measured by the annualized daily standard deviation in the subsequent block, or prior block as required. This procedure is repeated for volatility decreases. In addition, I divide the sample period into four "five-year" groups and repeat the above proceeding in order to see whether volatility characteristics vary over time. The results are presented in Table II. In Appendix 3, I provide a detailed explanation of the process followed in calculating the numbers tabulated in Table II.

Table II: Identified Volatility Shifts

VOLATILITY INCREASES			
Time Period	**Number of Events**	**Average Prior Volatility**	**Average Subsequent Volatility**
1977-1997	39	0,071221658	0,168727037
1977-1981	9	0,090342272	0,197888801
1982-1986	11	0,076552024	0,166033434
1987-1991	10	0,057207072	0,168582936
1992-1997	9	0,061157917	0,143017566
VOLATILITY DECREASES			
Time Period	**Number of Events**	**Average Prior Volatility**	**Average Subsequent Volatility**
1977-1997	36	0,179673935	0,079485445
1977-1981	7	0,202747049	0,090279408
1982-1986	10	0,175968040	0,080837333
1987-1991	7	0,222999062	0,089918925
1992-1997	12	0,144029875	0,065976197

As demonstrated in Table II, following the shifts, the volatility for increases approximately doubles on average. In like manner, the average volatility for decreases is approximately halved following the shifts. For the overall period, the annualized daily standard deviation in the subsequent block rises to 16,87% for volatility increases, as compared to a level of 7,12% in the prior to the shifts. Similarly, for volatility decreases I find that the average prior volatility for the overall period is 17,97% and it drops to 7,95% subsequently. This pattern is true for all the sub-samples as well. Moreover, it is consistent with the HTT patterns, even if the latter study covers 92 years of US data while the present study covers 20 years of Canadian data.

Furthermore, I calculate the annualized daily standard deviation of returns for the overall sample period to be 12,11%. Since the average volatility for the overall sample is approximately 7% prior to volatility increases and approximately 17% subsequently, one can conclude that increases in volatility occur when the level of volatility is *relatively* low. Similarly, prior to volatility decreases the average level of volatility for the entire sample period is approximately 18%. The average level of volatility drops to approximately 8% after these volatility shifts. Hence, one can conclude that volatility decreases tend to occur when the level of volatility is *relatively* high. This conclusion is in agreement to HTT and Merville & Pieptea (1989).

V. Significant Events Associated with Volatility Changes

In this section, I present the results of my research on extraordinary events and how they relate to the identified volatility shifts. Once again, I examine volatility increases and decreases independently. I search over the last day of the first block as well as all the days in the second block for the release of extraordinary events, for each and every volatility shift. Several sources are used in conducting this thorough investigation. I use the *Day by Day* source to identify important events from 1977 to 1979, the *Keesing's Record of World Events* for the period of 1983-1997 and *Facts on File* for the period of 1980 to 1982.

Unlike HTT, I am able to attach the timing of the majority of volatility shifts to the release of extraordinary information[8]. In particular, 34 out of 39 volatility increases (87%) and 26 out of 36 (72%) of volatility decreases are associated with important world and/or domestic events. These results disagree with the findings of Schwert (1989), Cutler, Poterba and Summers (1989), Roll (1988) who argue that news justify only a small portion of total stock volatility.

It is important to realize that a tremendous number of events is reported for each and every volatility shift date. Therefore, I concentrate on major world events, such as wars, economic crises and, of course, Quebec referendums and elections. Also, I searched for events relating to natural resources, since the majority of Canadian firms listed on the TSE 300 Index deal with natural resources. One might argue that some of these are not extraordinary events. I report all my findings and leave it up to the reader to decide the percentage of these events he/she considers extraordinary. In my opinion, they are all important events that could affect the Canadian stock market.

Table III A and III B reveal the date of the volatility shift, the date on which the associated event(s) occurred, the description of the event(s) and the variance ratio corresponding to the volatility shift.

Table III .a: Extraordinary 2nd Block Events Associated With Volatility Increases

Shift Date	Event Date	Event	Variance Ratio[9]
21-Oct-77	20-Oct-77	Federal throne speech announces referendum legislation with regards to Quebec.	4,5188
	31-Oct-77	British government floats the pound.	
	02-Nov-77	Soviet government announces significantly lower grain harvest than expected, due to poor weather & inefficiency.	
28-Aug-78	25-Aug-78	Federal Budget released.	4,7197
	06-Sep-78	Japan seeks trade links with China in wake of domestic economic problems.	
	11-Sep-78	Canadian dollar falls to a 45-yr low at 85.94 US.	
	24-Sep-78	Fighting erupts again in Beirut.	
07-May-79	03-May-79	Margaret Thatcher is the first woman to be elected PM in UK.	3,9582
	22-May-79	Clark becomes PM, ending Trudeau's 11-yr era.	
	26-May-79	386 companies have moved their head offices out of Quebec since PQ took office in 1976.	
	01-Jun-79	Mexico's current account deficit is rising.	
15-Aug-79	16-Aug-79	Federal Reserve raises discount rate to a record 10.5%.	3,6271
	07-Sep-79	The Bank of Canada raises bank rate to 12.25%.	
09-Oct-79	06-Oct-79	Federal Reserve raises discount rate to 12%.	10,2750
	25-Oct-79	Bank of Canada increases bank rate to 14%.	
	01-Nov-79	Bank of Japan raises its discount rate.	
	04-Nov-79	500 Iranian students seize the US Embassy in Teheran, along with 90 hostages.	
06-Mar-80	10-Mar-80	Bank of Canada announced that it would allow its bank rate to float.	4,4552
30-Oct-80	04-Nov-80	Mr. Ronald Regan won the US Presidential elections.	3,9698
	09-Nov-80	Iraqi President Saddam Hussein declared "holy war" against Iran.	
	12-14-Nov-80	Iranian planes bombed Kuwait border posts.	
02-Jul-81	30-Jun-81	Postal Strike begins.	4,3420
	07-Jul-81	Canadian Federal govt filed criminal charges against 6 Canadian firms, for taking part in worldwide uranium cartel that restrained competition and trade in uranium in Canada.	
03-Sep-81	02-Sep-81	NEP agrees to triple oil prices over five years.	5,5586
	02-Sep-81	1500 Canadian grain handlers striked, paralyzing the	

[8] I could not find a clear cut definition of "extraordinary" information. I tried to use my judgement in deciding whether an event represented extraordinary information.

[9] A significant variance increase occurs when $v_i > 3{,}32$.

