

# **EMPIRICAL OPTIMIZATION OF BOLLINGER BANDS FOR PROFITABILITY**

by

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Bachelor of Arts, The University of Western Ontario

PROJECT SUBMITTED IN PARTIAL FULFILLMENT  
OF THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF ARTS

In the Faculty of Business Administration

Financial Risk Management Program

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SIMON FRASER UNIVERSITY



Summer 2006

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## **ABSTRACT**

This paper endeavours to evaluate the profitability of Bollinger Bands through an empirical study. Bollinger Bands are able to capture sudden fluctuations in price level, which may be useful when tweaking its inputs to derive a trading rule. For the purpose of projecting prices, technical analysts have chosen a moving average of 20 days for short term analysis and 200 days for long term analysis. Moving averages in relation to profitability is the focus of this study. What follows is a discussion on the development of Bollinger Bands from trading bands, and moving averages. After testing a simple trading rule on the components of the DOW 30 index there is a revelation that a single moving average window cannot be used to derive an all (security) encompassing trading rule.

### **Keywords**

Bollinger Band, Bandwidth, Trading Rule, Trading Band, Technical Analysis, Moving Average

I dedicate the paper to Christine and Robert Williams.

The two have had a tremendous impact on my education and growth.

I am who I am because of you - I will forever be in your debt.

## **ACKNOWLEDGEMENTS**

I must acknowledge Geoffrey Poitras – his keenness and quick thinking gel with my personality. With his help I was able to accomplish ‘more with less.’

Derek Yee has been an invaluable resource to me from the beginning on this program. His guidance, balanced carefully great autonomy, helped the SIAS Compliance team add a new page to the development of our business school.

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# **1 HISTORICAL EVALUATION**

## **1.1 Introduction**

This paper will introduce and review the relevant topics of Bollinger Bands and combine them into a test for profitability. The following discussion is limited to one of the potential uses of Bollinger Bands; namely, the size of the moving average windows. The industry standard for Bollinger bandwidth is 20 days for short term evaluation and 200 days for long term evaluation. A simple trading rule will be used to determine if it is possible to find a single moving average window that will be profitable for any of the tested securities, all of which are components of the DOW 30 index. A positive result could drive research toward a more diverse range of securities. The alternative to this would require that the analyst use fundamental analysis to evaluate each security on an individual basis.

## **1.2 Measuring Risk**

The performance of money managers is usually gauged by their returns in relation to a benchmark. One way to look at this is in terms of tracking error. Tracking error is the difference between the actual returns of a portfolio (or fund) and the returns of some pre-set benchmark. While the returns of the benchmark will fluctuate, (sometimes wildly), it is mathematically considered a non-risky portfolio in relation to the benchmark risk level. So if a fund has a tracking error, it is considered risky, and stakeholders would be concerned if the fund's performance outweighs the added risk.

Another factor of performance measurement is ex-post risk - also known as historical risk. Ex-post risk is defined as the statistical variance of a portfolio returns around its mean. This

can be shown by the distribution of returns in a histogram or via the actual distribution function. Both resemble a normal distribution where most of the possible outcomes (returns), are centered on the mean and then fall off to the right and left tails of the function (see the upper charts in Appendix A).

It can be argued that using tracking error to calculate ex-post risk is not the best measure of risk since it looks at the returns relative to a benchmark which itself has a variance. Arguably, the most accurate measure would be the variance relative to the true mean. Tracking error is best left used to determine how closely a fund imitates the performance of another portfolio; this has little to do with the absolute variance the funds manager expects to experience in any given period.<sup>1</sup>

Ex-post risk, unlike tracking error, provides an estimate of the probability that the expected return of a fund will fall by a certain amount during the measuring period. This is why we observe practitioners studying value at risk (VaR), of which variance is an input. Tracking error, on the other hand, only makes sense as a measure of historical risk when the error itself is zero. When the fund's returns perfectly match those of the benchmark, the historical variance of the benchmark will match that of the securities held in the fund.

### **1.3 Technical Analysis**

Like the ex-post volatility measures discussed above, technical analysis is a method of evaluating securities by statistically analysing its historical trading data. Past prices, and volume are charted using different tools to identify patterns that can suggest future activity.

Technical analysts believe that the historical performance of stocks and markets are indications of future performance. Fundamental analysts, on the other hand, are inclined to

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<sup>1</sup> Investopedia, "Is tracking error a significant measure for determining ex-post risk?," Investopedia, <http://www.investopedia.com/ask/answers/06/trackingexpost.asp>.

evaluate financial statement documentation, and information from a company's management to estimate the future path of an equity price.

In a shopping mall, for instance, a fundamental analyst would go to each store, study the product that was being sold, and then decide whether to buy it or not. By contrast, a technical analyst would sit on a bench in the mall and watch people go into the stores. Disregarding the intrinsic value of the products in the store, his or her decision would be based on the patterns or activity of people going into each store.<sup>2</sup>

Thus, the concept of technical analysis is based more upon economic patterns rather than financial valuation. Put another way, it is the study of prices to make decisions on investments – with charts being the principal tool.

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<sup>2</sup> Investopedia, "Technical Analysis," Investopedia, <http://www.investopedia.com/terms/t/technicalanalysis.asp>.

## **2 TECHNICAL ANALYSIS CONCEPTS**

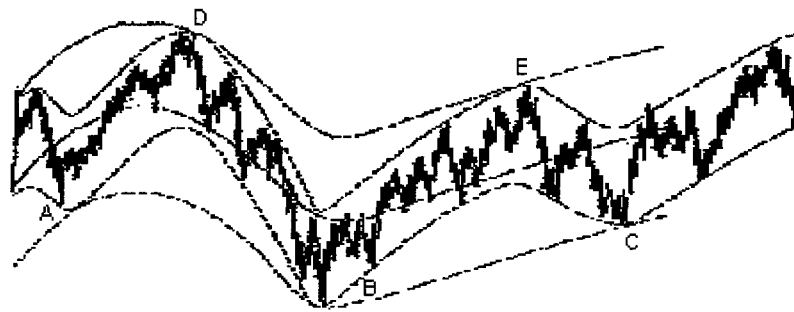
### **2.1 Trading Bands**

To introduce the approach this paper will take towards measuring profitability, we will examine the concept of trading bands. Trading bands envelop the price structure of an asset. Graphically, these trading bands would appear to be constraints on the asset's value throughout time, but this is not so. The bands however, are based on ex-post trading data – they are calculated after any asset change over a small change in time.

Behaviour of the price close to envelope is what this paper is concerned with. In the practice of technical analysis, the action of the prices close to the bands suggest buy and sell signals based on the distance between the price and the band reaching zero. Although there are exceptions to the rule, the tendency is for the bands to “contain” the asset price and to tell us whether the price is high or low on a relative basis. Thus, a trading rule can be developed based on the asset price's relationship to the bands.

Trading bands were originally developed by J.H. Hurst. The approach he used was simply to draw smoothed lines (an envelope) around a price series to identify cycles. Figure 1 shows an example of this technique. Note that different envelopes can be used to identify cycles of different lengths. The outer band was designed to touch the price at turnaround points in the asset's value.

**Figure 1      Trading Bands or Envelopes**



*Source: <http://www.bollingerbands.com/services/bb/>*

In the latter part of the 1970s, further developments in the idea of trading bands came to fruition. A moving average for the price series was calculated and then shifted up and down by a certain number of points or by a fixed percentage. This created a mathematically based envelope around the price. The concept gained popularity and is still used today.

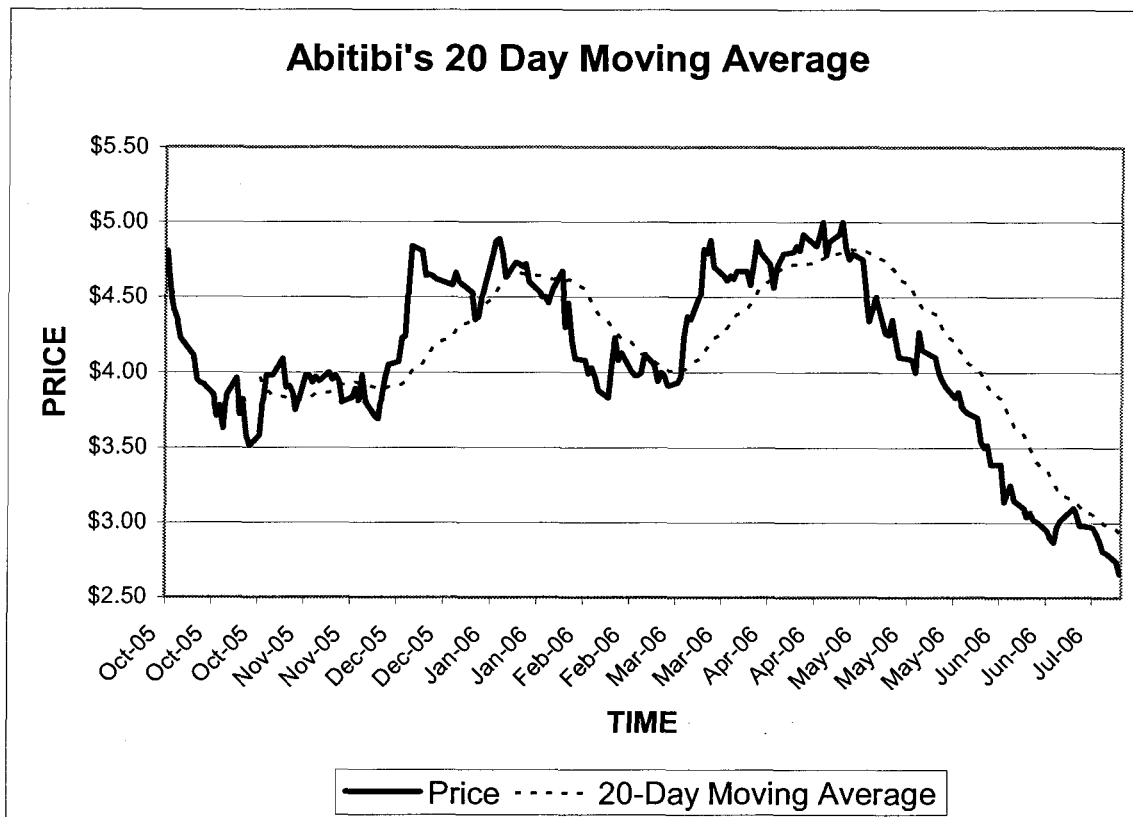
## **2.2 Moving Averages**

Moving averages indicate the average value of a security's price over a pre-set period of time. The calculation involves the determination of the securities average value over the measurement period. As the most recent observation of the security increases or decreases, so too does the average price. Different methods of the moving average calculation are available to be used for different purposes. In addition to a simple moving average (which we will be using for our calculations), exponential, triangular, variable, time series, volume adjusted, and weighted moving averages can be used to suit ones needs.

It is common practice to examine the relationship between the moving average of a security price and the price of the security itself. An indication that the price of the security is increasing occurs when the securities price rises above its moving average, and a signal that the price is in a downward trend is when it moves below its moving average. This price indicator can be used as a simple trading system to tell you when to buy (just after the security price bottoms)

and sell (just after the security price tops). However, it is not intended to get you in and out of a security with complete accuracy. This is similar to a stop-loss strategy for hedging an option where the strike price of the option is based on the moving average at a given time. Where the security price for Abitibi Consolidated Ltd. is plotted along with its 20-day arithmetic moving average, Figure 2 shows their relationship.

**Figure 2** Abitibi's 20-Day Moving Average



The critical input into the calculation of a moving average is the choice of the window used to calculate the average. Back-testing can be done to find the moving average window that will yield the most accurate trading strategy. But, of course, the past success of a given moving average window is not evidence of its future success. The reason for using a moving average as a



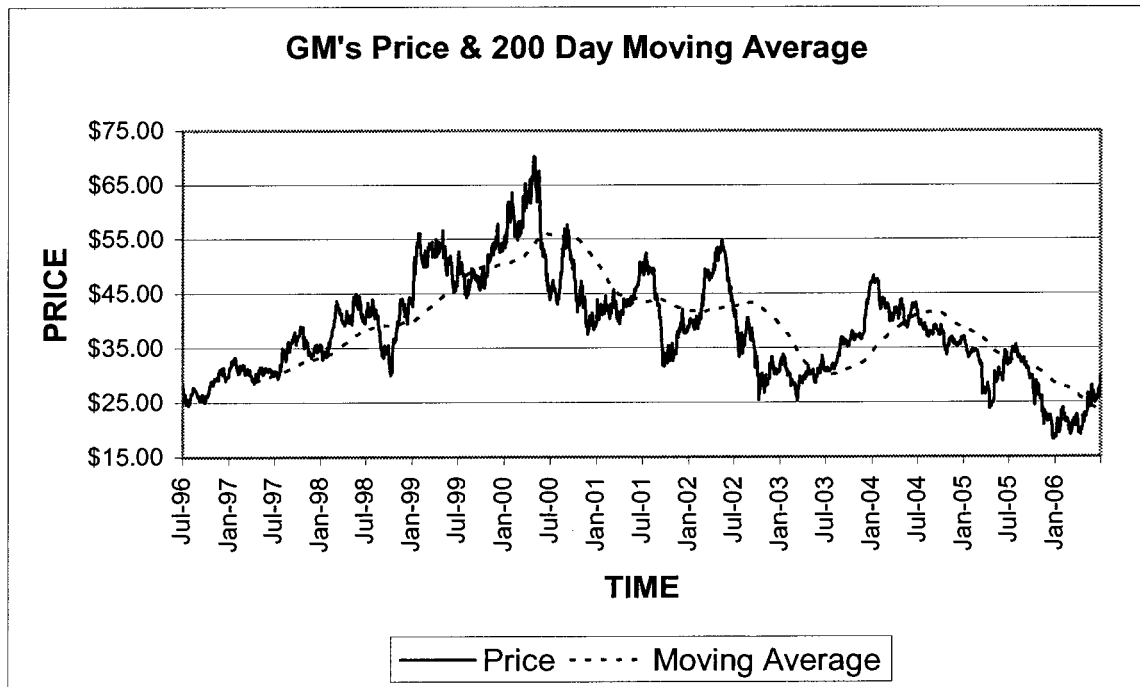
trading strategy is to yield consistent profits. Either the moving average window is chosen using fundamental analysis, or via econometric analysis as is done in this study. The most popular window is the 200-day moving average. It is used highly by technical analysts, and the media for reporting for long term market cycles. Those who study technical analysis determine the ideal moving average length according to the following formula:

**Equation 1 The Ideal Moving Average Length**

$$Ideal\ Moving\ Average\ Length = \frac{Cycle\ Length}{2} + 1$$

The cycle length for the formula is determined by the analyst through experience and examination of historical trends for the asset. Figure 3 is a plot of GM's stock price and its 200-day moving average. Indicator arrows could be inserted to point out resistance points that the price of the security sometimes rests on, but they would not pinpoint the tops and bottoms of the price.

Figure 3 GM's 200-Day Moving Average



### 2.3 Trading Bands

By combining two moving averages, we can create an envelope. To create the envelope, one moving average is shifted to the top of the price range and one is shifted to the bottom of the price range. The envelope defines the upper and lower boundaries of a security's normal trading range. The size of the band around the security's price represents the theoretical trading range of the security. Just as tracking error illustrates prices in relation to a preset benchmark, these bands illustrate volatility in relation to the [moving] average price

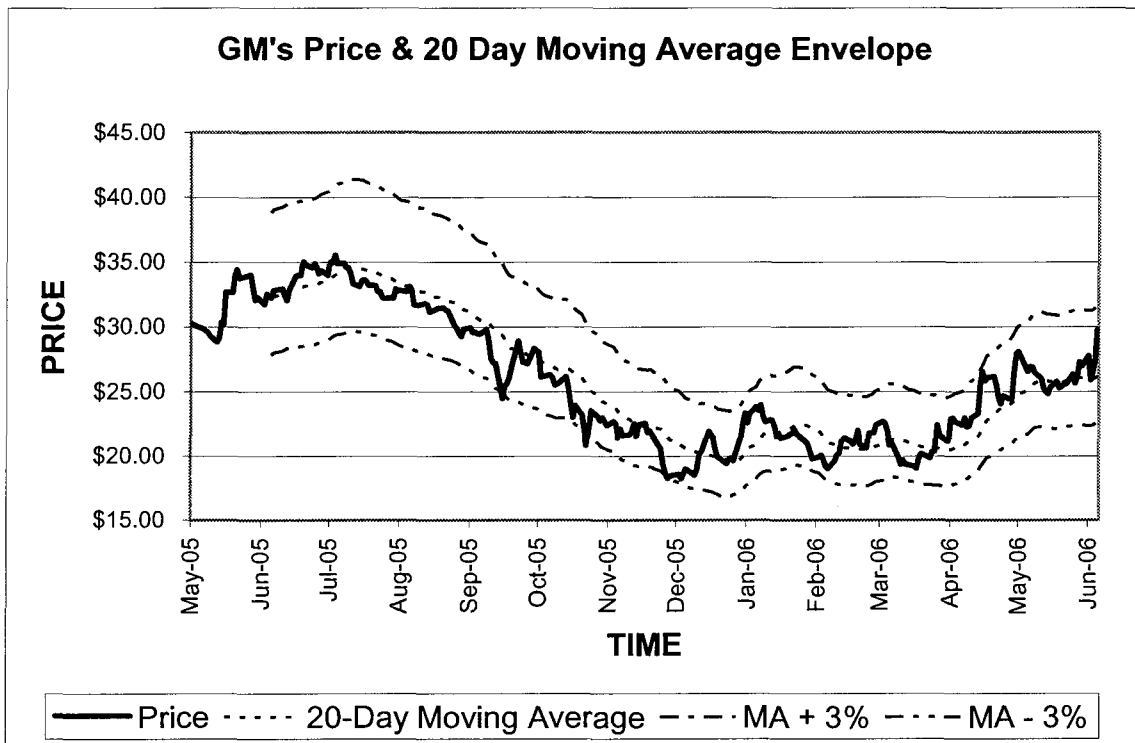
These trading bands, lines plotted above and below the price structure to form an envelope, are for the purpose of determining the probability of breaking through the bands. This is similar to the way traditional VaR measures determine the probability of losing a certain percentage of a portfolio's value (with a given percentage of confidence).

If the security reaches the top of its band, this suggests a ceiling price and thus the expectation of a turnaround. Likewise, when the security's price hits the lower band, this generates a buy signal. The reasoning behind the size of the band is that buyers and sellers push and pull prices to a certain percentage but no further. After a move to the extreme (band), the price should stabilize, returning to more realistic trading level.

Marc Chaikin of Bomar Securities was the next innovator in the development of trading bands. Chaikin attempted to find a way to have the market automatically determine the band widths rather than resorting to intuition or setting the amount randomly. His idea was that the bands should contain a fixed percentage of data over the past year. The Bomar bands he decided, similar to moving average envelopes, would contain 85% of the stock price data within its bands. To achieve this he shifted the bands up 3% and down 3%. With Bomer bands, not only does the total band width change across time, but the displacement around the average changes dynamically as well.