		country's biggest grain port.	
17-Aug-82	09-Sep-82 19-21-Sep-82	Quebec provincial cabinet changes. Mexico seeks emergency bailout package. Worst modern Mexican depression.	4,3750
23-Dec-82	23-Dec-82	IMF approves $3.96 billion loan to Mexico.	4,3715
11-Apr-83	15-Apr-83 18-Apr-83	US Embassy in Lebanon blown up. Bomb attack in US embassy in Beirut, 60 deaths.	6,3297
12-Jul-84	09-Jul-84	John Turner who became PM on June 30, announced that a general election would take place Sept 4.	10,1067
24-Apr-85	02-May-85	Provincial Elections in Ontario.	4,1566
09-Sep-85	19-Sep-85 23-Sep-85 29-Sep-85	Mexico City earthquake 7.8 Richter Mr. Fraser resigned as Minister of fisheries & oceans due to "tainted" tuna. Mr. Pierre-Marc Johnson was elected president of PQ.	5,3094
30-Dec-85	28-Dec-85	Peace agreement was signed in Damascus, ending civil war.	3,3486
08-Jan-86	29-Jan-86 30-Jan-86	US space shuttle Challenger exploded killing the crew. President Reagan declared national mourning. OPEC and Soviet Union announce plan to raise oil prices.	6,2965
05-Oct-87	08-Oct-87 15-Oct-87 19-Oct-87 22-Oct-87	US helicopters sank 3 Iranian gunboats. Iran sank US flagged tanker. US naval vessels destroyed an Iranian Rig in the Gulf. Iranian attack on Kuwait oil terminal.	74,2179
05-Oct-88	17-Oct-88	US offered Mexico an emergency loan due to its political instability.	3,7716
28-Sep-89	27-Sep-89	Liberals win Quebec election but PQ receives higher percentage than anticipated.	7,9427
18-Dec-89	11-Jan-90	Soviet Union: Lithuania & Azerbaijan Crises.	4,1546
26-Mar-90	24-Mar-90 26-Mar-90	Troops brought into Kosovo to quell the unrest between the Serbs & Ethnic Albanians. Minister Karakushi resigned after accusations that he had failed to protect the Albanians properly.	3,8795
24-Sep-90	03-Oct-90 19-Oct-90 October	East Germany ceased to exist. Soviet Union switched to market economy. Gulf crisis continues, oil prices fluctuated significantly during October.	3,7378
10-Jan-91	09-Jan-91 16-17-Jan-91 06-Feb-91	8th deadline extension of Iraq to withdraw from Kuwait is rejected by UN. Major military conflict began in the Gulf, US started air offensive against Iraq. Iraq announced the breaking-off of diplomatic relations with France US, UK, Italy, Saudi Arabia and Egypt.	4,1904
04-Oct-91	03-Oct-91 October	Israel and Soviet Union resume relations after 24 years. Civil War continues in Yugoslavia throughout October.	3,7894
23-Dec-91	19-Dec-91 20-Dec-91	Soviet Union breaks up after Gorbachev resigns. Yeltsin takes over Gorbachev's office	3,4502
14-Sep-92	11-Sep-92 14-28-Sep-92	Alberta Premier resigns. Also, the referendum bill on constitution passes from the parliament. European community currency crisis.	4,0159
07-Sep-93	03-Sep-93 08-Sep-93	TSE will launch 100 index. Canadian PM calls for general elections to be held Oct 25	3,8948
13-Oct-95	20-Oct-95 30-Oct-95	Israeli Prime Minister Yitzhak Rabin slain by Jewish extremist. Quebec Referendum. "No" won, only by an extra 1%.	9,0639
26-Jun-96	25-Jun-96 03-Jul-96	Quebec Riot Yeltsin is elected President.	3,5042

26-Jun-96	27-Jul-96	All TWA Flight 800 passengers die in an explosion.	3,5042
05-Nov-96	05-Nov-96	Re-election of President Clinton. Yeltsin underwent a succesful multiple bypass heart operation.	3,6062
05-Mar-97	11-Mar-97	Progressive Conservative Party won provincial elections in Alberta maintaining its 26-year unbroken tenure in the province.	4,6370
12-Mar-97	27-Mar-97	Soviet Union: nationwide strike due to continuing public disatisfaction with the state of the economy + unpaid salaries.	3,4976
03-Oct-97	16-Oct-97 23-Oct-97 October	Hong Kong stock market falls, shaking world financial markets. Further decrease in Hong Kong market by 10.4%. Thailand continues to face economic crisis throughout the month.	12,2172

Table III.b.: Extraordinary 2nd Block Events Associated With Volatility Decreases

Shift Date	Event Date	Event	Variance Ratio[10]
01-Feb-77	25-Feb-77	Canada & US agree to seek a wheat-stabilization pact with other wheat producing countries.	0,2823
17-Jan-78	24-Jan-78	Quebec superior court strikes down Bill 101, which makes French the official language of Quebec.	0,2086
02-Nov-78	16-Nov-78 21-Nov-78	Canadian Finance Minister Chretien presents 1978-9 budget, which includes spending cuts in order to reduce inflation. Total Soviet borrowed money is $41-47 billion.	0,2991
08-Nov-78	16-Nov-78 21-Nov-78 03-Dec-78	Canadian Finance Minister Chretien presents 1978-9 budget, which includes spending cuts in order to reduce inflation. Total Soviet borrowed money is $41-47 billion. Parti Quebecois Premier Levesque signs plan of an independent Quebec, which will maintain strong economic ties to the rest of Canada.	0,2270
06-Nov-79	05-Nov-79 21-Nov-79 21-Nov-79 26-Nov-79	NDP announces it will join in "no" confidence motion to overthrow the Clark government. Trudeau resigns as head of the liberal party. Mob of Pakistanis attack & set fire on US Embassy in Islamabad. PQ loses its 6th by-election of the yr. Liberals win.	0,1854
11-Apr-80	23-Apr-80	Iranian hostage rescue mission fails.	0,1406
30-Sep-81	29-Sep-81 14-Oct-81	PM Trudeau plans to alter the constitution. US cuts prime rate by 1%.	0,2108
29-Mar-82	26-Mar-82 05-Apr-82	Canada becomes legally fully independent from UK. PQ lost two by-elections in Quebec.	0,2190
19-Jul-82	05-Aug-82 06-Aug-82	Mexican Peso devalued, allowed to float freely. Canadian Fed. Govt. announced that provinces must return $400 M in overpayments for medicare and education expenses.	0,2325
04-Nov-82	09-Nov-82	Tentative agreement of IMF loan of $4.5 billion to Mexico.	0,1756
14-Aug-84	04-Sep-84	Canada general election; PCP won 211 seats.	0,1348
22-Mar-85	04-Apr-85	Iraq launched rocket attacks on 3 Iranian towns.	0,2012

[10] A significant variance decrease occurs when the ratio, $v_i < 0,3012$.

22-Mar-85	05-Apr-85	Iran thus fired a missile into central Baghdad.	0,2012
05-Feb-86	04-Feb-86	Canadian dollar falls below $0.70 US.	0,2934
22-May-87	03-Jun-87	PM Brian Mulroney and the 10 provincial Premiers signed a final amended version of an agreement...which defined the character of Canadian federalism and recognized the status of Quebec as a "distinct society" within Canada.	0,2544
11-Jan-88	13-Jan-88	US and Canada form free trade agreement.	0,2987
06-Sep-88	02-Sep-88 21-Sep-88	House of Commons passes free trade act. State of emergency declared in Soviet Union due to strikes, demonstrations and violence.	0,2328
01-Dec-88	21-Dec-88	PanAm Boeing 747 blew up killing everyone on board.	0,2987
09-Nov-89	08-Nov-89 09-Nov-89	East German Government resigns. Opening of borders; east Germans can now travel freely across the border. "the most stunning step since WW II".	0,1083
06-Mar-91	05-Mar-91 09-Mar-91 17-Mar-91	US declared war on Iraq. Political crisis in Yugoslavia. Soviet Union Referendum: "yes" to preserve the union of the USSR.	0,2211
23-Jan-92	22-Jan-92	The end of the Cold War is made official.	0,2676
18-Nov-92	20-Nov-92	EC-US GATT agreement on farm subsidies.	0,2687
13-Sep-93	09-Sep-93 16-Sep-93 24-Sep-93	Drop in the price of gold bullion caused TSE to drop 114 points. Japan asks for economic package to help boost its weak economy. NATO delivers ultimatum to Serbs.	0,2471
27-Apr-94	06-May-94	Paula Jones filed sexual harassment charges against Pres. Clinton.	0,2674
07-Nov-95	13-Nov-95 21-Nov-95	US Budget Crisis Bouchard announced he would seek elections as Premier of Quebec. His 1st priority is sovereignty and 2nd Quebec's weak economy.	0,1742
06-Aug-96	23-Aug-96	Bank of Canada lowered interest rates for a 2nd time in this month reflecting its increasing independence from the US Fed. Reserve.	0,1597
13-Nov-97	13-Nov-97 03-Dec-97 09-Dec-97	World Banks reinforce South Korea's economy. South Korea signs rescue package of $58 b. with IMF. Thailand closes down 56 financial firms.	0,2569

VI. Price Level and Expected Return Reactions to Changes in Volatility

The next step is to inspect the effects of the identified volatility shifts on the stock prices of the second block. That is, I explore how prices react immediately after the volatility shifts. This examination is done using daily stock returns. As stated earlier, if volatility shifts cause investors to revise discount rates, and assuming that expected future cash flows are not affected, then the stock prices immediately following volatility increases (decreases) will be declining (rising).