Figure 4 shows the 6% envelope of a 20-day moving average. Observe that from January 2006 to June 2006 the price tends to bounce off the bands rather than penetrate them. The envelopes are calculated by plotting two moving averages that have been shifted up and down. Clearly, there is a weakness in using moving average envelopes to contain the price of this series of GM prices. In the months previous to January 2006 there is a divergence in the prices and their bands. This is because the volatility in the first half of the time series is much higher than in the last half.

Figure 4 A 20-Day Moving Average Envelope



Bollinger Bands are similar to moving average envelopes and Bomer Bands. Bollinger Bands however, are plotted above and below the stock prices' moving average at standard deviation levels. Because standard deviation is a measure of volatility, the bands adjust according to the market volatility. Their band width will expand during volatile markets and will contract during less active periods.

## 2.4 Bollinger Bands

The philosophy behind Bollinger Bands is that asking the market what is happening is always a better approach than telling the market what do to. The designer of Bollinger Bands, Mr. Bollinger, was trading warrants and options in the early 1980's when index options started to trade. He, and others, focused on volatility as the key variable for these instruments. So when looking for a new approach to trading bands he turned to volatility as a key input into the band

calculation. Bollinger tested a number of volatility measures before opting for standard deviation as the method by which the band width was set by. His argument was that the bands were sensitive to extreme deviations and thus, reacted quickly to large price fluctuations.<sup>3</sup>

Bollinger suggests using 20 periods in the moving average, calculating the moving average using the “simple” (as shown in the formula for the middle band), and using 2 standard deviations. He has also found that moving averages of less than 10 periods do not work very well.

Bollinger Bands are displayed as three lines, (the bands). The middle band is a simple moving average. In the following formula, “n” is the number of time periods in the moving average (e.g., 20 days).

**Equation 2 Middle Bollinger Band**

$$Middle\ Band = \frac{\sum_{j=1}^n Close_j}{n}$$

The upper band is the same as the middle band, but it is transformed by a number of standard deviations (e.g. 2 deviations). In this next formula, “D” is the amount of standard deviations. Unlike moving average envelopes, in which the upper and lower bands are shifted versions of the security’s moving average, the Bollinger bands do not necessarily resemble each other because instead of a shift, the middle band is a transformation through the standard deviation.

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<sup>3</sup> Achelis, Steven, *Technical Analysis from A to Z*. New York: McGraw Hill, 2000.

**Equation 3 Upper Bollinger Band**

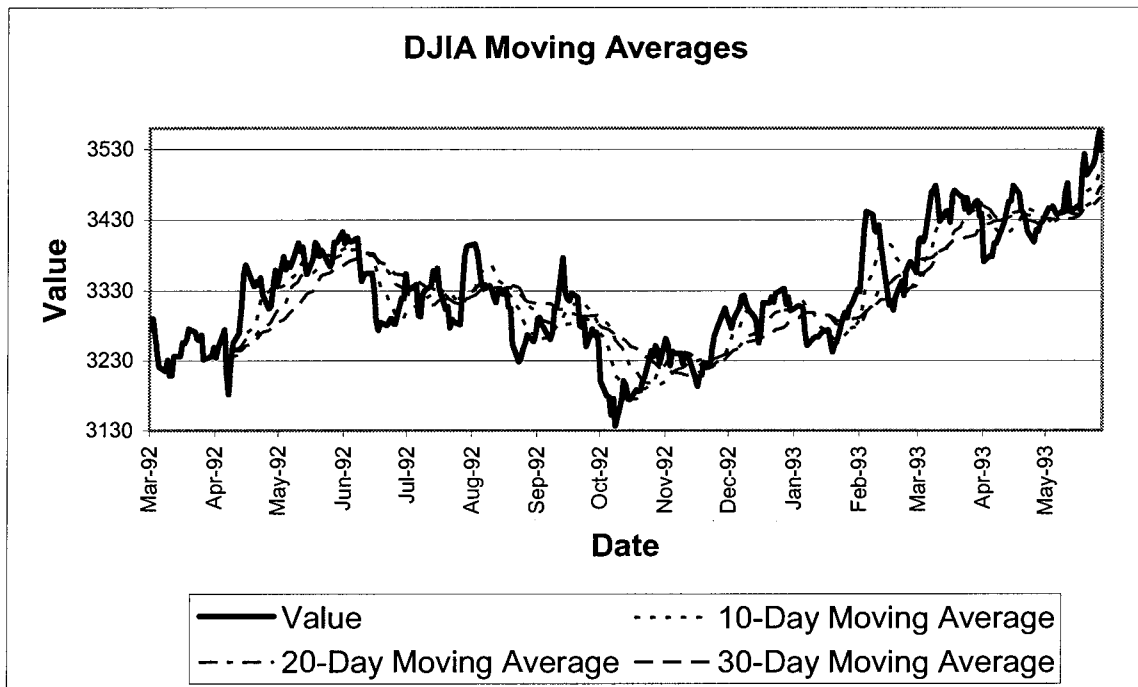
$$UpperBand = Middle Band + \left[ D \times \sqrt{\frac{\sum_{j=1}^n (Close_j - Middle Band)^2}{n}} \right]$$

**Equation 4 Lower Bollinger Band**

$$LowerBand = Middle Band - \left[ D \times \sqrt{\frac{\sum_{j=1}^n (Close_j - Middle Band)^2}{n}} \right]$$

The average that is selected should be descriptive of the chosen time frame. This is almost always a different average length than the one that proves most useful for crossover buys and sells. The best way to identify the proper average is to choose one that provides support to the correction of the first move up off a bottom. If the average is penetrated by the correction, then the average is too short. If, in turn, the correction falls short of the average, then the average is too long. For the stock market and individual stocks, the literature considers 20-day periods are optimal for calculating Bollinger Bands. This length is descriptive enough for medium term analysis, and has achieved wide acceptance. An average that is correctly chosen will provide support far more often than it is broken. See Figure 5.

Figure 5 Moving Averages



In most cases, the nature of the periods is immaterial; all seem to respond to correctly specified Bollinger Bands. They have been used on monthly and quarterly data, and there are traders that apply them on an intraday basis. The trading bands answer the question of whether prices are high or low on a relative basis. This statement actually depends on the key phrase "a relative basis." This is because the trading bands do not give absolute buy and sell signals when they brake through. Rather, they provide a framework within which price may be related to indicators.

## **3 TRADING**

### **3.1 Previous Work**

Some older work has stated that the deviation from a trend, as measured by the standard deviation from a moving average, could be used to determine extreme overbought and oversold states. These older authorities recommend the use of trading bands to generate buy and sell continuation signals through the comparison of an additional indicator to the action of price within the bands. If price tags the upper band and indicator action confirms it, no sell signal is generated. On the other hand, if price tags the upper band and indicator action does not confirm (that is, it diverges), we have a sell signal. The first situation is not a sell signal; rather, it is a continuation signal if a buy signal was in effect. This early work also recognised that it was possible to generate signals from price action within the bands alone. A top formed outside the bands followed by a second top inside the bands constitutes a sell signal. There is no requirement for the second top's position to be relative to the first top (peak), only relative to the bands. This often helps in spotting tops where the second push goes to a nominal new high. Of course, the converse is true for lows.

### **3.2 Characteristics of Price Movement**

The following conclusions are often drawn from Bollinger Bands analysis.<sup>4</sup>:

1. A tightening of the bands (decrease in volatility), suggest that sharp price changes will follow;
2. A continuation of the current trend is likely sustained when prices move outside the bands;

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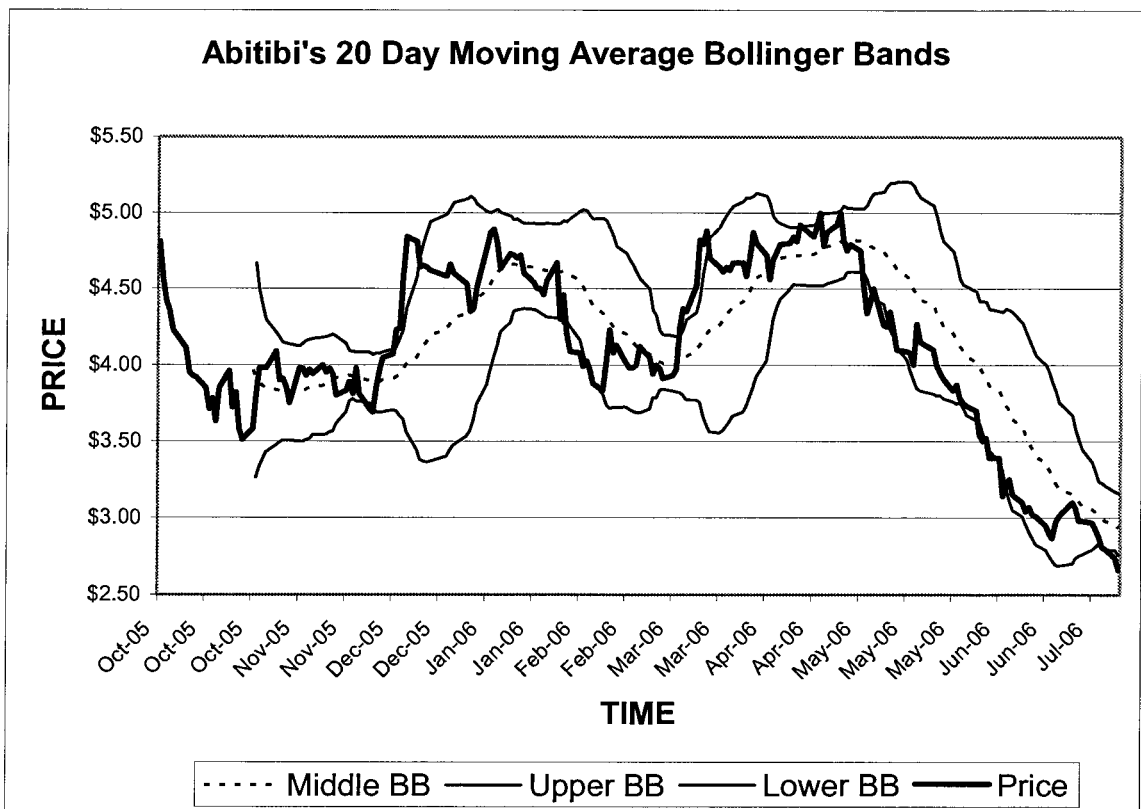
<sup>4</sup> Bollinger Bands. "Bollinger Bands Tutorial." <http://www.bollingerbands.com/services/bb/>



3. A reversal in the trend is usually results after bottoms and tops made outside the bands are followed by bottoms and tops made inside the bands; and
4. A move that originates at one band will tend to proceed fully to the other band, (this can be useful for projecting prices).

Figure 6 shows Bollinger Bands on Abitibi's prices. The Bands were calculated using a 20-day simple moving average and are spaced two deviations apart.

**Figure 6** Abitibi's 20-Day Moving Average Bollinger Bands



Now observe how many reversals occur near the bands, and that the average provides support and resistance at numerous points. This paper will confine its discussion of trading bands

to the use of closing prices for the construction of bands. It is most common in industry to use a moving average of 20-days for short term analysis of the price movement. Table 1 below shows recommendation for moving average window length.

**Table 1**      **Suggested Moving Averages for Market Cycles**

<b>Trend</b>	<b>Moving Average</b>
Very Short Term	5 – 13 days
Short Term	14 – 25 days
Minor Medium Term	26 – 49 days
Medium Term	50 – 100 days
Long Term	100 – 200 days

*Achelis, Steven, Technical Analysis from A to Z. New York: McGraw Hill, 2000.*

John Bollinger has invented an analytical technique that lends itself to various uses.

While there are many ways to use Bollinger Bands, the following are a few rules that serve as a good basis for the discussion to follow.

1. Bollinger Bands provide a relative definition of high and low.
2. That relative definition can be used to compare price action and indicator action to arrive at rigorous buy and sell decisions.
3. Appropriate indicators can be derived from momentum, volume, sentiment, open interest, inter-market data, etc.
4. Volatility and trend have already been deployed in the construction of Bollinger Bands, so their use for confirmation of price action is not recommended.
5. The indicators used for confirmation should not be directly related to one another. Two indicators from the same category do not increase confirmation. Avoid co-linearity.
6. Bollinger Bands can also be used to clarify pure price patterns such as M-type; tops and W-type bottoms, momentum shifts, etc.
7. Price can, and does, walk up the upper Bollinger Band and down the lower Bollinger Band.

8. Closes outside the Bollinger Bands can be continuation signals, not reversal signals-- as is demonstrated by the use of Bollinger Bands in some very successful volatility-breakout systems.
9. The default parameters of 20 periods for the moving average and standard deviation calculations, and two standard deviations for the bandwidth are just that, defaults. The actual parameters needed for any given market/task may be different.
10. The average deployed should not be the best one for crossovers. Rather, it should be descriptive of the intermediate-term trend.
11. If the average is lengthened the number of standard deviations needs to be increased simultaneously; from 2 at 20 periods, to 2.1 at 50 periods. Likewise, if the average is shortened the number of standard deviations should be reduced; from 2 at 20 periods, to 1.9 at 10 periods.
12. Bollinger Bands are based upon a simple moving average. This is because a simple moving average is used in the standard deviation calculation and we wish to be logically consistent.
13. Be careful about making statistical assumptions based on the use of the standard deviation calculation in the construction of the bands. The sample size in most deployments of Bollinger Bands is too small for statistical significance and the distributions involved are rarely normal.
14. Indicators can be normalized with %b, eliminating fixed thresholds in the process.
15. Finally, tags of the bands are just that, tags not signals. A tag of the upper Bollinger Band is NOT in-and-of-itself a sell signal. A tag of the lower Bollinger Band is NOT in-and-of-itself a buy signal.<sup>5</sup>

### **3.3 Problems with Using Bollinger Bands**

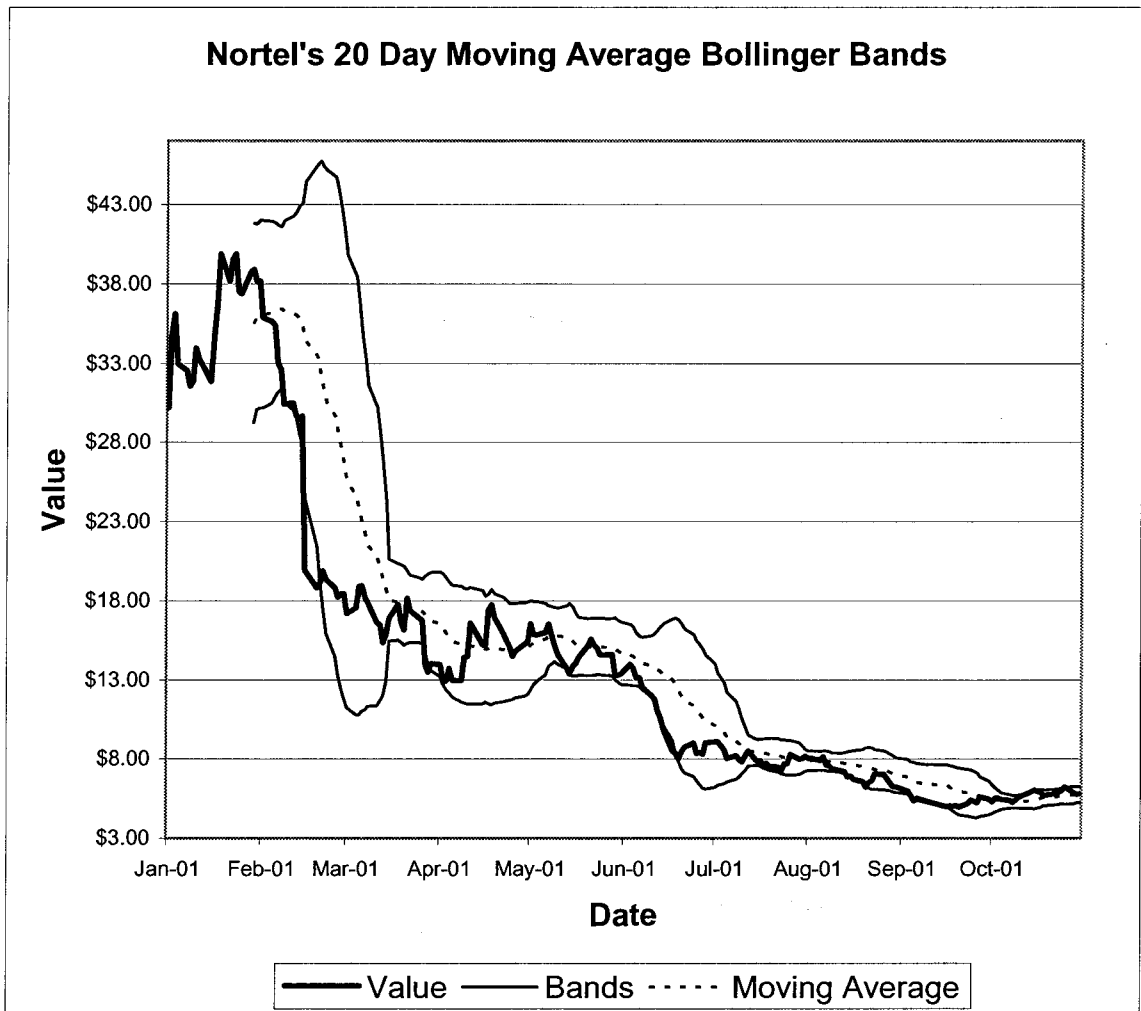
When using Bollinger Bands the upper and lower bands are designated as price targets. If the price deflects off the lower band and crosses above the 20-day average (which is the middle line), the upper band comes to represent the upper price target. In a strong uptrend, prices usually

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<sup>5</sup> Bollinger Bands. "Bollinger Bands Tutorial." <http://www.bollingerbands.com/services/bb/>

fluctuate between the upper band and the 20-day moving average. When that happens, a crossing below the 20-day moving average warns of a trend reversal to the downside.