In addition, the magnitude of returns in the third block will also be affected if investors revise their discount rates. In particular, third block returns will move in the same direction as the volatility shift. It is worth repeating the reasoning behind this relationship. An increase in volatility implies an increase in the level of risk investors must bear. Therefore, investors require higher returns in order to be compensated for this extra risk. On the other hand, a decrease in volatility causes the level of risk borne by investors to drop. As a result, investors' required returns should also drop. In this paper, this relationship is examined by concentrating on the realized returns in the third block and is presented in the following section, that is section VII.

I measure stock **return** reaction in the 4-week period following the volatility shift, that is the 2nd block. In addition, I measure mean **returns** in the 4-week period immediately following the second block, that is the 3rd block. Daily excess returns are obtained for each of these 4-week periods, by subtracting the prevailing daily risk-free rate from the daily return on the TSE 300 Index. The daily risk-free rates are calculated using the call-in rates. Appendix 4 demonstrates this calculation in detail.

VI.a. Price Adjustments in the Second Block

Table IV reveals a great deal of information concerning volatility increases. It reports the average *holding*-period returns and average excess *holding*-period returns for the first and second blocks. The results are provided for the entire sample period as well as for the four sub-periods. I conduct a t-test in order to test for the null hypothesis that mean returns are zero.

Further, I conduct a nonparametric sign test, which tests the null hypothesis that the sign of returns is randomly distributed. The advantage of the sign test is that it does not require any assumptions about the form of the distribution. Therefore, it is a more reliable test, which in combination with the t-test, will provide a stronger decision. Similarly, Table V reports the results for volatility decreases.

Table IV: Market Response to Volatility Increases

This table portrays how mean holding returns, and mean excess holding returns react around volatility increases. The results are presented for the overall sample period, as well as for four-five year sub-periods. The first number (white background) is the mean return for that time period. The second number corresponds to the t-statistic for testing the null hypothesis that the mean return equals zero. The last number is the p-value of the sign test, which tests for the null hypothesis that the sign of returns is randomly distributed during the particular time period. Also, *** suggests statistical significance at the 1% level, ** at the 5% level and * at the 10% level.

Time Period	Number of Events	Mean Holding Returns		Mean Excess Holding Returns	
	Increases	1st Block	2nd Block	1st Block	2nd Block
1977-1997	39	0,004	-0,002	-0,001	-0,007
	t-test sign test	[illegible]	[illegible]	[illegible]	[illegible]
1977-1981	9	0,018	-0,031	0,011	-0,038
	t-test sign test	[illegible]	[illegible]	[illegible]	[illegible]
1982-1986	11	**0,001**	**0,043**	**-0,005**	**0,037**
	t-test sign test	[illegible]	[illegible]	[illegible]	[illegible]
1987-1991	10	**-0,016**	**-0,011**	**-0,022**	**-0,016**
	t-test sign test	[illegible]	[illegible]	[illegible]	[illegible]
1992-1997	9	0,017	-0,021	0,015	-0,0204
	t-test sign test	[illegible]	[illegible]	[illegible]	[illegible]

Table IV demonstrates that for the overall time interval, both mean holding and mean excess holding period returns decrease in the subsequent block. This pattern is consistent with finance theory, as explained earlier. However, it is not statistically significant as revealed by the t-statistics. The p-values reinforce this conclusion for the overall period, since one fails to reject the null hypothesis. In other words, the sign of the returns is randomly distributed for the years of 1977 through 1997. Furthermore, mean holding and mean excess holding period returns also drop in the second block, for the 1977-1981 and 1992-1997 sub-periods. As for with the overall period, this result is not statistically significant as revealed by the t-statistics and the p-values.

The remaining sub-periods present exceptions, as shown by the **bold** rows. That is, the returns in the sub-periods 1982-1986 and 1987-1991 rise following variance increases. Surprisingly, the results for the 1987-1991 sub-period are statistically significant. In summary, Table IV reveals that variance increases lead 2nd block returns to alter direction. However, even though the sign of the returns in the 2nd block is in the expected direction, there is no statistical significance in the results as shown by the statistical tests. That is, the mean holding returns in the 1st and 2nd blocks are not statistically significantly different from zero. In the HTT study, the mean holding returns in the 2nd block reveal the expected sign and are statistically significantly different from zero, for the overall sample period. Regardless, the reader must keep in mind that the present results are not directly comparable to those of HTT since their study covers 92-years of data and this one only 20-years of data.

In order to provide even more robust results, I perform a nonparametric Behrens-Fisher test for the data tabulated in Table IV. The advantage of using such a test is that it does not assume equal variances (unlike the sign test). I test whether the mean holding returns (mean excess holding returns) in the 1st block are statistically different from the mean holding returns (mean excess holding returns) in the 2nd block. In other words, I obtain a Behrens-Fisher statistic for each pair of **prior** (1st block) and **subsequent** (2nd block) returns to test the null hypothesis that there is *no* statistically significant change in returns surrounding the shifts in volatility. Appendix 5 provides an example of how to calculate the Behrens-Fisher test. The results are provided in Table IV.a. for volatility increases.

Table IV.a.: Behrens-Fisther Test for Volatility Increases

The results are presented for the overall sample period, as well as for four-five year sub-periods. For this table, *** suggests statistical significance at the 2% level, ** at the 5% level and * at the 10% level.

Time Period	Number of Events	Mean Holding Returns	Mean Excess Holding Returns
1977-1997	39	0,382496046	0,205212584
1977-1981	9	1,247096942	1,109174281
1982-1986	11	-0,925274054	-1,142186126
1987-1991	10	-0,588360977	-0,588360977
1992-1997	9	**2,354511889	***3,188482469

As explained above, one Behrens-Fisher test statistic is obtained for each pair of prior–subsequent returns shown in Table IV. I fail to reject the null hypothesis for both mean holding and mean excess holding period returns for the entire sample period. This conclusion holds at the 1% and 5% significance levels. In other words, there is no statistically significant change in returns surrounding volatility increases for the entire sample period. The Behrens-Fisher test confirms the conclusion reached with the t-test and the nonparametric sign test for the overall sample period. This pattern is also true for the first three sub-periods; however, it is not the case for the very last sub-period of 1992-1997. This latter sub-period reveals statistically significant results for both mean holding returns and mean excess holding returns. Therefore, during the 1992-1997 sub-period, there seems to be a significant change in holding returns surrounding volatility increases. Furthermore, according to Table IV, this statistically significant change in stock returns is in the expected direction. In other words, the 1^{st} block mean holding and mean excess holding returns are positive and the corresponding 2^{nd} block returns are negative.