**Figure 7** Nortel Networks' Bollinger Bands

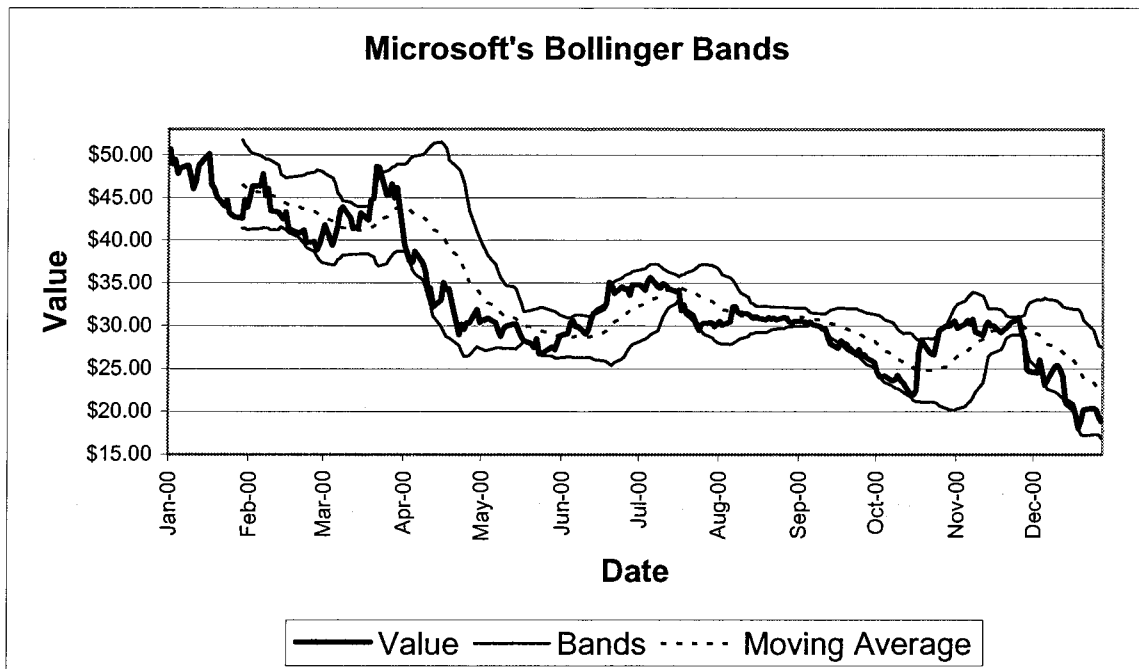


This chart, showing changes in the market value of the shares of Nortel Networks (Figure 7), demonstrates that from the start of 2001 that the stock price was often touching the lower band, and the stock price fell from the \$40 level in the dead of winter to its October position of \$5.69. There were a couple of instances that saw the price action cut through the centerline (mid-

January and early April), but for many traders, this was certainly not a buy signal as the trend had not been broken.

In the 2001 chart of Microsoft Corporation (Figure 8), you can see the trend reversed to an uptrend in the early part of January, but not how slow it was in showing the trend change. Before the price action crossed over the centerline, the stock price had moved from \$40 to \$47 and then on to between \$48 and \$49 before some traders would have confirmation of this trend reversal.

**Figure 8** Microsoft's Bollinger Bands



This is not to say that Bollinger Bands are not well regarded indicator of overbought or oversold securities, but it is important to note that trends should be first recognized with moving averages before more exotic indicators are used to confirm a trend.<sup>6</sup>

<sup>6</sup> Investopedia, "Technical Analysis," Investopedia, <http://www.investopedia.com/articles/technical/102201.asp>.

## 4 METHODOLOGY

### 4.1 Trading Rule

Since the Bollinger Bands take the price volatility into account, it will be interesting to test if a trading rule based on the bandwidth yields a profit. The width of the Bollinger Bands depends on the fluctuation of the prices around the mean, adjusted for volatility. When the volatility increases but the moving average remains unchanged, the Bollinger Bands will expand to capture the price fluctuations. If the stock prices follow a normal distribution, the Bollinger Bands with 2 standard deviations will capture about 95% of the price movements. This means that the rare event of a greater than 2 standard deviation price movement can be captured in a trading rule that will allow one to profit from changes outside this interval. The region above the upper bound of the Bollinger Band will be considered as an overbought area, while the region below the lower bound will be considered as oversold. A broad rule would assume that when a stock is considered as overbought, investors should sell it because the price of the stock is expected to fall, and vice versa.

A problem arises because it is hard to predict how long a stock will stay in overbought or oversold region. Our rule then will be designed so that we do not take any position until the stock moves away from those regions. For the Bollinger Bands, the trading rules are defined as follows:

**Equation 5 Buy Rule**

$$P_N(t-1) < BB_N^{low}(t-1) \text{ and } P_N(t) > BB_N^{low}(t)$$

**Equation 6 Sell Rule**

$$P_N(t-1) > BB_N^{up}(t-1) \text{ and } P_N(t) < BB_N^{up}(t)$$

Therefore, a buy signal will be generated when the price crosses the lower bound from below and then a sell signal will be generated when the price penetrates the upper bound from above. In this paper, Bollinger Bands will be studied by using moving averages from 20 days to 300 days with 2 standard deviations. To help standardize the results, this paper will assume that the transaction costs and the stock dividends are negligible. The effects of dividends are somewhat negated though the large number of data points used for the trading rule used in this paper. However, it should be noted that the price is affected on the ex-dividend date and this could be taken into account in further studies. This paper also assumes that short selling is allowed on the first transaction, and since transactions cannot be accumulated a short position must be liquidated via a repurchase and vice-versa, i.e., two consecutive buying actions are not allowed and the trading account must contain no securities at the end of the period (only cash from profit or loss). The performance of the trading action is evaluated in terms of relative return on investment by means of Equation 7:

**Equation 7 Profit/Loss Calculation**

$$\text{Profit} = \frac{\textit{ending cash balance}}{P_N(1)}$$

**4.2 Data**

This paper will test the trading rule on the widely held stocks that makeup the components of the Dow 30. Our data will consist of prices from 3362 trading days ranging from March 1st, 1993 to June 30th, 2006. The range dates back to 1993 because this is the first date that all present day components began to trade in US markets (although many were trading previous to this date).

**Table 2**      **Components of the DOW 30**

<b>Symbol</b>	<b>Name</b>	<b>Symbol</b>	<b>Name</b>
MMM	3M Company	INTC	Intel Corporation
AA	Alcoa Incorporated	IBM	International Business Machines
MO	Altria Group Incorporated	JNJ	Johnson & Johnson Co.
AXP	American Express Company	MS	JP Morgan & Chase & Co.
AIG	American International Group, Inc.	MCD	McDonald's Corporation
T	AT&T Inc.	MRK	Merck & Co., Inc.
BA	Boeing Co.	MSFT	Microsoft Corporation
CAT	Caterpillar Inc.	PFE	Pfizer Inc
C	Citigroup, Inc.	KO	The Coca-Cola Company
DD	E.I. du Pont de Nemours and Company	HD	The Home Depot, Inc.
XOM	Exxon Mobil Corp	PG	The Procter & Gamble Company
GE	General Electric Company	UTX	United Technologies Corporation
GM	General Motors Corporation	VZ	Verizon Communications
HPQ	Hewlett-Packard Co.	WMT	Wal-Mart Stores, Inc.
HON	Honeywell Intl Inc	DIS	Walt Disney Company (The) (Holding Company)

*Note: Components of the DOW 30 as at July 1<sup>st</sup>, 2006.*

### **4.3 Testing**

Before the Bollinger Bands are tested for profitability. The components of the DOW 30 (the test data) are tested to verify that this papers assumption of normality is reasonable. Although the distributions of the security returns would fail a formal test for normality, the assumption can be verified via the general shape of a histogram of the security returns. The histogram plots of returns for all of the DOW 30 components from March 1st, 1993 to June 30th, 2006 can be seen in Appendix A. All of the securities tested here conform to the general shape of a normal distribution, and therefore the assumption can hold as valid.

To further legitimate this papers assumption of normality, the 3<sup>rd</sup> and 4<sup>th</sup> moments have been calculated for the returns of the 30 DOW components. Table 3 contains this date for the dataset. While the 3<sup>rd</sup> moment is reasonably close to normal, the 4<sup>th</sup> moment demonstrates that



the tails of many of the distributions are thicker than normal. This means that these securities in particular tend to be outlier-prone.

**Table 3** Calculated Moments of the DOW 30 Return Data

<b>Security</b>	<b>3rd Moment</b>	<b>4th Moment</b>	<b>Security</b>	<b>3rd Moment</b>	<b>4th Moment</b>
MMM	0.1039	6.7242	INTC	-0.4286	8.7853
AA	0.2098	5.6800	IBM	0.0926	9.4249
MO	-0.8534	18.3700	JNJ	-0.3030	9.6762
AXP	0.3165	10.0880	MS	0.0314	6.4260
AIG	0.1167	6.3388	MCD	-0.0781	7.5938
T	-0.0703	6.4313	MRK	-1.4885	29.0570
BA	-0.5809	11.2290	MSFT	-0.1298	8.1620
CAT	-0.0440	6.0168	PFE	-0.1172	5.4316
C	0.0611	7.8847	KO	-0.1548	7.3989
DD	0.0270	6.0161	HD	-1.1127	21.9820
XOM	-0.0099	5.5601	PG	-3.1511	70.9800
GE	0.0422	7.0550	UTX	-1.4931	29.0940
GM	0.0912	7.0928	VZ	0.1448	6.8363
HPQ	-0.0918	7.9594	WMT	0.0674	5.4059
HON	-0.2762	15.8220	DIS	-0.1165	10.5510

*Note: Skewness is zero for all symmetric distributions including the normal. Kurtosis is equal to 3 for the normal distribution.*

The Bollinger Bands for each security are calculated based on multiple moving averages and a standard deviation of 2. This paper uses moving averages ranging from 1 to 300 to get a full range of profit possibilities. The trading rules are run according to the algorithm as stated previously. The output of the trading rule algorithm is a 300 by 30 cell matrix with contains the profit for each moving average window in the rows, and the profit for the corresponding security in the columns. As can be seen in Table 4 below, a small sample of the 300 by 30 matrix, there is no moving average that yields a negative profit for this trading rule. The trading rule was designed to account for investors acting rationally, not willing to sell/short or buy/long a unit of stock at a loss.

**Table 4 Trading Rule Profits According to Moving Average Length**

MA	Security (Symbol)																													
	MMM	AA	MO	AXP	AIG	T	BA	CAT	C	DD	XOM	GE	GM	HPQ	HON	INTC	IBM	JNJ	MS	MCD	MRK	MSFT	PFE	KO	HD	PG	UTX	VZ	WMT	DIS
1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	0.6	0.0	11.7	0.0	0.0	0.0	3.8	0.0	13.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	19.8	0.8	0.0	34.4	1.0	25.6	0.0	2.4	0.0
7	3.4	1.6	2.7	0.5	1.7	1.4	1.0	0.0	0.4	2.1	1.1	0.9	8.7	2.1	0.0	0.2	0.9	2.2	0.3	0.2	3.2	0.4	0.0	2.1	1.9	0.0	0.0	7.2	6.9	1.3
8	2.0	0.3	0.5	0.0	1.4	0.0	1.7	0.0	1.0	1.5	2.0	0.6	0.0	1.7	0.0	0.1	0.9	0.9	0.8	0.3	2.6	0.3	0.0	2.7	1.8	1.2	0.0	5.7	0.0	2.8
9	2.0	0.9	3.3	0.0	2.1	1.4	0.0	0.0	1.3	1.5	2.6	0.7	5.9	1.3	1.7	0.1	0.9	2.1	2.1	0.2	2.8	0.2	0.1	4.3	2.4	1.4	0.0	5.7	0.0	1.4
10	2.0	1.2	0.2	0.0	1.7	0.6	0.0	0.0	0.6	0.3	2.3	1.3	7.4	1.5	0.5	0.1	0.9	1.8	2.1	0.1	4.0	0.2	0.2	2.4	0.6	0.7	0.0	0.1	0.0	0.5
11	2.2	1.3	0.2	0.0	3.0	0.0	0.0	0.0	0.5	1.3	2.0	1.2	6.0	1.9	1.4	0.5	0.7	1.4	1.3	0.1	3.5	0.5	0.3	3.6	3.2	1.1	0.0	0.7	0.0	0.7
12	2.2	0.0	0.3	0.0	2.6	0.0	0.0	0.0	1.1	1.1	2.0	0.0	6.0	1.1	1.6	0.5	0.6	1.2	2.5	0.3	1.5	0.5	0.3	3.2	4.9	1.1	0.0	0.7	0.0	1.1
13	2.9	1.5	0.3	0.0	3.1	0.1	0.0	0.0	0.9	0.7	1.5	0.0	5.5	1.1	1.5	0.4	0.6	1.2	2.3	0.3	1.7	0.5	0.6	3.1	4.6	0.7	0.0	0.7	0.0	1.0
14	1.4	1.5	0.5	0.0	2.6	0.1	0.0	0.0	0.9	0.7	1.8	0.0	5.3	1.1	1.5	0.4	3.7	0.6	2.3	0.3	2.6	0.7	0.8	3.8	4.4	1.1	0.0	0.7	0.0	1.1
15	1.8	1.5	0.5	0.0	2.5	0.2	0.0	0.0	1.8	1.6	1.8	0.0	5.3	0.9	1.4	0.2	3.8	1.7	2.4	0.3	2.2	0.4	0.4	3.8	4.7	0.7	0.0	0.7	0.0	1.4
16	1.6	1.5	0.5	0.0	1.8	0.2	0.0	0.0	1.2	1.6	2.1	0.0	6.3	0.9	0.9	0.2	0.6	1.5	1.5	0.3	1.6	0.3	0.2	3.9	1.4	0.4	0.0	1.4	0.0	1.5
17	1.5	1.5	0.5	0.0	2.2	2.4	0.0	0.0	1.2	0.4	1.6	0.0	6.8	0.9	1.2	0.2	1.3	0.5	0.6	0.6	1.1	0.3	0.2	2.8	5.6	0.8	0.0	1.4	0.2	2.8
18	1.8	1.0	0.1	0.0	2.6	0.0	0.0	0.0	1.2	0.4	1.4	0.0	7.4	1.1	3.7	0.2	1.3	0.5	0.9	0.6	1.1	0.3	0.3	1.7	5.4	0.8	0.0	1.4	0.2	3.1
19	1.8	0.9	0.1	0.0	2.2	0.3	0.0	0.0	1.9	0.4	1.0	0.0	7.4	1.1	3.0	0.2	1.8	0.5	0.9	0.6	1.4	0.3	0.3	1.7	10.0	0.8	0.0	1.4	0.2	6.7
20	1.7	1.1	1.5	0.0	2.2	0.3	0.0	0.0	1.6	0.4	0.8	0.0	7.3	1.1	2.8	0.2	1.8	0.6	1.9	0.1	1.9	0.3	0.3	1.5	10.2	0.7	0.0	3.0	0.2	6.4
21	2.8	1.1	1.5	0.0	2.2	0.3	0.0	0.0	1.1	0.4	1.3	0.0	7.2	1.3	2.5	0.2	1.8	0.5	1.9	0.1	1.2	0.3	0.3	2.0	9.5	2.1	0.0	3.0	0.2	9.4
22	3.1	0.4	1.3	0.0	2.5	0.3	0.4	0.0	1.3	0.4	1.1	0.0	8.0	1.2	2.5	0.2	1.0	0.5	1.9	0.2	1.2	0.3	0.3	1.8	9.5	1.7	0.0	1.1	0.2	7.5
23	3.7	0.9	1.3	0.0	2.3	0.3	0.4	0.0	1.3	0.4	1.5	0.0	8.5	1.2	2.5	0.2	1.9	0.6	1.0	0.2	0.8	0.3	0.3	1.5	9.3	2.0	0.0	1.6	1.8	8.4
24	3.7	1.0	1.3	0.0	1.5	0.3	0.4	0.0	1.3	0.4	1.1	0.0	6.3	1.2	2.4	0.2	1.9	0.2	1.8	0.2	0.8	0.6	0.7	1.6	10.1	2.1	0.0	1.6	1.0	6.7
25	3.9	1.1	1.5	0.0	1.5	0.3	0.5	0.0	1.5	0.4	1.1	0.0	3.7	1.2	2.4	0.2	1.9	0.6	1.8	0.2	0.6	0.4	0.7	2.6	9.9	2.0	0.0	1.4	1.8	6.7
26	3.9	1.2	1.5	0.0	1.8	0.3	0.5	0.0	1.5	0.4	1.5	0.0	1.5	1.2	3.6	0.4	1.9	0.6	1.8	0.2	0.9	0.3	0.7	2.6	8.6	2.0	0.0	3.9	1.8	3.0
27	3.9	1.5	0.9	0.0	1.8	4.9	0.0	0.0	1.2	0.4	0.8	0.0	1.5	1.2	3.3	0.4	1.9	0.6	0.9	0.1	1.4	0.3	0.7	2.6	9.1	2.0	0.0	4.6	2.4	3.4
28	3.4	1.5	1.1	0.0	1.8	4.9	0.0	0.0	1.3	0.5	0.9	0.0	1.5	1.1	2.0	0.4	1.2	0.6	0.9	0.7	2.2	0.3	0.7	2.6	8.4	2.1	0.0	4.6	2.4	3.6
29	3.5	1.5	1.1	0.0	1.8	4.7	0.0	0.0	1.4	0.5	0.8	0.0	3.3	1.1	2.0	0.4	1.2	0.3	0.9	0.8	2.2	0.3	0.3	2.6	9.0	1.4	0.0	2.4	2.1	3.7
30	4.3	1.5	0.5	0.0	2.6	2.6	0.0	0.0	1.0	0.5	0.8	0.0	2.8	1.1	2.0	0.8	1.2	0.7	0.9	1.2	2.3	0.3	0.3	2.6	4.6	0.7	0.0	1.6	2.8	4.6
31	4.2	0.1	0.4	0.0	2.6	2.6	0.0	0.0	1.2	0.5	0.4	0.0	1.0	1.0	2.0	0.8	1.2	0.7	0.7	0.7	2.1	0.3	0.3	2.4	4.2	1.4	0.0	1.6	3.0	5.1
32	2.8	0.1	0.4	0.0	1.9	0.0	0.0	0.0	1.2	0.5	0.4	0.0	1.0	1.2	2.0	0.9	1.9	0.7	0.7	0.7	2.1	0.3	0.3	3.0	4.2	0.7	0.0	1.6	2.3	4.4
33	2.2	0.1	0.5	0.0	2.2	0.0	0.0	0.0	1.2	0.5	0.4	0.0	2.9	1.1	2.0	0.9	1.9	1.1	0.6	0.7	2.1	0.3	0.5	3.0	3.4	0.7	0.0	1.6	2.7	2.9
34	2.2	0.1	0.5	0.0	2.2	0.0	0.0	0.0	0.9	0.5	0.4	0.0	2.9	1.2	2.0	0.9	1.9	1.1	0.6	0.7	1.1	0.3	0.5	3.0	5.6	0.7	0.0	0.6	1.8	2.9
35	2.2	0.0	0.5	0.0	2.2	0.0	0.0	0.0	0.9	0.5	0.4	0.0	3.3	1.2	1.8	0.6	1.9	1.1	0.7	0.7	1.1	0.3	0.5	3.0	4.6	0.7	0.0	0.6	2.2	2.9
36	0.6	0.0	0.5	0.0	2.0	0.0	0.1	0.0	0.2	0.0	0.4	1.0	3.3	1.1	1.8	0.6	1.9	1.1	0.7	0.7	1.1	0.3	0.5	0.3	5.3	0.7	0.0	0.6	2.7	2.6
37	3.0	0.0	0.5	0.0	2.0	0.0	0.1	0.0	0.2	0.0	0.4	0.9	3.5	0.9	1.8	2.4	1.9	1.1	0.7	0.7	1.1	0.3	0.2	1.7	2.9	0.9	0.0	0.6	2.9	2.6
38	2.3	0.0	0.5	0.0	2.2	0.0	0.1	0.0	0.2	0.0	0.7	0.6	3.5	0.9	2.0	2.4	1.9	1.1	0.6	0.8	0.6	0.3	0.5	1.7	2.9	0.9	0.0	0.3	3.2	2.6
39	2.3	0.0	0.5	0.0	2.2	0.0	0.1	0.0	0.7	0.7	1.0	0.6	3.5	0.9	2.0	2.5	1.9	1.1	0.7	0.8	1.0	0.3	0.5	1.7	2.6	0.9	0.0	0.3	3.1	2.1
40	1.6	0.0	0.5	0.0	2.2	0.0	1.3	0.0	0.7	0.7	0.8	0.9	3.5	0.9	2.0	2.5	1.9	0.9	0.7	0.8	1.0	0.3	0.5	1.7	2.6	0.9	0.0	2.5	3.1	2.1
41	1.6	0.4	0.5	0.0	2.2	0.0	1.3	0.0	0.7	0.7	0.8	0.4	3.5	0.3	2.0	2.2	1.9	0.9	0.7	0.8	1.0	0.2	0.5	1.7	2.6	0.9	0.0	2.3	3.9	2.1
42	1.6	0.4	1.5	0.0	1.5	0.0	1.3	0.0	0.7	0.7	0.5	0.8	3.2	0.3	1.8	1.6	2.1	0.9	0.7	0.8	1.0	0.2	0.5	1.7	2.8	0.9	0.0	2.7	3.9	2.1
43	1.6	0.4	1.5	0.0	1.5	0.0	1.3	0.0	0.7	0.7	0.5	1.0	3.2	0.4	0.3	1.3	1.4	1.2	0.7	0.8	1.0	0.2	0.5	1.7	2.8	0.9	0.0	2.9	4.4	1.9
44	2.6	0.6	2.3	0.0	1.4	0.0	1.3	0.0	0.7	0.7	0.6	0.5	3.2	0.5	0.3	1.3	1.4	1.2	0.7	0.8	1.0	0.2	0.5	1.7	2.7	0.9	0.0	2.9	4.4	1.1
45	2.6	0.6	2.3	0.0	1.4	0.0	1.3	0.0	0.7	0.9	0.6	0.4	3.2	0.5	0.3	1.3	1.4	1.2	0.7	0.8	1.0	0.2	0.5	1.7	3.7	0.9	0.0	1.9	4.5	1.1
46	2.2	0.6	2.3	0.0	1.4	0.0	1.3	0.0	0.8	0.9	0.6	0.4	3.2	0.5	0.3	0.4	1.4	0.9	0.7	0.8	0.7	0.2	0.5	2.1	4.1	0.9	0.0	1.9	5.8	1.1
47	2.1	0.6	2.3	0.0	1.2	0.0	1.3	0.0	0.8	0.6	0.6	0.4	7.6	0.5	0.3	0.2	1.4	1.6	0.7	0.0	0.7	0.2	0.5	2.1	3.8	0.9	0.0	1.9	5.8	1.1
48	2.1	0.4	2.3	0.0	1.3	0.0	1.3	0.0	0.8	0.6	0.6	0.4	6.9	0.5	0.3	0.2	1.6	1.2	0.7	0.0	0.6	0.4	0.7							