Table V: Market Response to Volatility Decreases

This table portrays how mean holding returns, and mean excess holding returns react around volatility decreases. The results are presented for the overall sample period, as well as for four-five year sub-periods. The first number (white background) is the mean return for that time period. The second number corresponds to the t-statistic for testing the null hypothesis that the mean return equals zero. The last number is the p-value of the sign test, which tests for the null hypothesis that the sign of returns is randomly distributed during the particular time period. Also, *** suggests statistical significance at the 1% level, ** at the 5% level and * at the 10% level.

Time Period	Number of Events Decreases	Mean Holding Returns 1st Block	Mean Holding Returns 2nd Block	Mean Excess Holding Returns 1st Block	Mean Excess Holding Returns 2nd Block
1977-1997	36	-0,015	0,008	**-0,020**	**-0,001**
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1977-1981	7	-0,068	0,016	-0,074	-0,016
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1982-1986	10	**0,019**	**0,008**	**0,013**	**0,001**
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1987-1991	7	**-0,035**	**-0,001**	**-0,039**	**-0,006**
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1992-1997	12	-0,002	0,011	-0,006	0,008
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

For the overall sample, variance decreases appear to cause the market to respond with an increase in subsequent returns, consistent with the theory. This is true only for the mean holding returns, but not for the mean excess holding returns. Statistically speaking, there is no consistent pattern in the results. For instance, the mean holding returns in the 1st block for the overall period are not statistically significant. However, the corresponding 2nd block returns are statistically significant. On the other hand, mean excess holding returns in the 1st block for the overall period are significant whereas 2nd block returns are not.

For the sub-periods, the results are inconclusive. In particular, the first (1977-1981) and last (1992-1997) sub-periods present results consistent with the theory. However, the remaining two sub-periods present contradictory results. These are shown in **bold**. Statistically speaking, there is no consistent pattern in the results.

Next, I conduct a Behrens-Fisher test for the effects of volatility decreases just like I did for volatility increases. These results are presented in Table V.a.

Table V.a.: Behrens-Fisher Test for Volatility Decreases

The results are presented for the overall sample period, as well as for four-five year sub-periods. For this table, *** suggests statistical significance at the 2% level, ** at the 5% level and * at the 10% level.

Time Period	Number of Events	Mean Holding Returns	Mean Excess Holding Returns
1977-1997	36	**-2,491915827	**-2,161801909
1977-1981	7	***-8,643935474	***-3,093592168
1982-1986	10	-0,341992784	-0,276263122
1987-1991	7	-0,723042464	-0,723042464
1992-1997	12	*-1,733102976	*-1,889542472

For the entire sample period of volatility decreases I reject the null hypothesis at the 5% significance level, but fail to reject it at the 1% significance level. Moreover, the null hypothesis is rejected at the 2% significance level for the first sub-period. In addition, the last sub-period (1992-1997) also rejects the null hypothesis at the 10% significance level. The remaining two sup-periods reveal that the null hypothesis cannot be rejected. That means that there is no statistically significant change in holding returns surrounding volatility decreases for those two sub-periods. However, there is such a statistically significant change for the overall sample as well as for the sub-periods of 1977-1981 and 1992-1997.

Bringing the results of Tables V and Va together, it seems that the returns, which possess the correct direction (positive versus negative), are statistically significant based on the Behrens-Fisher test. An example is the sub-period of 1977 through 1981. On the other hand, the sub-periods that present exceptions in the direction of returns (1982-1986 and 1987-1991) are not statistically significant, as revealed by the Behrens-Fisher test. The only exception to this conclusion is the result for the mean *excess* holding period returns for the overall sample. In this latter case, the signs of the returns contradict the theory, however they are statistically significant according to Table Va.

In short, the above tables reveal that for the overall period, an increase in volatility causes stock returns to drop. However, even if the signs of the returns are in agreement to the theory, their statistical significance levels are rather weak. On the other hand, decreases in volatility cause stock prices to rise. These results are again consistent with finance theory.

Further, my statistical tests in Tables IV and V do not provide supporting evidence in that the stock market reacts more severely to variance increases than to variance decreases, as reported by HTT. On the contrary, by comparing the statistically significant results of tables IV.a and V.a, one could say that volatility decreases create prices to react more severely than volatility increases. Also, it is important to emphasize that the sub-period representing the 1990s presents statistically significant results for both volatility increases and decreases.

In order to provide a stronger picture of how the market reacts to variance changes, I acquire cumulative average excess returns. Like HTT, I define day +1 as the first day of the second block. Then, I calculate the average of all the variance increases (decreases) over the entire sample period for t = -20 through t = +30:

$$AER_t = \left(\sum_{i=1}^{K} ER_{it}\right) \div K,$$

for t = -20,.......,+30.

where "AER_t" stands for average excess return on day *t*, "K" stands for the number of volatility events, and "ER_{it}" is the excess return on *i* at time *t*. Intuitively, I gather the excess return on day +1 for every volatility increase (decrease). Then, I obtain the average excess return for day +1 across all variance increases (decreases). This procedure is repeated for all the days in the interval of t = -20 through t = +30. Therefore, I end up with the average excess return for each day (-20 through +30) for variance increases (decreases).

Next, I obtain the cumulative average excess returns:

$$CAR_t = \sum_{s=-20}^{t} AER_s$$

for t = -20, ...,+30.

Thus,

$CAR_{-20} = AER_{-20}$,

$CAR_{-19} = AER_{-20} + AER_{-19}$,

$CAR_{-18} = AER_{-20} + AER_{-19} + AER_{-18}$, and so forth.

In a similar manner, I also obtain the average variance ratios (AVR) for volatility increases (decreases) for t = -20, ...,+30. I present these results in Figure 2 for variance increases and Figure 3 for variance decreases. More precisely, I plot the day (-20 through +30) on the x-axis. Then, I plot the calculated CAR on the left y-axis and the corresponding average variance ratios (AVR) on the right y-axis.

Figure 2 clearly displays that the average variance ratio jumps up high on day +1 and then gradually drops. On the other hand, the cumulative average excess returns present a shaky decreasing pattern after the shift in volatility. This adjustment is the exact opposite for volatility decreases as displayed in Figure 3. That is, the variance ratio is at its lowest on day +1 and the cumulative average returns have an increasing behavior. In short, I find that, for both volatility increases and decreases, the market response carries through most of the second block.

Figure 2: Cumulative Average Excess Returns & Average Variance Ratios, Volatility Increases

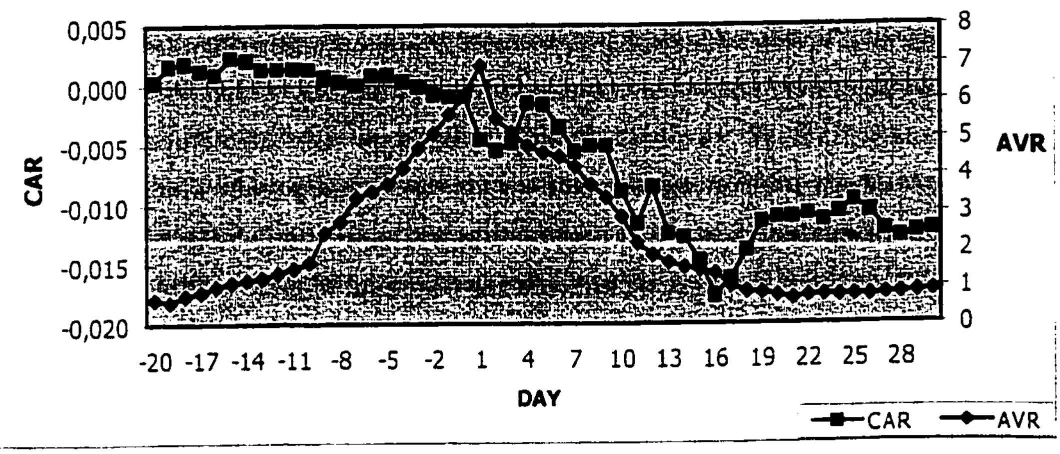
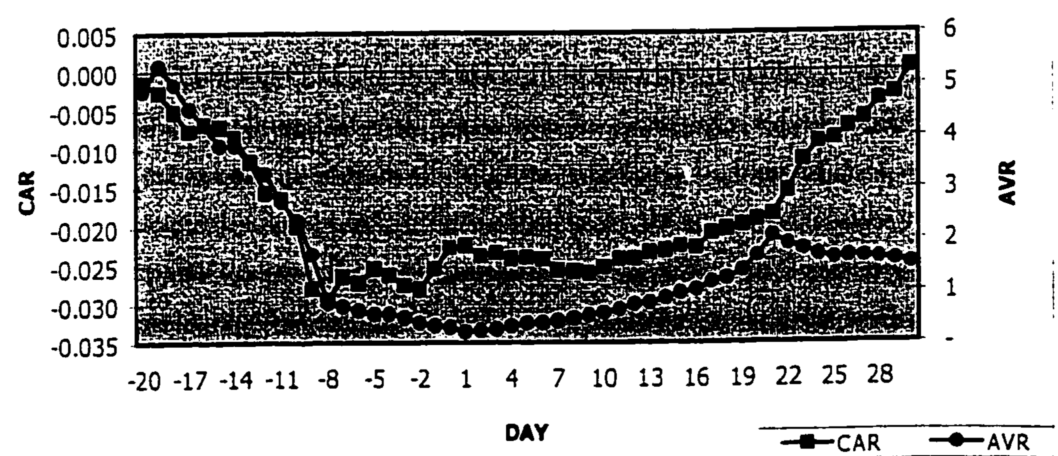


Figure 3: Cumulative Average Excess Returns & Average Variance Ratios, Volatility Decreases



One might question how the patterns displayed in Figures 2 & 3 compare with the corresponding patterns obtained by HTT. Prior to making any such comparisons, it is crucial to emphasize three major differences that exist between their graphs and the present study's graphs. First, the US study covers 92-years of data, whereas the present study covers 20 years of data. Second the behavior of the 1970s and 1980s is a small part of the HTT graphs, but a major part of the present graphs. Third, the time period covered by HTT does not include the

1990s, during which both the US and Canadian stock markets more than tripled. On the other hand, the results of the current study do reflect the dynamics of the 1990s. In short, the graphical results of the two studies are not directly comparable.

However, one can still detect similar patterns among the two sets of graphs. First, the present patterns of the CAR and AVR lines are similar to those in the HTT study. Second, the market adjustment for volatility decreases is more gradual and smooth as compared to that of volatility increases in both studies. Still, an important difference is evident in Figure 3 as compared to that of HTT. The CAR for volatility decreases starts increasing after the shift, but remains way below zero. On the contrary, the corresponding CAR in HTT climbs above zero.

As mentioned earlier, HTT find that a decrease in volatility causes prices to rise for the overall period studied. However, this is not found to be the case for the 1970s and the 1980s. That is, for these two decades decreases in volatility cause prices to drop. This is in contradiction to finance theory. However, HTT's Figure 3 does not portray this finding since it covers the entire 92-year period. As a result, one could say that HTT are "masking" the inconsistency of the 1970s and 1980s in this figure. A graph of these two decades with US data and Canadian data alone will provide a better basis for comparison. Based on HTT-s results for the 1970s and the 1980s, I believe that future researchers might find that during these decades, the patterns of the US data are more similar to those of the Canadian data. On the other hand, one could argue that the results of this study also present conclusions that contradict finance theory. However, these results are not statistically significant. Moreover, the present study covers a time period of only 20 years, not 92 years; hence, the graphs do not "mask" the exceptions to the same extent.

The last inquisition as to how stock prices react due to volatility shifts involves a regression analysis. Again, I perform one regression for volatility increases and a separate one for volatility decreases. Basically, I examine the relationship between the mean excess returns in the 2^{nd} block (dependent variable) and the log of the ratio of the variance in the 2^{nd} block to variance in the 1^{st} block (independent variable).

The regression equation is shown below:

$$\overline{R}_2 = a_0 + a_1 \log\left(\frac{\sigma_2^2}{\sigma_1^2}\right) + \varepsilon$$

The relationship underlying this regression is how 2nd block daily mean excess returns are affected by the logarithm of the variance ratio, which quantifies the growth in the variance process from the 1st block to the 2nd block. The intercept, (α_0) reflects how daily mean excess returns in the 2nd block will move if the ratio of variances is 1, which will make the logarithm of the ratio zero. On the other hand, α_1 shows how strongly 2nd block daily mean excess returns rely on volatility changes.

Table VI demonstrates my results for volatility increases in more detail. The results for volatility decreases are provided in Table VII. Consistent with HTT, I find that this relationship is significant only for volatility increases; hence, I analyze this result in greater detail.

Table VI: Market Response to Variance Increases

The Daily Mean Excess returns in the 2nd block subsequent to an identified volatility increase are regressed against the log of the ratio of the variance in the 2nd block to the variance in the 1st block for volatility increases. The numbers in parentheses are the t-statistics and the underlined numbers are the p-values.

α_0	α_1	R^2	F
0.004394622 (2.273625323) _0.02942165_	-0.006900978 (-2.58360879) _0.01424912_	0.164106423	6.675034403

The estimate for α_1 is significant for volatility increases at the 5% significance level. Moreover, it is almost significant at the 1% level. For volatility increases, the regression results suggest that the higher the variance in the 2nd block as compared to the 1st block, the greater the deduction in the daily mean excess returns of the 2nd block. In other words, an increase in variance causes subsequent daily mean excess returns to drop. This is consistent with the overall sample period results shown in Table IV. Moreover, HTT find an R-sq of 14.8%, whereas I find an R-sq of 16.4%. Both these numbers reveal that a very small portion of daily mean excess returns in the 2nd block can be explained by the above relationship for variance increases.

As argued earlier, Tables IV and IVa do not provide evidence of statistically significant results in the 2nd block. However, when concentrating on 2nd block data alone, Table VI reveals that there is a statistically significant decrease in the daily mean excess 2nd block returns after volatility increases. In other words, I uncover evidence that mean daily excess 2nd block returns are moving in the opposite direction in relation to the growth in the variance from the 1st to the 2nd block. This is consistent with increases in risk aversion as a result of increases in volatility.

On the other hand, Table VII reveals that this relationship is insignificant for volatility decreases. Even though Tables V and Va reveal several statistically significant patterns in the 2nd block behavior of returns, such significance is not evident from the regression analysis as shown in Table VII.

Table VII: Market Response to Variance Decreases

The Daily Mean Excess returns in the 2nd block subsequent to an identified volatility decrease are regressed against the log of the ratio of the variance in the 2nd block to the variance in the 1st block for volatility decreases. The numbers in parentheses are the t-statistics and the underlined numbers are the p-values.