## 5 DISCUSSION AND CONCLUSION

Bollinger bands are typically used by traders to detect extreme unsustainable price moves, capture changes in trend, identify support/resistance levels and spot contractions/expansions in volatility. Some traders believe that when the prices break above or below the upper or lower band, it is an indication that a breakout is occurring. These traders will then take a position in the direction of the breakout.<sup>7</sup>

Alternatively, some traders use Bollinger Bands as an overbought and oversold indicator. As shown in the chart below, when the price touches the top of the band, traders will sell, assuming that the currency pair is overbought and will want to revert back to mean or the middle moving average band. If the price touches the bottom of the band, traders will buy the currency pair, assuming that it is oversold and will rally back towards the top of the band. The spacing or width of the band is dependent on the volatility of the prices. Typically, the higher the volatility, the wider the band, and the lower the volatility, the narrower the band.<sup>8</sup>

In order to conclude that there is or is not commonality between moving average window size and profitability of this papers trading rule, a correction matrix is produced and examined.

Table 5 shows the correlation matrix for the full spectrum of profits (for each moving averages 0 to 300) for each security.

Further examination of the correlation matrix by calculating the p-values for each correlation coefficient yield no supposing results. While the some of the correlation coefficients

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<sup>7</sup> Refco F/X Associates. "Trade Using Charts: The Most Popular Indicators Used in FX." REFCOFX, <http://www.refcofx.com/education/trade-using-charts/most-popular-indicators.html;jsessionid=NFNDDNGADOBI>.

<sup>8</sup> Refco F/X Associates. "Trade Using Charts: The Most Popular Indicators Used in FX." REFCOFX, <http://www.refcofx.com/education/trade-using-charts/most-popular-indicators.html;jsessionid=NFNDDNGADOBI>.

are significant, they are not strong enough to show significant correlation. Our results are exceedingly mixed. While the trading rule was profitable for each security, the result of the test is that there is no significant correlation from one security to the next with regards to using a common moving average. Therefore this paper must conclude that this trading rule based on a Bollinger bandwidth cannot be used globally.

Alone, Bollinger Bands do not seem to yield the extraordinary results. Fundamental analysis is required to determine the best moving average window to match the business cycle of the asset. When combined with other techniques such as fundamental analysis. Bollinger Bands can give systematic traders a method of choosing their buy and sell points.

Table 5 Profitability Correlation Matrix

	Security (Symbol)																														
	MMMI	AA	MO	AXP	AIG	T	BA	CAT	C	DD	XOM	GE	GM	HPQ	HON	INTC	IBM	JNJ	MS	MCD	MRK	MSFT	PFE	KO	HD	PG	UTX	VZ	WMT	DIS	
MMM	1.0	0.3	0.1	-0.1	0.2	0.5	0.4	-0.3	0.1	0.1	0.1	0.4	0.2	0.6	-0.2	0.1	0.3	0.5	-0.1	0.0	0.5	-0.1	0.0	0.5	0.1	0.4	-0.2	0.5	0.3	0.2	
AA	0.3	1.0	0.2	-0.1	0.7	0.3	0.3	-0.5	0.2	0.5	0.4	0.3	0.1	0.4	-0.2	0.2	0.7	0.5	-0.3	0.1	0.5	-0.1	-0.3	0.6	0.4	0.7	-0.2	0.2	-0.0	0.2	
MO	0.1	0.2	1.0	-0.2	0.3	0.1	0.4	-0.3	0.1	0.1	0.1	-0.1	0.1	0.1	-0.2	0.2	0.1	0.1	-0.3	-0.1	0.1	0.7	-0.1	0.1	0.7	0.3	0.6	0.1	0.0	0.0	
AXP	-0.1	-0.1	-0.2	1.0	-0.3	-0.0	-0.2	0.1	-0.2	-0.2	0.1	-0.2	-0.0	-0.2	-0.1	-0.2	-0.2	-0.1	0.8	0.1	0.1	-0.1	0.4	0.1	-0.3	-0.2	-0.1	0.2	0.2	-0.1	
AIG	0.2	0.7	0.3	-0.3	1.0	0.1	0.4	-0.5	0.1	0.7	0.2	0.4	0.1	0.4	-0.2	0.6	0.7	0.5	-0.5	0.0	0.4	0.1	-0.4	0.5	0.4	0.8	-0.2	0.1	0.1	0.3	
T	0.5	0.3	0.1	-0.0	0.1	1.0	0.3	-0.4	0.3	0.1	0.1	0.2	0.1	0.4	-0.3	-0.0	0.1	0.4	-0.2	-0.0	0.6	-0.0	-0.1	0.3	0.2	0.2	-0.1	0.5	0.0	0.0	
BA	0.4	0.3	0.4	-0.2	0.4	0.3	1.0	-0.6	1.0	-0.3	-0.4	-0.1	0.7	0.3	0.6	-0.7	0.2	0.4	0.7	-0.5	-0.7	0.4	-0.2	0.4	0.3	0.5	0.1	0.4	0.5	-0.1	
CAT	-0.3	-0.5	-0.3	0.1	-0.5	-0.4	-0.6	1.0	0.4	-0.3	-0.4	-0.1	-0.6	-0.1	-0.6	0.6	-0.3	-0.5	-0.7	0.4	-0.0	-0.7	0.1	-0.5	-0.3	-0.6	0.2	-0.4	-0.2	-0.1	
CAT	0.1	0.2	0.7	-0.2	0.1	0.3	0.4	0.3	1.0	0.1	0.0	0.1	-0.1	0.1	0.3	-0.2	0.0	0.1	0.2	-0.2	0.2	0.3	0.9	-0.1	0.1	0.8	0.2	0.7	0.3	-0.2	
DD	0.1	0.5	0.4	-0.2	0.7	0.1	0.3	-0.4	0.1	1.0	0.1	0.3	0.0	0.2	0.3	0.5	0.4	0.3	-0.4	-0.1	0.2	0.0	-0.3	0.4	0.2	0.5	-0.1	0.0	0.0	0.1	
XOM	0.1	0.4	-0.1	0.1	0.2	0.1	-0.1	-0.1	0.0	0.1	1.0	0.1	0.2	0.2	0.1	-0.2	0.2	0.2	0.2	0.2	-0.0	0.4	-0.1	-0.2	0.3	0.0	0.2	-0.2	0.2	0.1	
GE	0.4	0.3	0.1	-0.2	0.4	0.2	0.7	-0.6	0.1	0.3	0.1	1.0	0.2	0.6	-0.6	0.3	0.4	0.8	-0.4	-0.4	-0.0	0.6	0.0	-0.2	0.5	0.0	0.5	-0.2	0.3	0.4	-0.1
GM	0.2	0.1	-0.1	-0.0	0.1	0.1	0.3	-0.1	-0.1	0.0	0.2	1.0	0.2	0.3	-0.1	-0.1	0.2	0.4	-0.0	0.1	0.3	-0.1	0.1	0.2	-0.1	0.1	-0.1	0.0	0.4	0.1	
HPQ	0.6	0.4	0.1	-0.2	0.4	0.4	0.6	-0.6	0.3	0.2	0.2	0.6	0.3	1.0	-0.5	0.1	0.4	0.7	-0.4	0.2	0.7	0.0	-0.3	0.5	0.2	0.4	-0.2	0.5	0.3	0.0	
HON	-0.2	-0.2	-0.2	-0.1	-0.2	-0.3	-0.7	0.6	-0.2	-0.3	0.1	-0.6	-0.1	-0.5	1.0	-0.1	-0.2	-0.6	0.3	0.0	-0.5	-0.1	0.1	-0.4	-0.0	-0.2	0.1	-0.4	-0.4	0.3	
INTC	0.1	0.2	0.2	-0.2	0.6	-0.0	0.2	-0.3	0.0	0.5	-0.2	0.3	-0.1	0.1	-0.1	1.0	0.4	0.2	-0.4	0.0	0.1	0.0	-0.2	0.2	0.2	0.4	-0.1	-0.0	0.0	0.1	
IBM	0.3	0.7	0.1	-0.2	0.7	0.1	0.4	-0.5	0.1	0.4	0.2	0.4	0.2	0.4	0.2	0.4	1.0	0.5	-0.4	0.1	0.4	0.1	-0.3	0.6	0.4	0.8	-0.2	0.1	0.1	0.3	
JNJ	0.5	0.5	0.1	-0.1	0.5	0.4	0.7	-0.7	0.2	0.3	0.2	0.8	0.4	0.7	-0.6	0.2	0.5	1.0	-0.3	0.0	0.8	0.0	-0.2	0.6	0.1	0.6	-0.2	0.4	0.4	0.0	
MS	-0.1	-0.3	-0.3	0.8	-0.5	-0.2	-0.5	0.4	-0.2	-0.4	0.2	-0.4	-0.0	-0.4	0.3	-0.4	-0.4	-0.3	1.0	0.1	0.1	-0.2	0.5	-0.1	-0.4	-0.5	-0.0	0.1	-0.0	-0.1	
MCD	0.0	0.1	-0.1	0.1	0.0	-0.0	-0.0	-0.0	0.2	-0.1	-0.0	0.0	0.1	0.2	0.0	0.0	0.1	0.0	0.1	1.0	0.1	0.0	0.2	-0.0	-0.0	-0.0	-0.0	0.1	0.4	0.0	-0.1
MRK	0.5	0.5	0.1	0.1	0.4	0.6	0.5	-0.7	0.3	0.2	0.4	0.6	0.3	0.7	-0.5	0.1	0.4	0.8	-0.1	0.1	1.0	0.0	-0.2	0.5	0.1	0.4	-0.2	0.6	0.2	0.0	
MSFT	-0.1	0.1	0.7	-0.1	0.1	-0.0	0.4	-0.1	0.9	0.0	-0.1	0.0	-0.1	0.0	-0.1	0.0	0.1	0.0	-0.2	-0.0	0.0	1.0	-0.0	-0.0	0.8	0.2	0.9	-0.0	-0.0	-0.1	
PFE	0.0	-0.3	-0.1	0.4	-0.4	-0.1	-0.2	0.3	-0.1	-0.3	-0.2	-0.2	0.1	-0.3	0.1	-0.2	-0.3	-0.2	0.5	0.2	-0.2	-0.0	1.0	0.0	-0.2	-0.3	0.0	0.1	0.1	0.0	
KO	0.5	0.6	0.1	0.1	0.5	0.3	0.4	-0.5	0.1	0.4	0.3	0.5	0.2	0.5	-0.4	0.2	0.6	0.6	-0.1	0.2	0.5	-0.0	0.0	1.0	0.2	0.6	-0.3	0.4	0.2	0.1	
HD	0.1	0.4	0.7	-0.3	0.4	0.2	0.3	-0.3	0.8	0.2	0.0	0.0	-0.1	0.2	-0.0	0.2	0.4	0.1	-0.4	-0.0	0.1	0.8	-0.2	0.2	1.0	0.6	0.6	0.0	-0.2	0.3	
PG	0.4	0.7	0.3	-0.2	0.8	0.2	0.5	-0.6	0.2	0.5	0.2	0.5	0.1	0.4	-0.2	0.4	0.8	0.6	-0.5	-0.0	0.4	0.2	-0.3	0.6	0.6	1.0	-0.1	0.1	0.1	0.4	
UTX	-0.2	-0.2	0.6	-0.1	-0.2	-0.1	0.1	0.2	0.7	-0.1	-0.2	-0.1	-0.2	0.1	-0.1	-0.1	-0.2	-0.2	-0.0	-0.1	-0.2	0.9	0.0	-0.3	0.6	-0.1	1.0	-0.2	-0.1	0.4	
VZ	0.5	0.2	0.1	0.2	0.1	0.5	0.4	-0.4	0.3	0.0	0.2	0.3	0.0	0.5	-0.4	-0.0	0.1	0.4	0.1	0.4	0.6	-0.0	0.1	0.4	0.0	0.1	-0.2	1.0	0.2	-0.1	
WMT	0.3	-0.0	0.0	0.2	0.1	0.0	0.5	-0.2	-0.2	0.0	-0.2	0.4	0.4	0.3	-0.4	0.0	0.1	0.4	-0.0	0.0	0.2	-0.0	0.1	0.2	-0.2	0.1	-0.1	0.2	1.0	-0.1	
DIS	0.2	0.2	0.0	-0.1	0.3	0.0	-0.1	-0.1	-0.0	0.1	0.1	-0.1	0.1	0.0	0.3	0.1	0.3	0.0	-0.1	-0.1	0.0	-0.1	0.0	0.1	0.3	0.4	-0.1	-0.1	-0.1	1.0	

Note: This correlation matrix illustrates poor correlation between the results from running the trading rules on each security. While the trading rule yielded one pattern of profits by changing the moving average from 1 to 300, other securities yielded totally different patterns.

Table 6 Correlation of Profit Vectors & P-Values (Securities 1-10)

CORR	MMM	AA	MO	AXP	AIG	T	BA	CAT	C	DD
1.000	(1.000)									
0.300	(0.000)	1.000	(1.000)							
0.094	(0.106)	0.211	(0.000)							
-0.095	(0.100)	-0.147	(0.011)							
0.227	(0.000)	0.741	(0.000)	1.000	(1.000)					
0.501	(0.000)	0.306	(0.000)	-0.252	(0.000)	1.000	(1.000)			
0.440	(0.000)	0.265	(0.000)	-0.190	(0.001)	0.273	(0.000)			
-0.323	(0.000)	-0.457	(0.000)	0.142	(0.014)	-0.430	(0.000)			
0.142	(0.014)	0.184	(0.001)	-0.168	(0.004)	0.256	(0.000)	1.000	(1.000)	
0.141	(0.014)	0.506	(0.000)	-0.230	(0.000)	0.059	(0.000)	-0.276	(0.000)	1.000
0.139	(0.016)	0.415	(0.000)	0.095	(0.099)	0.130	(0.025)	-0.377	(0.000)	0.066
0.444	(0.000)	0.323	(0.000)	-0.185	(0.001)	0.229	(0.000)	-0.149	(0.010)	0.006
0.215	(0.000)	0.148	(0.010)	-0.007	(0.910)	0.064	(0.347)	-0.589	(0.000)	0.114
0.559	(0.000)	0.424	(0.000)	-0.217	(0.000)	0.388	(0.000)	-0.147	(0.011)	-0.064
-0.247	(0.000)	-0.181	(0.002)	-0.081	(0.161)	-0.273	(0.000)	-0.604	(0.000)	0.257
0.099	(0.087)	0.201	(0.000)	-0.206	(0.000)	-0.001	(0.981)	0.609	(0.000)	-0.167
0.301	(0.000)	0.675	(0.000)	-0.157	(0.006)	0.073	(0.206)	-0.322	(0.000)	0.021
0.505	(0.000)	0.460	(0.000)	-0.082	(0.155)	0.398	(0.000)	-0.492	(0.000)	0.133
-0.149	(0.010)	-0.343	(0.000)	0.827	(0.000)	-0.158	(0.000)	-0.704	(0.000)	0.360
0.032	(0.583)	0.089	(0.122)	0.119	(0.039)	-0.002	(0.966)	0.439	(0.000)	0.242
0.458	(0.000)	0.451	(0.000)	0.063	(0.277)	0.569	(0.000)	-0.005	(0.937)	0.150
-0.095	(0.101)	0.062	(0.285)	-0.064	(0.272)	-0.011	(0.854)	-0.709	(0.000)	0.856
0.045	(0.442)	-0.325	(0.000)	0.417	(0.000)	-0.088	(0.127)	-0.119	(0.040)	0.047
0.500	(0.000)	0.570	(0.000)	0.062	(0.282)	0.260	(0.000)	0.282	(0.000)	-0.066
0.130	(0.024)	0.434	(0.000)	-0.266	(0.000)	0.164	(0.004)	-0.532	(0.000)	0.129
0.408	(0.000)	0.722	(0.000)	-0.229	(0.000)	0.207	(0.000)	-0.296	(0.000)	0.789
-0.242	(0.000)	-0.160	(0.005)	0.595	(0.000)	-0.132	(0.022)	0.467	(0.000)	0.210
0.456	(0.000)	0.207	(0.000)	0.247	(0.000)	0.543	(0.000)	0.152	(0.008)	0.738
0.291	(0.000)	-0.025	(0.671)	0.165	(0.004)	0.024	(0.683)	-0.356	(0.000)	0.294
0.194	(0.001)	0.235	(0.000)	-0.117	(0.042)	0.032	(0.584)	-0.162	(0.005)	-0.154
								-0.113	(0.050)	-0.007
										1.000
										0.126
										0.265
										0.002
										0.243
										-0.329
										0.457
										0.360
										0.289
										-0.420
										0.185
										0.047
										-0.281
										0.397
										0.489
										-0.132
										0.045
										0.023
										0.059

Note: P-Values represent power of the correlation between the percentage profit vectors of each security tested by the trading rule.

Table 7 Correlation of Profit Vectors & P-Values (Securities 11-20)

	XOM	GE	GM	HPQ	HON	INTC	IBM	JNJ	MS	MCD
CORR										
P-Value										
1.000	(1.000)									
0.102	(0.076)	1.000	(1.000)							
0.157	(0.006)	0.201	(0.000)							
0.169	(0.003)	0.648	(0.000)							
0.125	(0.031)	-0.569	(0.000)							
-0.171	(0.003)	0.329	(0.000)							
0.223	(0.000)	0.428	(0.000)							
0.195	(0.001)	0.766	(0.000)							
0.222	(0.000)	-0.419	(0.000)							
-0.018	(0.754)	-0.034	(0.554)							
0.380	(0.000)	0.578	(0.000)							
-0.126	(0.029)	0.012	(0.833)							
-0.165	(0.004)	-0.240	(0.000)							
0.303	(0.000)	0.471	(0.000)							
0.012	(0.835)	0.043	(0.460)							
0.191	(0.001)	0.473	(0.000)							
-0.170	(0.003)	-0.194	(0.001)							
0.167	(0.004)	0.350	(0.000)							
-0.212	(0.000)	0.401	(0.000)							
0.089	(0.122)	-0.052	(0.371)							
				1.000	(1.000)					
				0.127	(0.028)	1.000	(1.000)			
				0.423	(0.000)	0.407	(0.000)			
				0.719	(0.000)	0.192	(0.001)			
				-0.420	(0.000)	-0.418	(0.000)			
				0.186	(0.001)	0.035	(0.549)			
				0.652	(0.000)	0.092	(0.111)			
				0.031	(0.588)	0.037	(0.525)			
				-0.287	(0.000)	-0.221	(0.000)			
				0.537	(0.000)	0.202	(0.000)			
				0.201	(0.000)	0.206	(0.000)			
				0.447	(0.000)	0.430	(0.000)			
				-0.196	(0.001)	-0.113	(0.051)			
				0.531	(0.000)	-0.049	(0.402)			
				0.266	(0.000)	0.047	(0.421)			
				0.012	(0.835)	0.077	(0.185)			
				0.080	(0.165)	0.279	(0.000)			
								1.000	(1.000)	
								-0.345	(0.000)	1.000
								0.019	(0.745)	0.075
								0.777	(0.000)	-0.138
								0.015	(0.793)	-0.165
								-0.239	(0.000)	0.539
								0.622	(0.000)	-0.139
								-0.289	(0.000)	0.212
								0.583	(0.000)	-0.378
								0.376	(0.000)	-0.471
								0.793	(0.000)	-0.471
								-0.173	(0.003)	-0.041
								0.115	(0.047)	0.073
								0.067	(0.251)	0.000
								0.279	(0.000)	-0.092
										0.036
										0.530
										0.110
										0.176
										0.212
										0.000
										0.516
										0.635
										0.201
										0.442
										0.033
										0.574
										0.226

Note: P-Values represent power of the correlation between the percentage profit vectors of each security tested by the trading rule.

Table 8 Correlation of Profit Vectors & P-Values (Securities 21-30)

	MRK	PFE	MSFT	KO	HD	PG	UTX	VZ	WMT	DIS
<b>CORR</b>	1.000	0.776	0.936	0.154	0.635	0.552	1.000	0.167	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)
	1.000	0.034	0.026	0.154	0.635	0.552	1.000	0.167	0.000	0.000
	(0.910)	(0.681)	(0.651)	(0.008)	(0.000)	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)
	0.040	-0.024	0.104	-0.292	0.413	0.109	-0.210	0.100	0.000	0.000
	(0.001)	(0.000)	(0.000)	(0.078)	(0.072)	(0.887)	(0.060)	(0.000)	(0.000)	(0.000)
	0.537	0.776	0.936	0.154	0.635	0.552	1.000	0.167	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)
	0.102	0.078	0.168	-0.337	0.104	0.109	-0.210	0.100	0.000	0.000
	(0.078)	(0.000)	(0.006)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	0.367	0.168	0.936	0.154	0.635	0.552	1.000	0.167	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)
	-0.225	0.000	0.936	0.154	0.635	0.552	1.000	0.167	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)
	0.574	0.000	0.936	0.154	0.635	0.552	1.000	0.167	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)
	0.205	0.000	0.936	0.154	0.635	0.552	1.000	0.167	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)
	0.004	0.037	0.037	0.145	0.268	0.367	0.081	-0.103	-0.140	0.000
	(0.949)	(0.524)	(0.377)	(0.012)	(0.000)	(0.000)	(0.159)	(0.076)	(0.015)	(1.000)

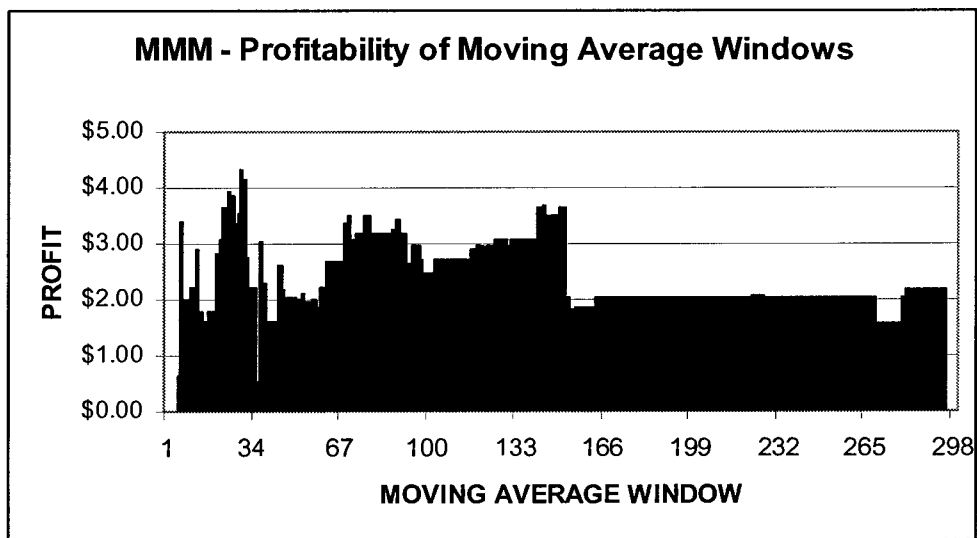
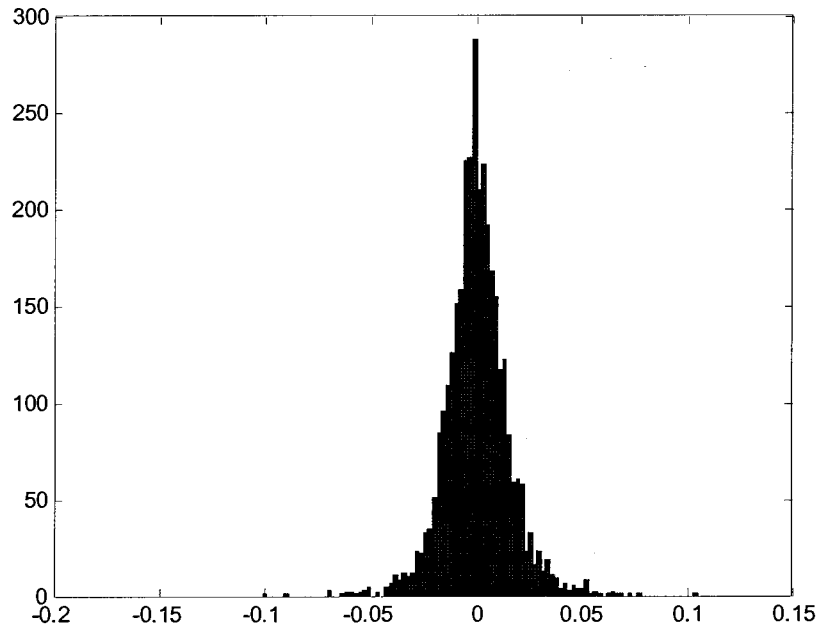
Note: P-Values represent power of the correlation between the percentage profit vectors of each security tested by the trading rule.



# APPENDICES

## Appendix A: Histogram of Returns & Trading Rule Profits

Figure 9 3M Company



**Figure 10 Alcoa Incorporated**

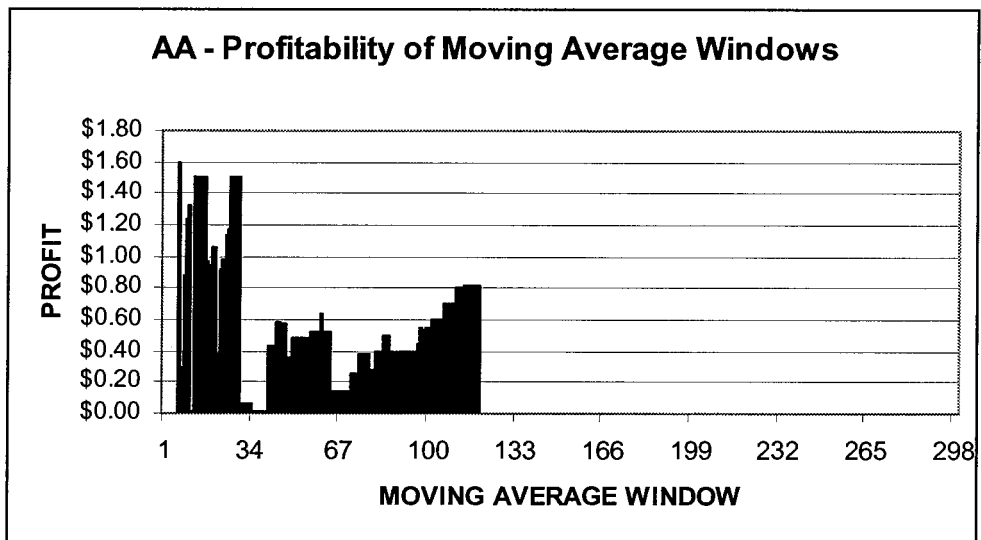
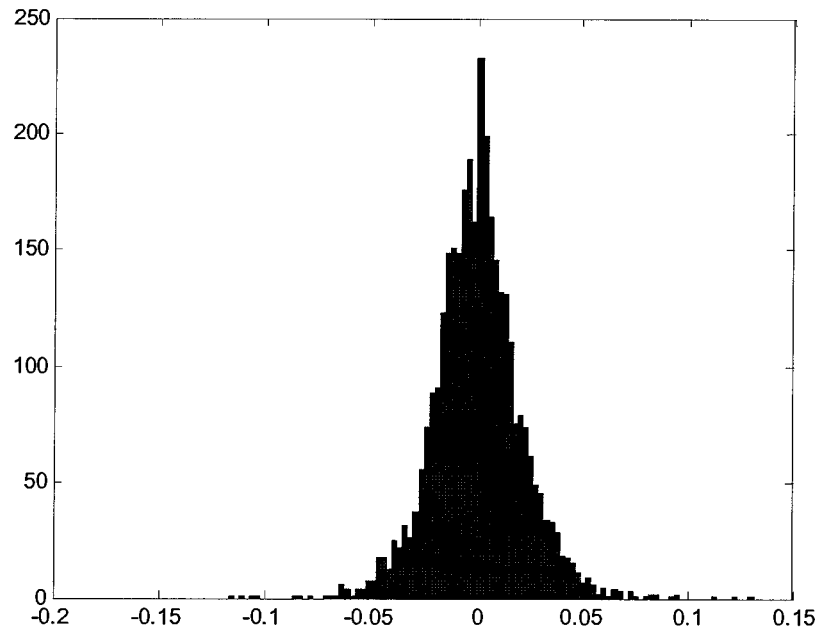


Figure 11 Altria Group Company

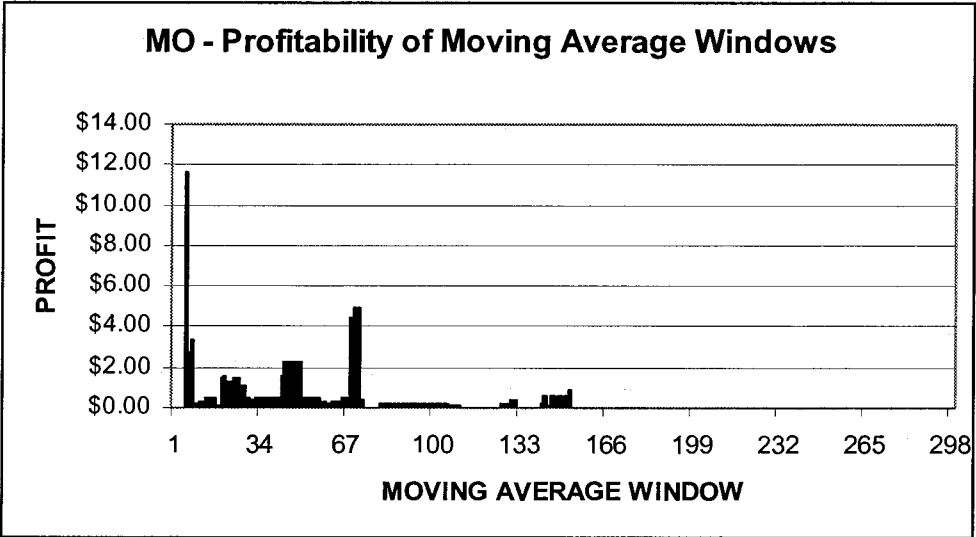
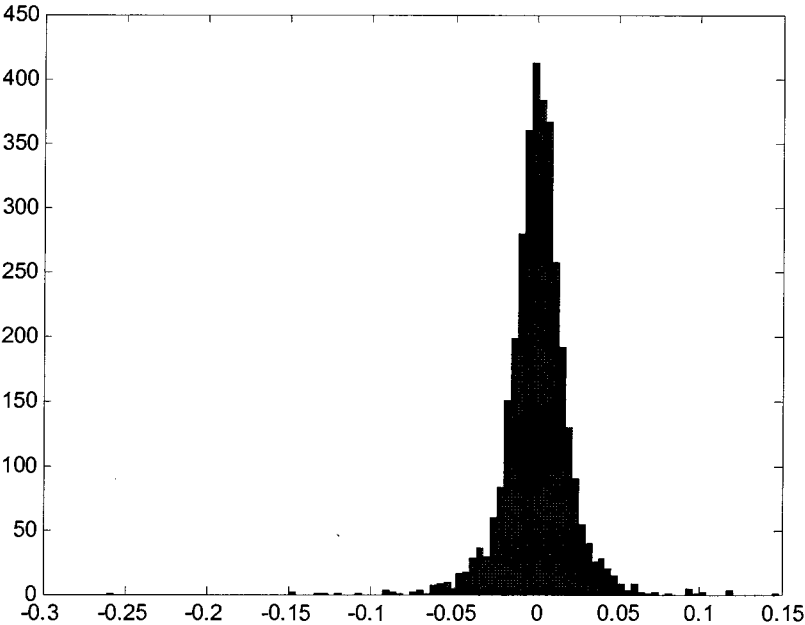
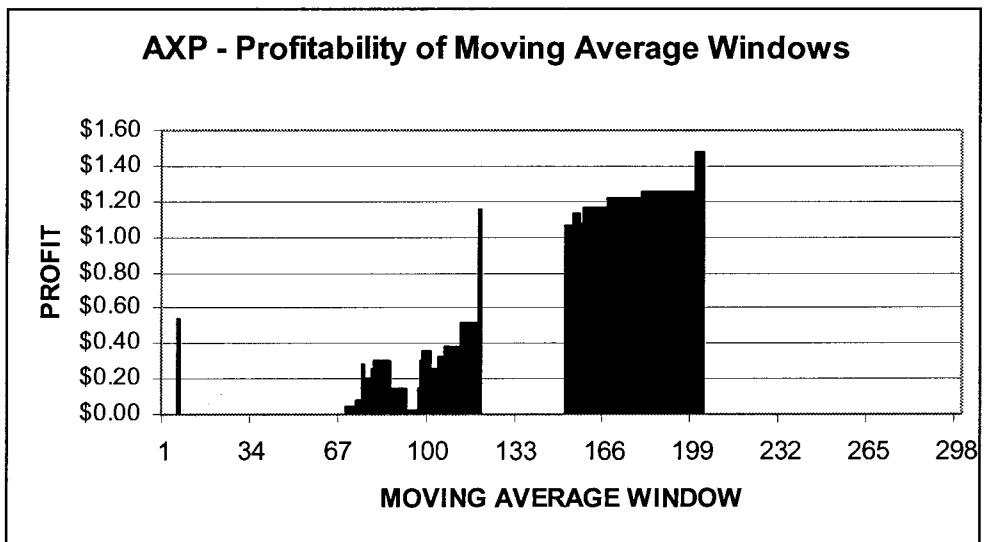
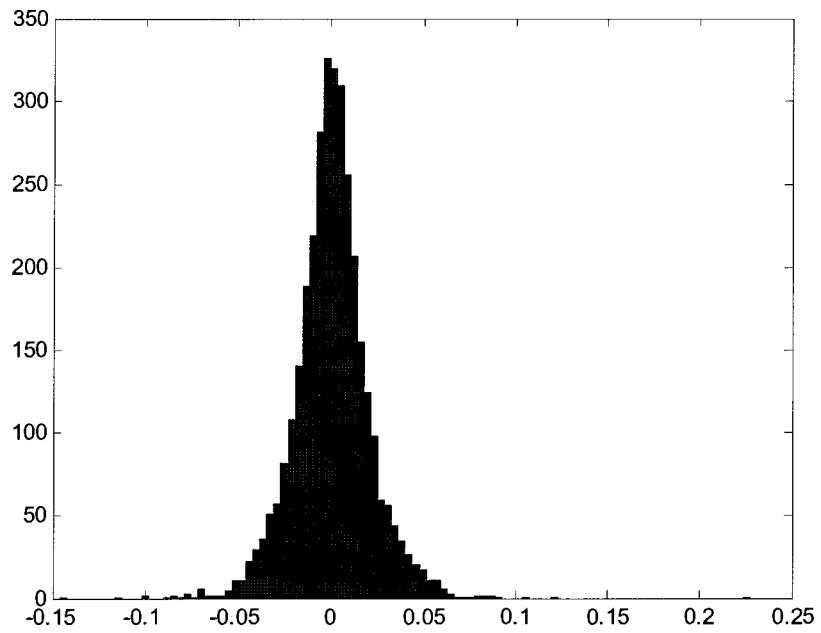