α_0	α_1	R^2	F
0.000349483 (0.221556) 0.825984834	0.000608595 (0.268428) 0. 789991918	0.002114741	0.07205358

VII. Realized Returns in the Third Block

The last investigation of this paper involves the reaction of realized returns in the third block. That is, I study the behavior of stock prices after they have adjusted in the second block. As previously mentioned, HTT suggest that investors adjust their discount rates after volatility shifts; hence, subsequent stock prices should move in the opposite direction of the shift. The previous section of the present study has shown this to be true. In continuation, HTT argue that once prices have adjusted in the 2nd block, the expected returns in the third block ought to be of the same direction as the variance shift. Therefore, an increase (decrease) in volatility should increase (decrease) future realized returns. The intuition behind this statement is that investors require higher (lower) returns for higher (lower) levels of risk.

Using a Behrens-Fisher test, I investigate whether this is the case. More specifically, the average returns in the third block are used to test the null hypothesis that the realized returns after volatility increases are the same as after volatility decreases. HTT find that the " 3rd block mean returns for variance increases significantly exceed the 3rd block mean returns for variance decreases" (HTT, p. 998). Moreover, I obtain the Behrens-Fisher test for the overall period as well as for each decade in the sample. Table VIII demonstrates my results.

It is important to understand the difference between the Behrens-Fisher test conducted in this section and that of the previous section. In this section, the two groups I am comparing are the 3rd block mean returns across **volatility increases** and the 3rd block mean returns across **volatility decreases**. Therefore, I obtain one Behrens-Fisher test statistic for each such group, as shown in Table VIII. In the previous section, the two groups I am comparing are the **prior** and **subsequent** mean holding (and mean excess) period returns. In that case, I calculate a test statistic for each group of prior and subsequent mean holding (mean excess) period returns, as shown in Tables IVa and Va.

Table VIII: Differences in 3rd Block Mean Returns

This table tabulates the significance of the difference between the mean returns in the 3rd block following volatility increases and volatility decreases across all events. This is revealed for the overall sample period as well as for the four five-year sub-periods.

1977-1997	**Increases**	**Decreases**
Volatility Observations Mean Daily Return	780 0,0435%	720 0,1640%
[redacted]	[redacted]	[redacted]
1970s	**Increases**	**Decreases**
Volatility Observations Mean Daily Return	100 0,0997%	100 0,1613%
[redacted]	[redacted]	[redacted]
1980s	**Increases**	**Decreases**
Volatility Observations Mean Daily Return	380 0,00939%	360 0,2613%
[redacted]	[redacted]	[redacted]
1990s	**Increases**	**Decreases**
Volatility Observations Mean Daily Return	300 0,06796%	260 0,0297%
[redacted]	[redacted]	[redacted]

For the overall sample period, the Behrens-Fisher statistic suggests that the realized returns between the two types of volatility are not the same. This in itself seems to be consistent with the conclusion of HTT. However, the above table reveals that the 3rd block mean returns following volatility decreases are positive, instead of negative. This is in disagreement with both the finance theory and the findings of HTT. The same result is also true for the decade of 1980s. For the 1970s and 1990s the pattern is similar but statistically insignificant. Moreover, the 1970s and 1980s reveal that volatility increases cause 3rd block mean returns to rise higher than the rise caused by volatility decreases. It is important to highlight the peculiarity of how volatility decreases cause 3rd block mean returns to rise (instead of drop), for the overall period as well as for each of the sub-periods.

In summary, the reaction of realized returns is statistically different for the two types of shifts for the overall period. However, 3rd block realized returns do not act according to finance theory. That is, volatility increases cause 3rd block realized returns to rise and volatility decreases cause 3rd block realized returns to rise even more (instead of drop). Further research is essential in order to clarify this bizarre result.

VIII. Summary & Conclusion

At the beginning of this paper, the importance of understanding stock market volatility is emphasized. To summarize, stock market volatility is essential in asset management decisions, in valuing derivatives, in forming efficient international portfolios and in obtaining accurate empirical results.

To the best of my knowledge and as revealed in the literature review, Canadian volatility studies are rather limited. The current study helps bring the amount of Canadian stock market volatility research a step closer to the extensive U.S. research that is available on the topic.

Canadian stock market volatility is examined using daily returns from the Toronto Stock Exchange 300 Price Index, for the time period of January 1977 through December 1997. Using the moving-block methodology of Wichern, Miller and Hsu (1986), I identify 39 statistically significant volatility increases and 36 volatility decreases. Further, volatility increases are stronger and wider in range than volatility decreases. In addition, volatility increases occur when the level of volatility is rather low. Similarly, volatility decreases occur when the level of volatility is rather high. These results are for the most part consistent with the findings of HTT even though the time periods studied differ to a great extent. However, in contrast to HTT, most of the identified shifts in volatility can be associated to important macro-news. In particular, 87% of volatility increases and 72% of volatility decreases can be possible explained by important news. This is in disagreement with the conclusion of Roll (1988), Schwert (1989) and Cutler, Poterba & Summers (1989). Furthermore, an increase in volatility causes subsequent stock returns to fall. In like manner, a decrease in volatility causes subsequent stock returns to rise. Therefore, for the most part, the **direction** (positive versus negative sign) of my results is in agreement with the theory and HTT. However, these results are **not** consistently significant as revealed by the t-tests, the nonparametric sign and the Behrens-Fisher tests. Also, these insignificant results do not allow me to make any asymmetry conclusions about the reactions of stock prices to variance increases versus variance decreases, as done by HTT. Finally, I find that volatility increases cause third block future realized returns to increase. Surprisingly, volatility decreases create an increase in 3rd block future realized returns.

It is important to emphasize that cash flows are assumed to be *constant* in conducting this entire study. Therefore, one cannot be certain that the reactions of stock prices and returns to volatility shifts are caused by investors' revision of discount rates and/or time-varying risk-premia. Finally, this paper provides several interesting ideas for future research. These are explained in detail in the last section of the paper.

IX. Future Research Recommendations

The study at hand has added some knowledge on Canadian stock price volatility. However, there is still a long way to go in order for Canadian stock market volatility research to reach the level of U.S. volatility research. As mentioned in the introduction, research on Canadian stock price volatility is essential and must not be assumed to be identical to that of the US. The two countries might be highly integrated, but at the same time, they are very much different. Therefore, this last section provides several recommendations for future research on Canadian stock volatility.

First, the present methodology can be used to analyze the volatility changes, stock price effects and future realized returns for individual firms and organizations. In addition, one can test whether variance shifts reflect the release of specific information about the individual company, such as a merger announcement.

Second, I believe that this study must be repeated using the TSE 100 and/or TSE 35 Indices. These indices include stocks that seem to be more actively traded and are not heavily based on natural resource companies. Then, combined with the present results, we will have more complete Canadian results and be able to actually compare them to the American results. Studying the reasons for the strange positive reaction of 3rd block realized returns to volatility decreases is also an intriguing research question.

Third, the moving-block-variance methodology can be used in order to test for volatility spillovers from one market to the other. For instance, does volatility in the US spill over to the Canadian markets? Is the opposite true? Or maybe there are no volatility spillovers?
Appendix 6 suggests how these questions may be answered by modifying HTT's methodology. Moreover, one can go on to investigate whether volatility spillovers occur in any combination of world markets. Such information will be of great value in forming internationally diversified portfolios.

Very importantly, researchers must study volatility on a dynamic basis, since its behavior changes over time. This is strongly emphasized by Seguin and Schwert (1990). In all, volatility research must continue because it is essential in finance. This is even more the case for Canadian volatility research, which is rather behind as compared to its American counterpart.

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Appendix 1: Screened Volatility Shifts

The two tables that follow reveal the screened volatility shifts. The table at the left represents the volatility shifts that remain after the first screening. The table at the right represents the second screening procedure.

Originally I identify 248 volatility increases and 269 volatility decreases. The first screening results in 47 volatility increases and 43 volatility decreases. In performing the first screening I look for sequences of significant volatility increases and sequences of significant volatility decreases. Assuming I first find a sequence of volatility increases, I look for the **most** significant volatility increase in that sequence. That is the **only** shift that I keep from that group of volatility increases. This is repeated for all the sequences of significant volatility increases as well as for all the sequences of significant volatility decreases. That is why there is such a large reduction in volatility shifts after the first screening is completed.

Second, I examine whether volatility shifts of the same direction (either an increase followed by an increase, or a decrease followed by a decrease) continue to exist after the first screening is completed. When such a sequence is found, I trace the data entries that were used in calculating the variance ratios for each of the shifts that make up the particular sequence. If such an overlap exists, the most significant shift is kept. However, significant shifts of opposite directions are kept, even if overlapping data were used to obtain them.

The table on the left-hand side reveals the shifts that pass the first screening. Then, the shifts that survive the second screening are shown on the right-hand side table. For ease of identification, I place the number "1" on either the "DEC" or "INC" column, to identify a decrease and an increase in volatility

First Screening	Variance Ratio	DEC	INC
770301	0,282316103	1	
771117	4,518833256		1
780213	0,208597	1	
780925	4,719670		1
781107	3,398954		1
781129	0,299125	1	

Second Screening	Variance Ratio	DEC	INC
770301	0,282316103	1	
771117	4,518833256		1
780213	0,208597	1	
780925	4,719670		1
781129	0,299125	1	
781205	0,226970	1	

781205	0,226970	1	
781214	0,295425	1	
790604	3,958213		1
790912	3,627190		1
791105	10,275029		1
791203	0,185352	1	
791210	0,250315	1	
800402	4,455154		1
800508	0,140565	1	
800630	0,283802947	1	
801126	3,969774		1
810729	4,342023		1
811001	5,558550		1
811005	3,341666		1
811028	0,210767	1	
811111	0,256976	1	
820201	5,003408		1
820205	3,638567		1
820426	0,218982	1	
820816	0,232516	1	
820914	4,374955		1
821103	6,812694		1
821201	0,175603	1	
821216	0,294462	1	
821221	0,278241	1	
830124	4,371454		1
830128	3,469474		1
830408	0,135743	1	
830415	0,295803	1	
830506	6,329746		1
840809	10,106723		1
840911	0,134832	1	
850419	0,201180	1	
850522	4,156578		1
850606	3,917508		1
851004	5,309395		1
851106	0,279117	1	
860127	3,348581		1
860204	6,296455		1
860304	0,293350	1	
861029	0,190823	1	
870128	6,607950		1
870618	0,254431	1	
871102	74,217910		1
871127	0,105898	1	
880205	0,298683	1	
881003	0,232773	1	
881102	3,771629		1
881229	0,178593	1	
891026	7,942691		1

790604	3,958213		1
790912	3,627190		1
791105	10,275029		1
791203	0,185352	1	
800402	4,455154		1
800508	0,140565	1	
801126	3,969774		1
810729	4,342023		1
811001	5,558550		1
811028	0,210767	1	
820201	5,003408		1
820426	0,218982	1	
820816	0,232516	1	
820914	4,374955		1
821103	6,812694		1
821201	0,175603	1	
821221	0,278241	1	
830124	4,371454		1
830408	0,135743	1	
830506	6,329746		1
840809	10,106723		1
840911	0,134832	1	
850419	0,201180	1	
850522	4,156578		1
851004	5,309395		1
851106	0,279117	1	
860127	3,348581		1
860204	6,296455		1
860304	0,293350	1	
861029	0,190823	1	
870128	6,607950		1
870618	0,254431	1	
871102	74,217910		1
871127	0,105898	1	
880205	0,298683	1	
881003	0,232773	1	
881102	3,771629		1
881229	0,178593	1	
891026	7,942691		1
891206	0,108309	1	
900117	4,154647		1
900423	3,879466		1
901022	3,737758		1
910206	4,190426		1
910403	0,221109	1	
911101	3,789479		1
911108	4,602082		1
920122	3,450198		1
920219	0,158001	1	
921009	4,015928		1

891206	0,108309	1	
900117	4,154647		1
900423	3,879466		1
900427	3,729740		1
901022	3,737758		1
910206	4,190426		1
910213	3,568865		1
910403	0,221109	1	
911101	3,789479		1
911108	4,602082		1
920122	3,450198		1
920219	0,158001	1	
920304	0,262386	1	
921009	4,015928		1
921215	0,268702	1	
921218	0,267587	1	
931004	3,894762		1
931008	0,247133	1	
940525	0,267360	1	
940812	0,225383	1	
950724	3,504183		1
950822	0,174168	1	
951109	9,063860		1
951204	0,142267	1	
960412	0,205724	1	
960724	3,504243		1
960802	3,498639		1
960903	0,159722	1	
961202	3,606237		1
970130	0,189050	1	
970402	4,637017		1
970409	3,497594		1
971031	12,217157		1
971210	0,256923	1	
		43	47

921215	0,268702	1	
921218	0,267587	1	
931004	3,894762		1
931008	0,247133	1	
940525	0,267360	1	
940812	0,225383	1	
950724	3,504183		1
950822	0,174168	1	
951109	9,063860		1
951204	0,142267	1	
960412	0,205724	1	
960724	3,504243		1
960903	0,159722	1	
961202	3,606237		1
970130	0,189050	1	
970402	4,637017		1
970409	3,497594		1
971031	12,217157		1
971210	0,256923	1	
		36	39

Appendix 2: Actual Dates of Shifts and Variance Ratios

	DECREASES	
	Actual Date	Ratios
1	770202	0,2823161030
2	780117	0,2085973877
3	781102	0,2991253267
4	*781108*	0,2269695252
5	791106	0,1853521014
6	800411	0,1405645447
7	810930	0,2107673124
8	820329	0,2189815112
9	820719	0,2325155018
10	821104	0,1756026268
11	821124	0,2782405785
12	830311	0,1357434689
13	840814	0,1348315178
14	850322	0,2011800275
15	851009	0,2791171607
16	860205	0,2933500770
17	861001	0,1908232107
18	870522	0,2544312240
19	871102	0,1058982752
20	880111	0,2986831791
21	880906	0,2327731530
22	881201	0,1785928949
23	891109	0,1083088196
24	910306	0,2211093296
25	920123	0,1580011792
26	921118	0,2687018633
27	921123	0,2675870836
28	930913	0,2471332820
29	940427	0,2673600269
30	940715	0,2253833824
31	950725	0,1741678096
32	951107	0,1422670868
33	960315	0,2057235662
34	960806	0,1597216058
35	970103	0,1890504486
36	971113	0,2569231392

Average	0,2126637592

	INCREASES	
	Actual Date	Ratios
1	771021	4,5188332556
2	780828	4,7196699742
3	790507	3,9582127877
4	790815	3,6271899789
5	791009	10,2750287235
6	800306	4,4551537331
7	801030	3,9697738094
8	810702	4,3420231218
9	810903	5,5585501683
10	820105	5,0034084362
11	820817	4,3749554418
12	821006	6,8126943766
13	821223	4,3714538753
14	830411	6,3297460100
15	840712	10,1067234135
16	850424	4,1565778034
17	850909	5,3093950601
18	851230	3,3485814877
19	860108	6,2964552562
20	861231	6,6079504236
21	871005	74,2179100682
22	881005	3,7716293264
23	890928	7,9426906737
24	891218	4,1546468932
25	900326	3,8794664685
26	900924	3,7377584001
27	910110	4,1904260322
28	911004	3,7894786968
29	911011	4,6020816126
30	911223	3,4501978733
31	920914	4,0159283257
32	930907	3,8947617694
33	950626	3,5041831675
34	951013	9,0638604866
35	960626	3,5042426133
36	961105	3,6062369391
37	970305	4,6370173701
38	970312	3,4975940917
39	971003	12,2171567993

Average	6,9184524293

Appendix 3: Procedure of Obtaining Numbers in Table II

I now provide a visual example of the procedure used to obtain the numbers in Table II. For this illustration, I concentrate on volatility increases for the entire sample period. Therefore, I use 39 volatility increases.