Figure 12 American Express Company



**Figure 13 American International Group Incorporated**

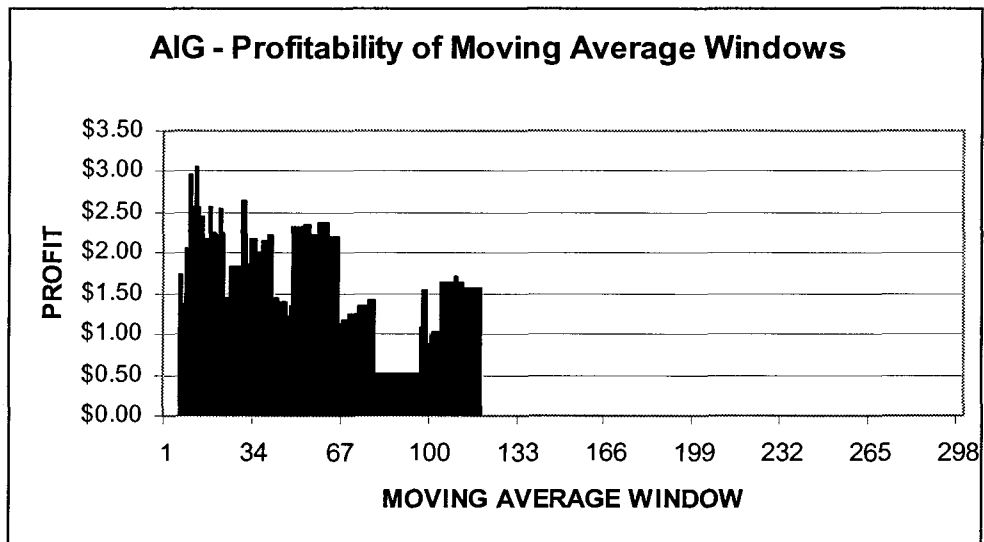
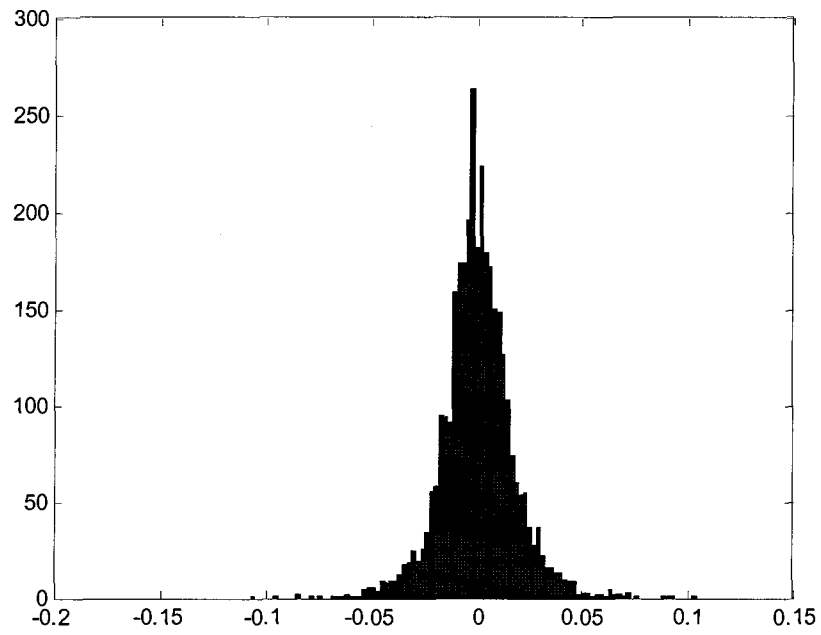


Figure 14 AT&T Incorporated

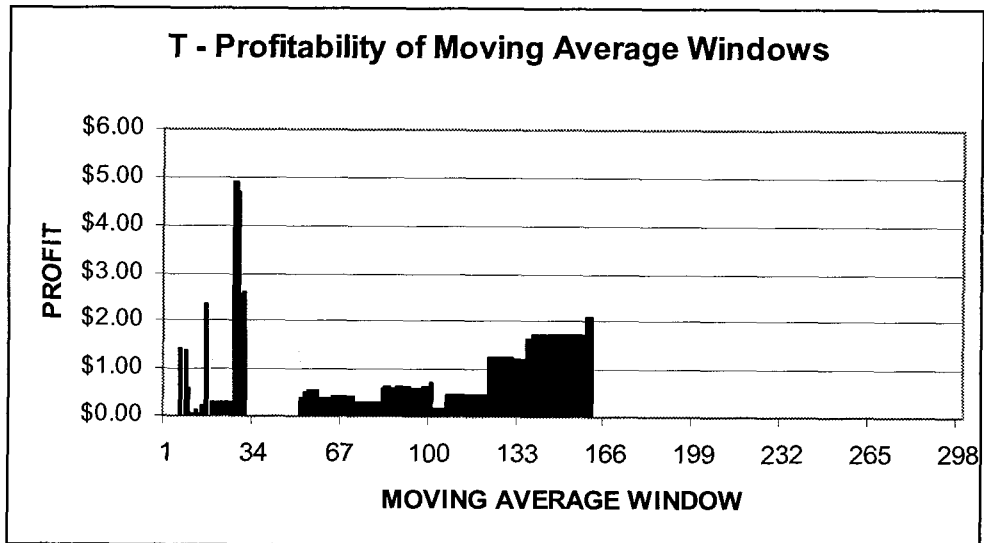
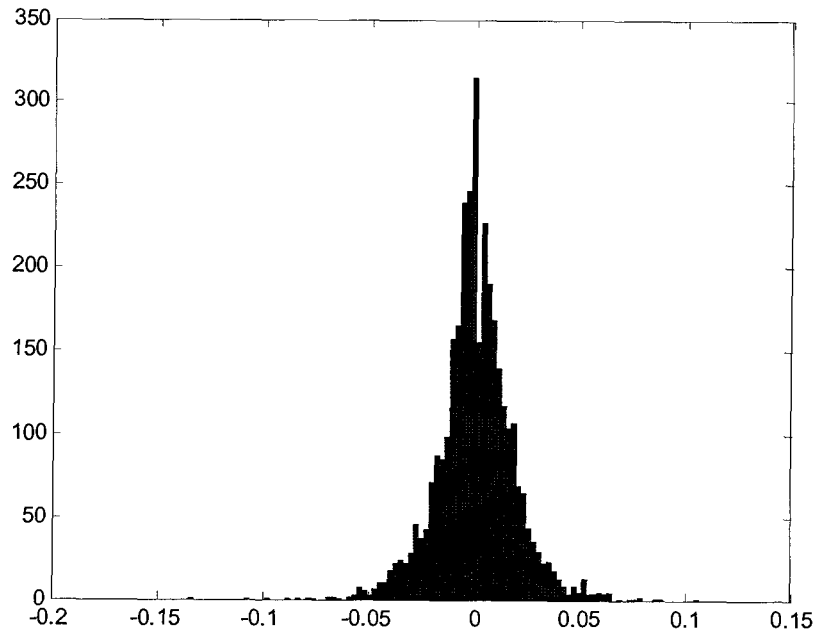
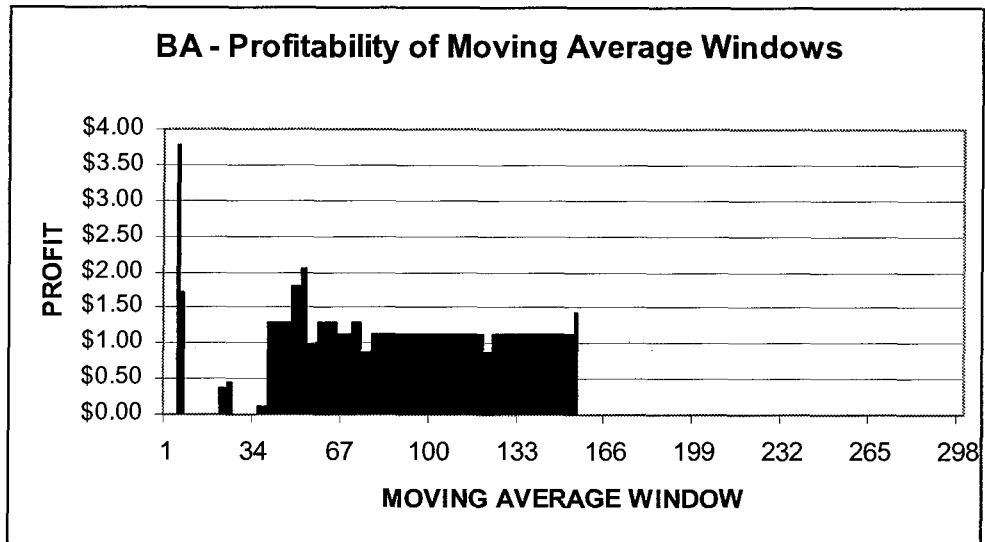
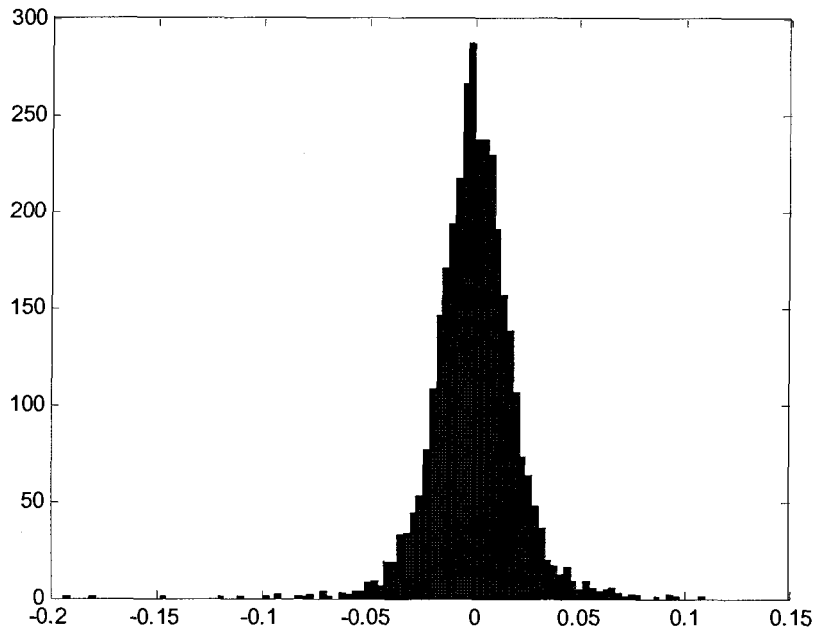
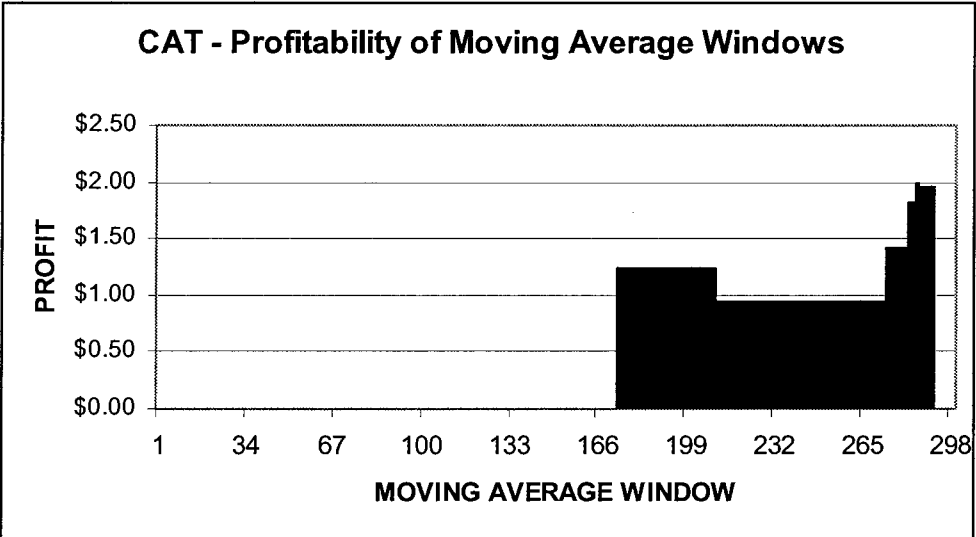
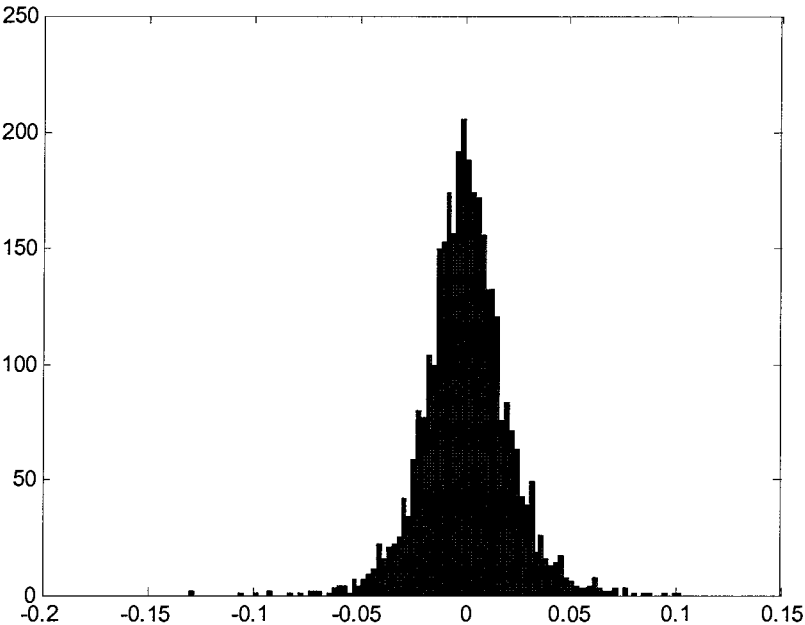


Figure 15 Boeing Company



**Figure 16 Caterpillar Incorporated**





**Figure 17** Citigroup Incorporated

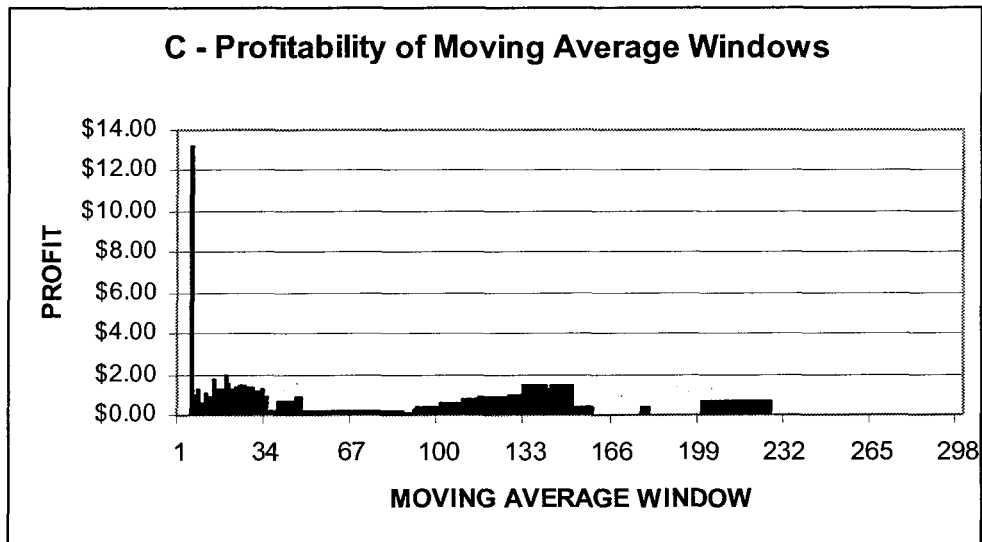
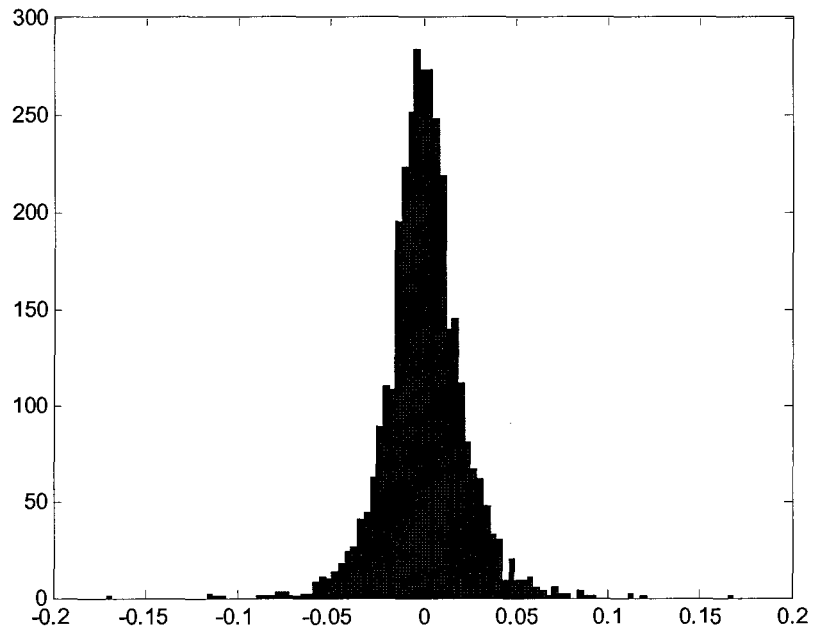
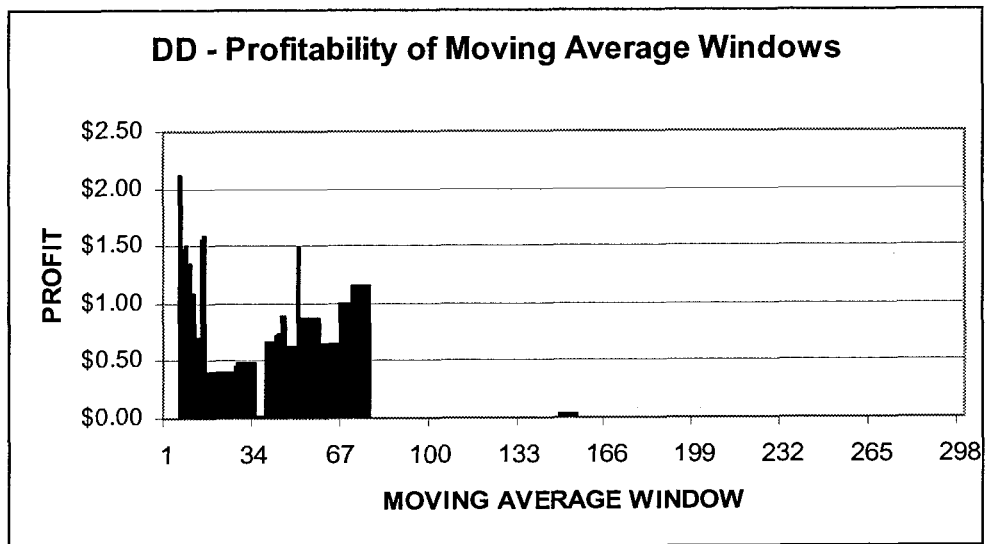
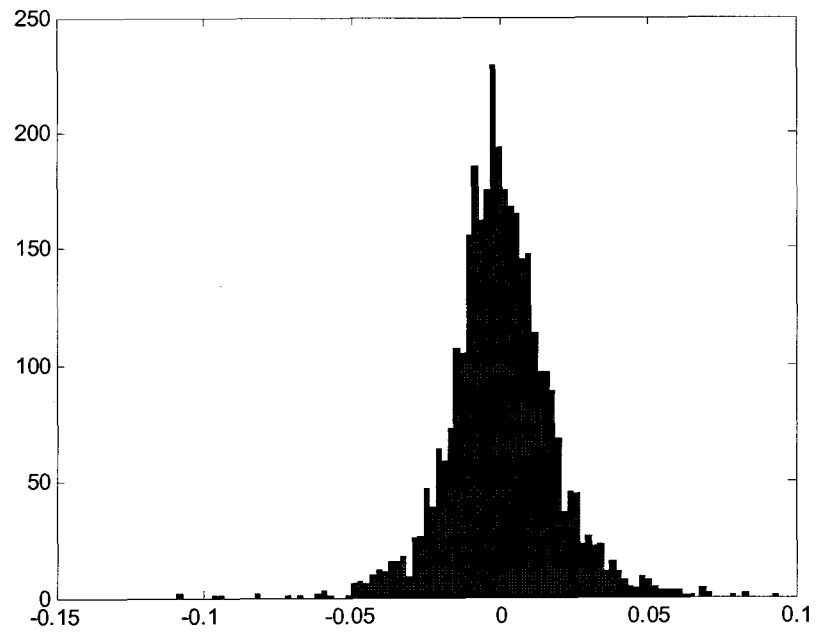
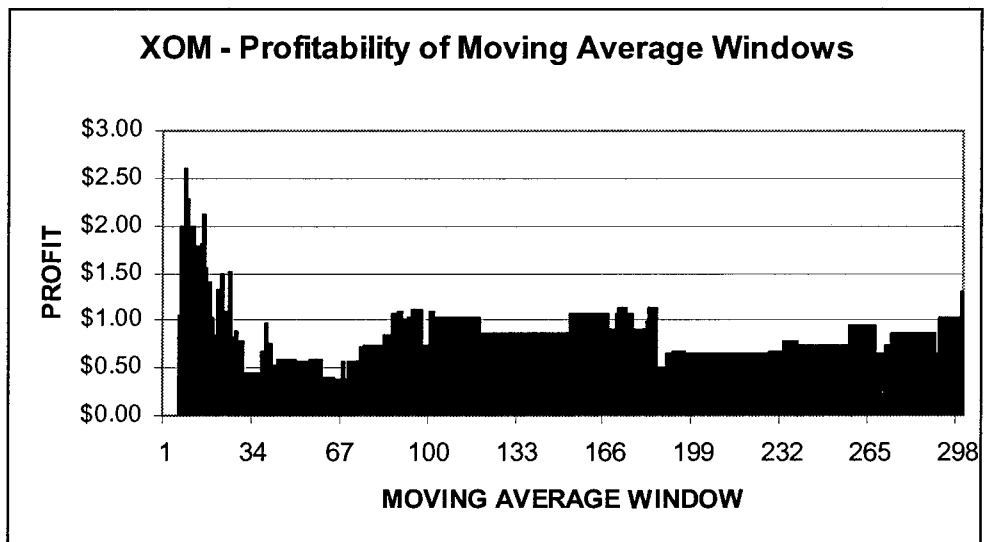
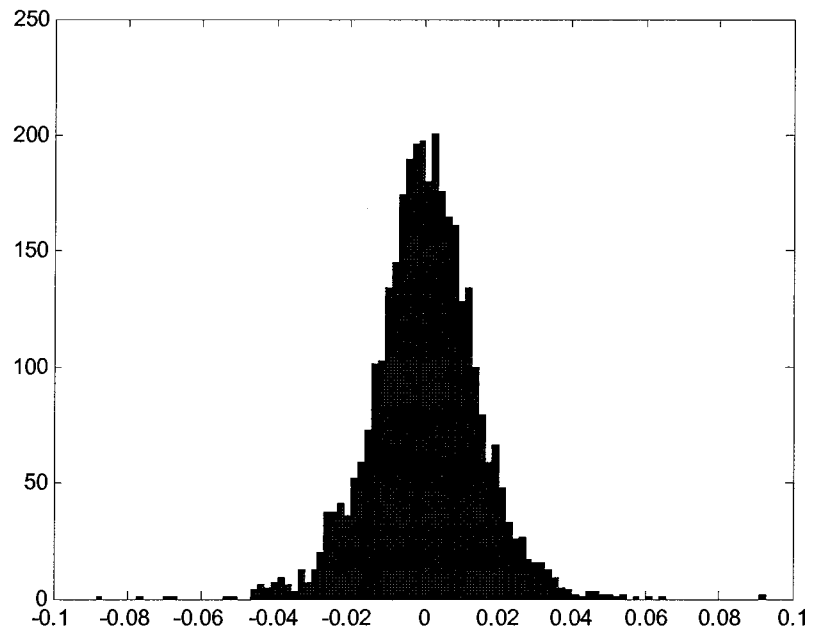


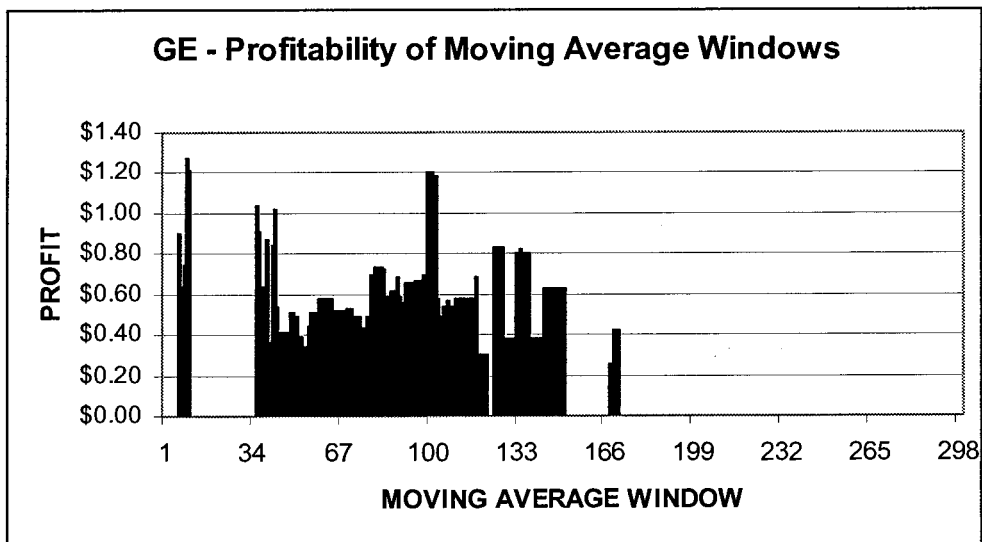
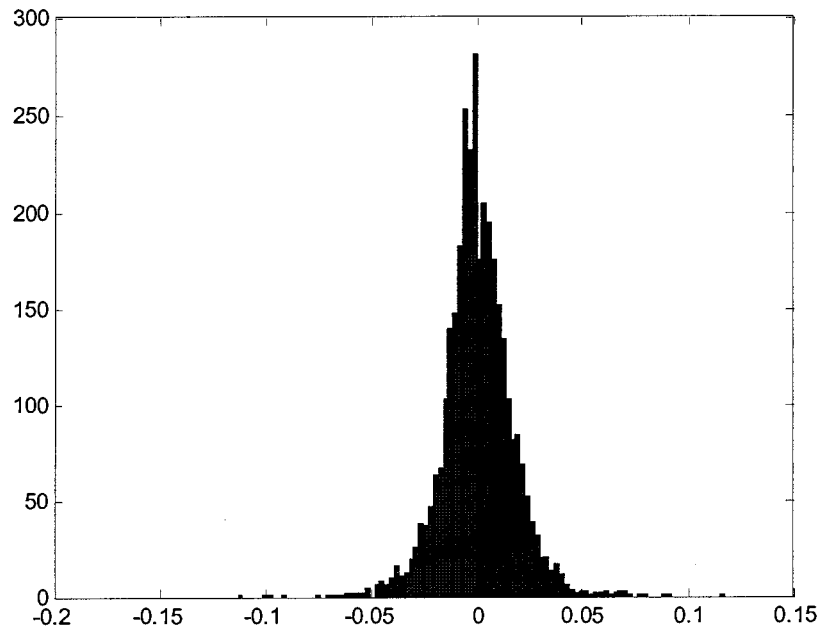
Figure 18 E.I. du Pont de Nemours and Company



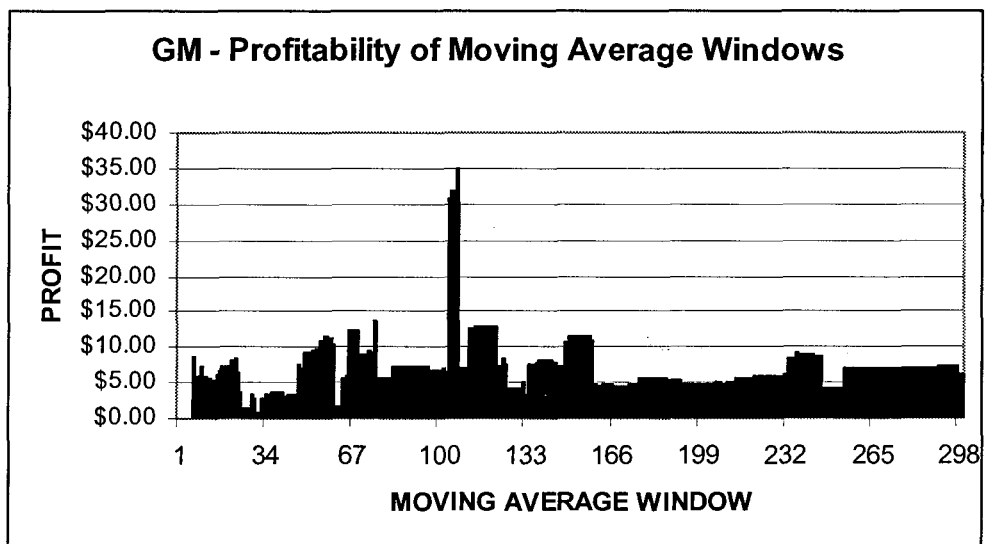
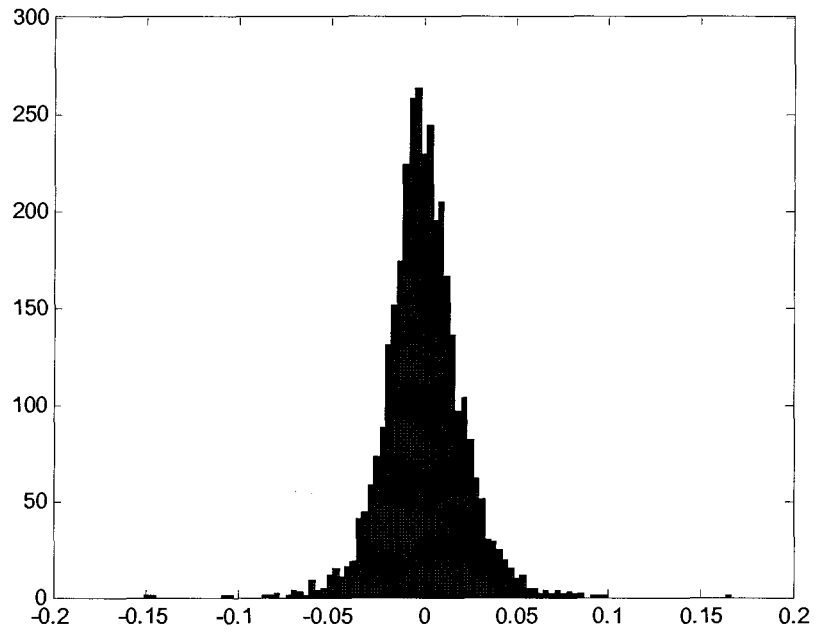
**Figure 19 Exxon Mobil Corporation**



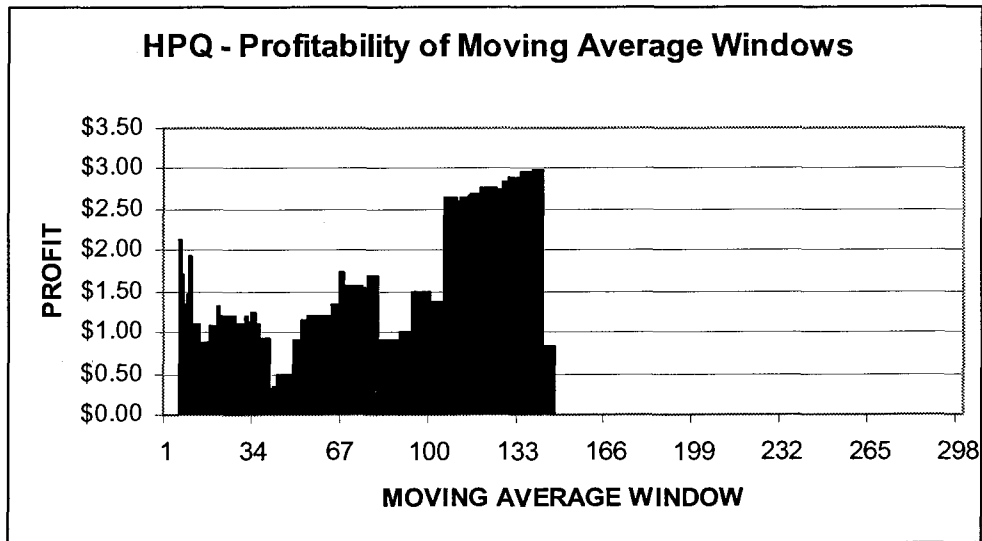
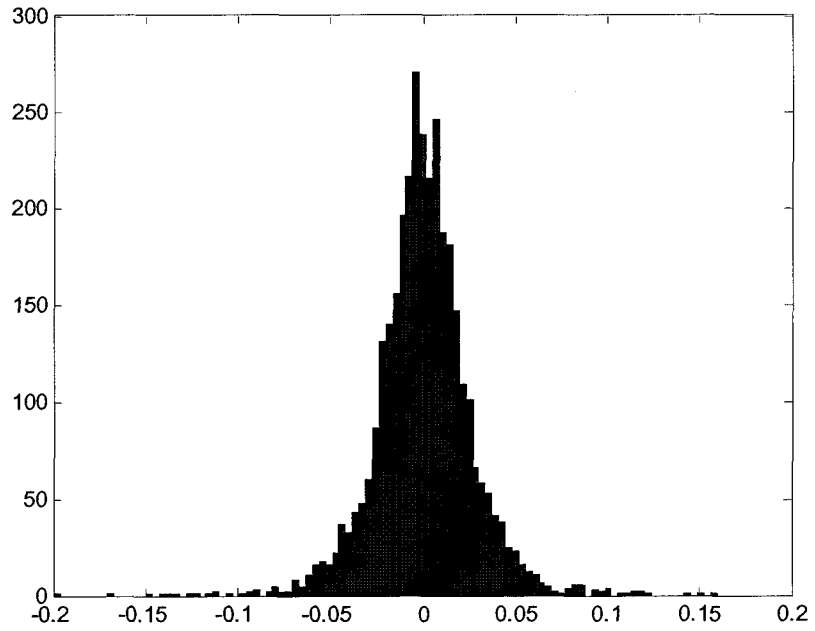
**Figure 20**    **General Electric Company**