From the 5,292 returns, I initially spot the first increase in volatility and go **back** twenty days (prior block) and calculate the average return of those days. That is my average prior return for the first volatility increase.

Second, I obtain its daily standard deviation using the following equation:

$$s_{daily} = \left[1/19 * \sum (r - \bar{r})^2\right]^{1/2}$$

Third, I annualize this using:

$$s_{annualized} = s_{daily} * \sqrt{260}$$

Therefore, I have now obtained the **prior** annualized daily standard deviation for the first volatility increase. This process must be repeated for the rest of the volatility increases. The last step is to average the thirty-nine **prior** annualized daily standard deviations. This gives us the number: 0.071221658 in Table 2. The rest of the numbers in that same column are obtained by averaging the analogous standard deviations.

Further, to obtain the average **subsequent** volatility, I spot the first volatility increase and go **forward** (subsequent block) and calculate the average return. The remaining procedure remains identical. Please recall that this must be repeated separately for volatility decreases.

Appendix 4: Daily Risk-Free Rates

Using the Western database, I obtain the call-in rates for the time period of January 1st, 1977 through December 31st, 1997. These rates are then divided by 100 in order to convert them into percents. Lastly, I divide these rates by 365 in order to turn them into daily turns. A sample of that Excel worksheet is provided below.

Date	Call-In	Percent	Daily T-bill rate
750102	-9	-0,09	-0,000246575
750103	9,75	0,0975	0,000267123
750106	10,5	0,105	0,000287671
750107	9,75	0,0975	0,000267123
750108	9,625	0,09625	0,000263699
750109	9,25	0,0925	0,000253425
750110	8,375	0,08375	0,000229452
.....	.....	.....	.....
780509	7,75	0,0775	0,000212329
780510	8	0,08	0,000219178
780511	8	0,08	0,000219178
780512	7,5	0,075	0,000205479
780515	8,38	0,0838	0,000229589
.....	.....	.....	.....
830407	10,88	0,1088	0,000298082
830408	9,5	0,095	0,000260274
830411	9,63	0,0963	0,000263836
830412	9,38	0,0938	0,000256986
830413	9,63	0,0963	0,000263836
830414	9,88	0,0988	0,000270685
830415	8,63	0,0863	0,000236438
830418	9,88	0,0988	0,000270685
830419	10,5	0,105	0,000287671
830420	10,5	0,105	0,000287671
830421	9,63	0,0963	0,000263836
.....	.....	.....	.....
910514	9,3125	0,093125	0,000255137
910515	9,25	0,0925	0,000253425
910516	9,1875	0,091875	0,000251712
910517	9,1875	0,091875	0,000251712
910521	9,25	0,0925	0,000253425
910522	9,3125	0,093125	0,000255137
.....	.....	.....	.....

Appendix 5: Behrens-Fisher Procedure

This appendix demonstrates the procedure of calculating the Behrens-Fisher statistic. This example is taken directly from the textbook of Sidney Siegel and N. John Castellan, Jr. The title of which is: *Nonparametric statistcs for the Behavioral Sciences*, 1988, p. 138.

In all, we are dealing with two groups of data for which we want to obtain the Behrens-Fisher statistic. Hence, the purpose is to estimate a Behrens-Fisher statistic for every two groups of numbers.

Therefore, let ***m*** be the number of observations in the first group **X**, and ***n*** be the number of cases in the second group, **Y**. In this example, we assume there is only one comparison to be done, that is, there is only two groups of numbers. In the paper itself, there are many more two group combinations to be tested using this technique.

Example:

X: 9 11 15

Y: 6 8 10 13

Therefore, m = 3 and n= 4.

Step 1: Combine the observations of both groups and rank them in increasing order, while sustaining the group to which every number belongs to.

Rank: 6 8 9 10 11 13 15

Group: Y Y X Y X Y X

Step 2: For each X_i we count the number of observations Y with a lower rank. This number is called $U(YX_i)$.

In this example:

X_i	$U(YX_i)$
9	2
11	3
15	4

Next, we calculate the average:

$$U(YX) = \sum_{i=1}^{m} U(YX_i) / m$$

In this case: (2+3+4)/3 = 3.

In like manner, we obtain $U(XY_i)$, the number of X observations before each Y_i.

U_j	$U(XY_j)$
6	0
8	0
10	1
13	2

We then calculate the average, just like before.

$$U(XY) = \sum_{j=1}^{n} U(XY_j) / n$$

That is: (0+0+1+2)/4 = 0.75

Step 3: We now calculate the variances of $U(YX_i)$ and $U(XY_j)$.

$$V_x = \sum_{i=1}^{m} \left[U(YX_i) - U(YX)\right]^2$$

$$V_y = \sum_{j=1}^{n} \left[U(XY_j) - U(XY)\right]^2$$

In this example:

$V_x = (2-3)^2 + (3-3)^2 + (4-3)^2 = 2$

$V_y = (0-0.75)^2 + (0-0.75)^2 + (1-0.75)^2 + (2-0.75)^2 = 2.75$

Step 4: We are now ready to calculate the test statistic ***U***.

$$U = \frac{mU(YX) - nU(XY)}{2\sqrt{V_x + V_y + U(XY)U(YX)}}$$

$$U = \frac{3(3) - 4(0.75)}{2\sqrt{2 + 2.75 + (0.75)(3)}}$$

U = 1.13

The authors suggest that when *m* and *n* are greater than 12, one can use the normal distribution in testing the null hypothesis. However, if these numbers are less than 12 special tables at the end of their text-book must be used. This appendix aims to provide the reader with some background on the process involved in conducting the Behrens-Fisher test. It is an easy test to conduct, as shown in this example. However, one must be careful because it gets long and tedious with large sample sizes.

Appendix 6: Testing for Spillovers Using the HTT methodology

Two suggestions are made in this Appendix for those interested in examining volatility spillovers.

Spillover 1: Does US volatility affect Canadian volatility?

$$F = \frac{Q_{2,i}^{CA} / \sigma_{i,CA}^{2}}{Q_{1,i}^{US} / \sigma_{i,US}^{2}}$$

This is distributed with 20,20 degrees of freedom.

In order to test whether US volatility has an effect on Canadian volatility, one could form the above ratio. The numerator is the 2nd block Canadian data divided by the corresponding Canadian variance. The denominator is the 1st block US data, divided by the corresponding US variance. We divide by the appropriate variances in order to standardize those ratios. Intuitively, we are examining whether 1st block US volatility spills over to the Canadian markets, by investigating the Canadian 2nd block.

Spillover 2: Does Canadian volatility affect US volatility?

$$F = \frac{Q_{2,i}^{US} / \sigma_{i,US}^{2}}{Q_{1,i}^{CA} / \sigma_{i,CA}^{2}}$$

Which is also distributed with 20,20 degrees of freedom.

In this case, we are using 2nd block US data and 1st block Canadian data in order to determine whether Canadian volatility spills over to the US market.