**Figure 21**    **General Motors Corporation**



**Figure 22 Hewlett-Packard Company**



**Figure 23 Honeywell International Incorporated**

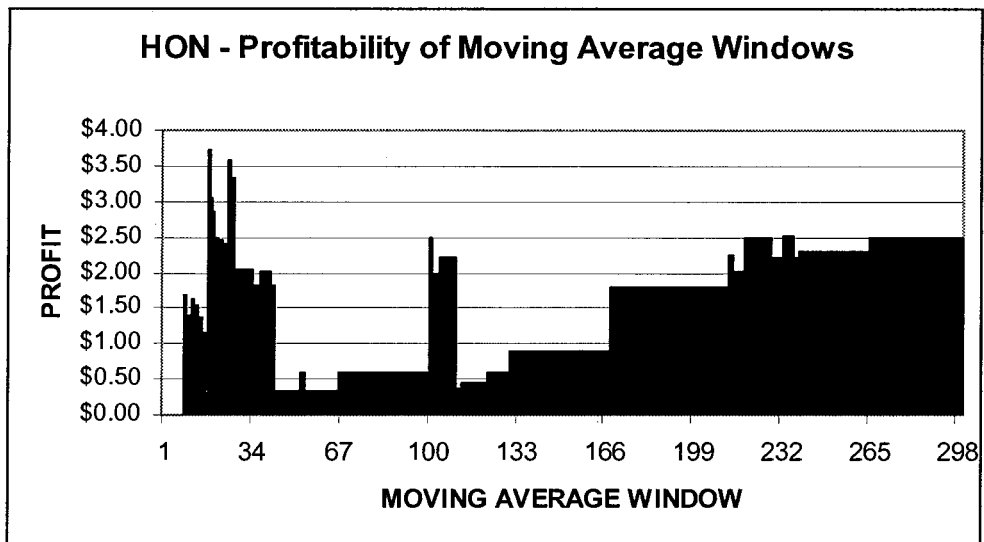
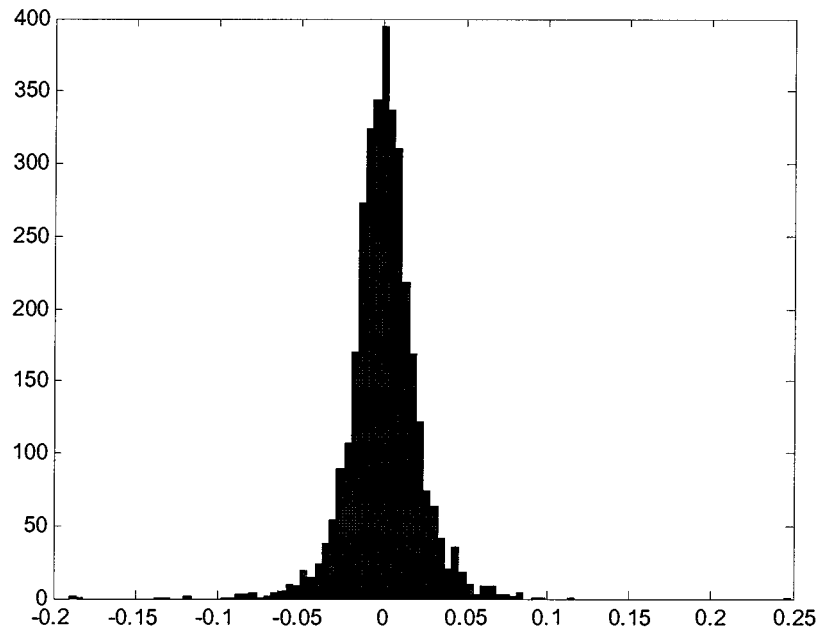
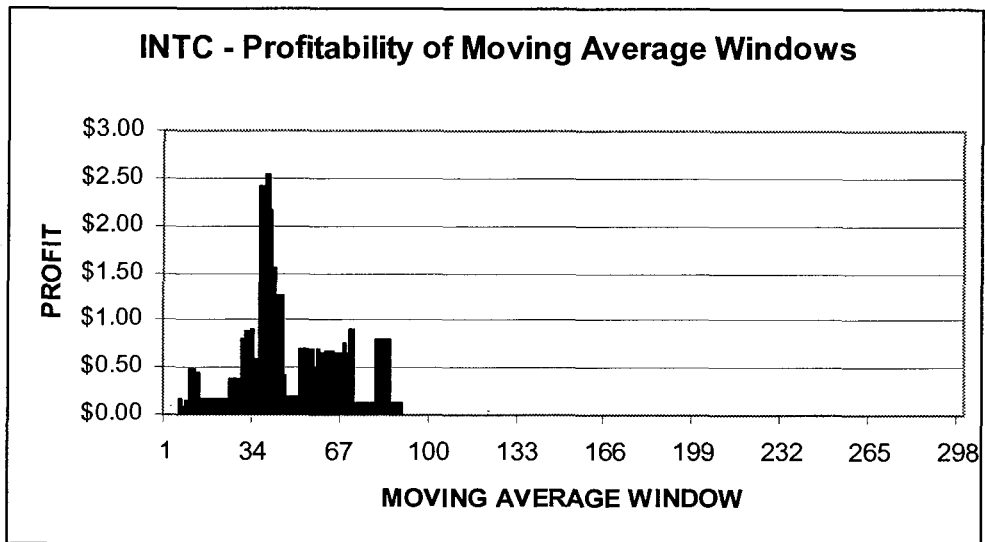
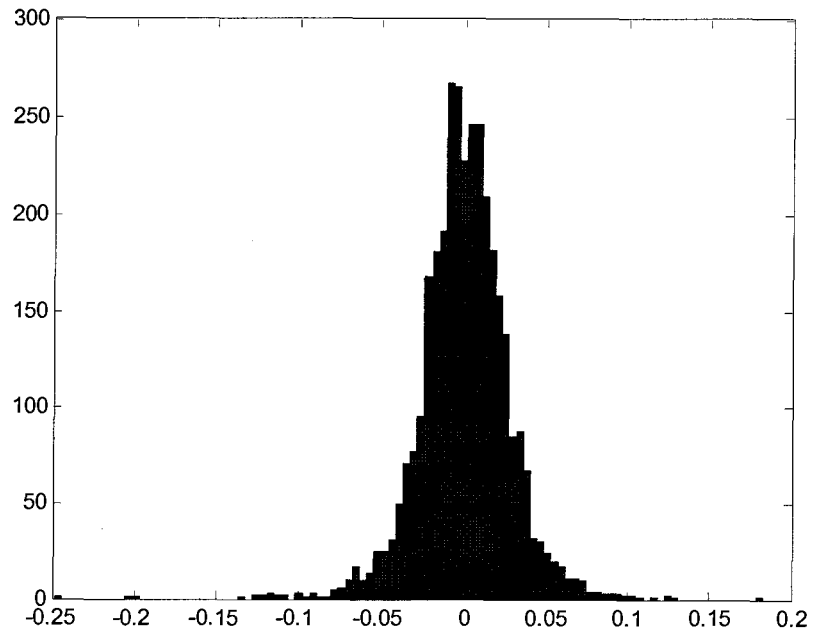
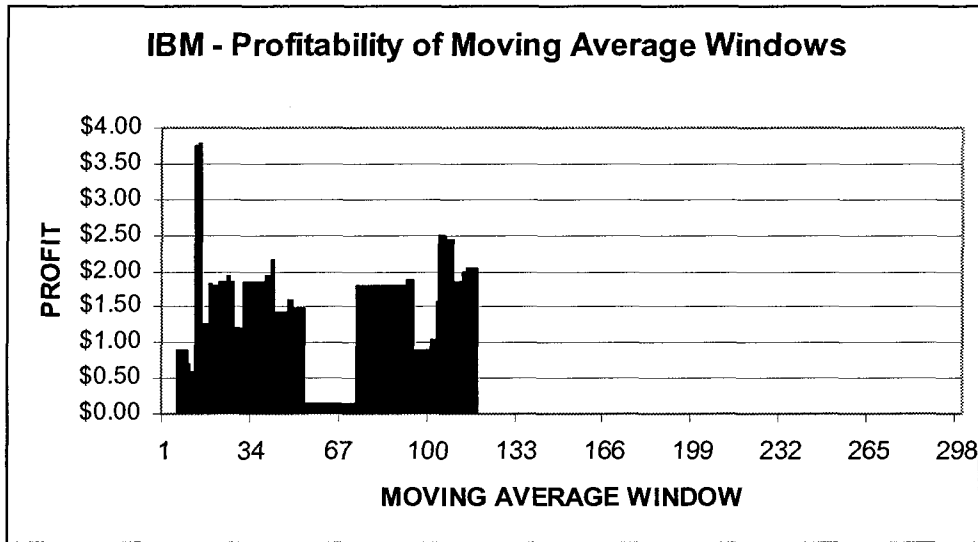
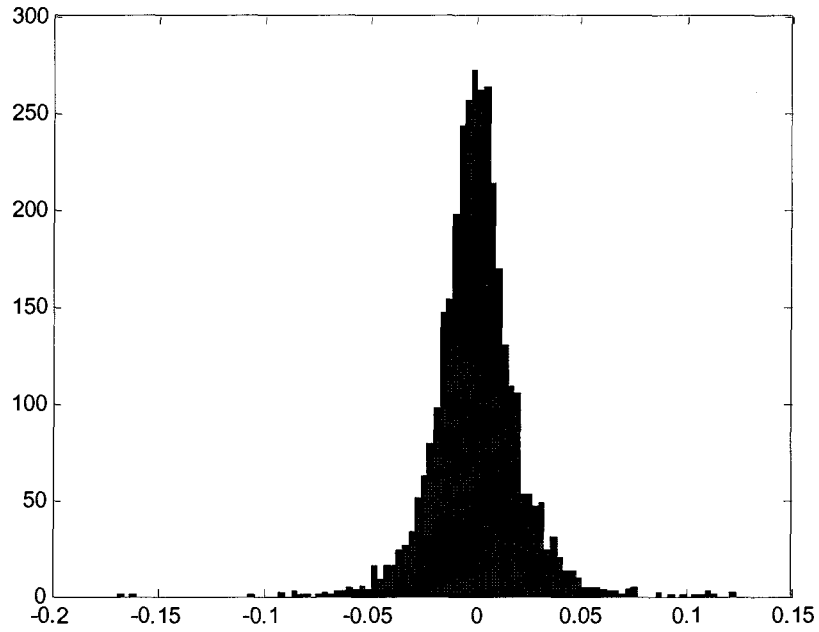


Figure 24 Intel Corporation

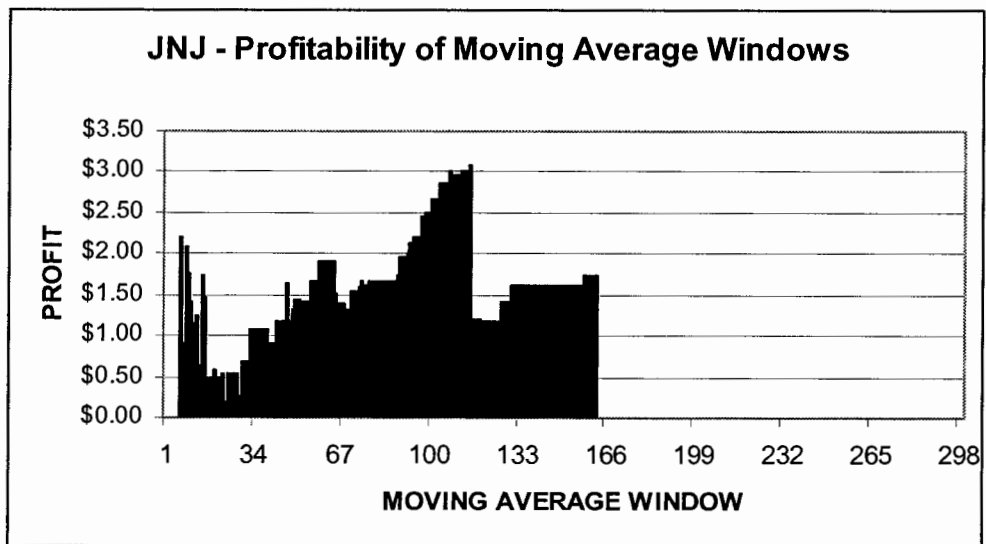
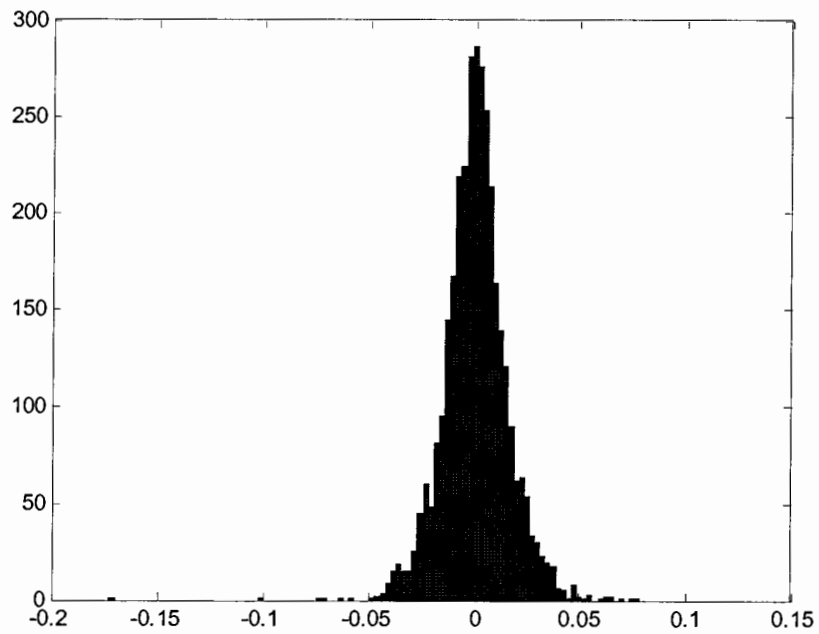




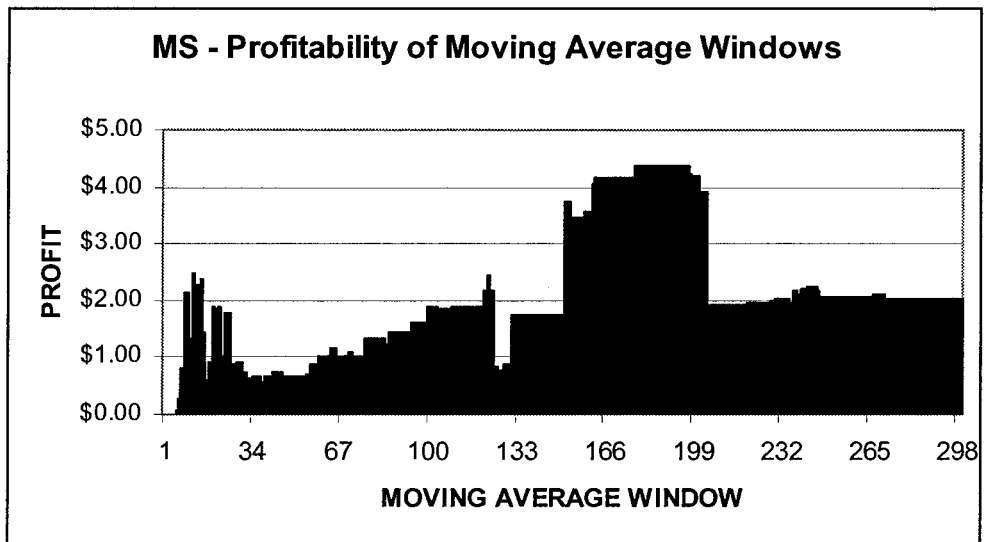
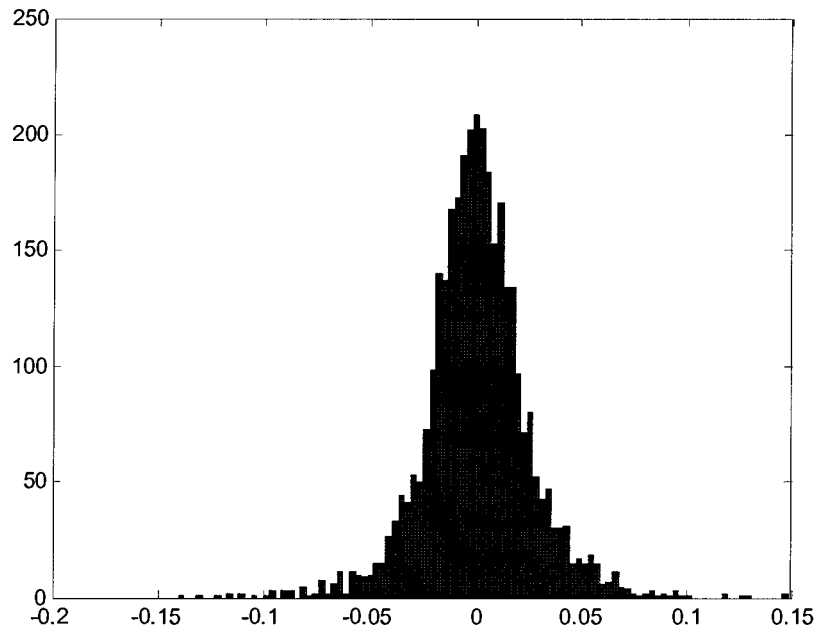
**Figure 25 International Business Machines**



**Figure 26 Johnson & Johnson**



**Figure 27** JP Morgan & Chase & Company



**Figure 28**    **MaDonald's Corporation**

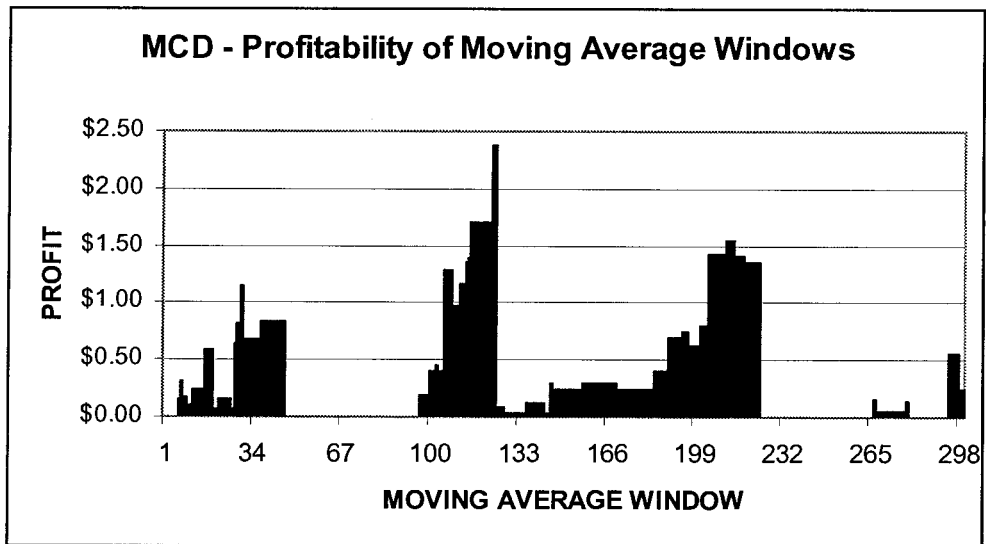
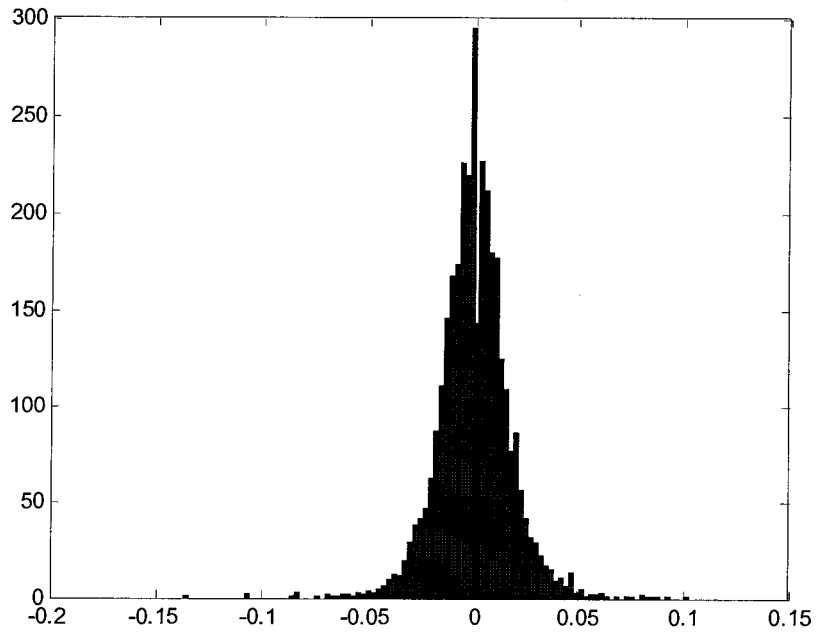
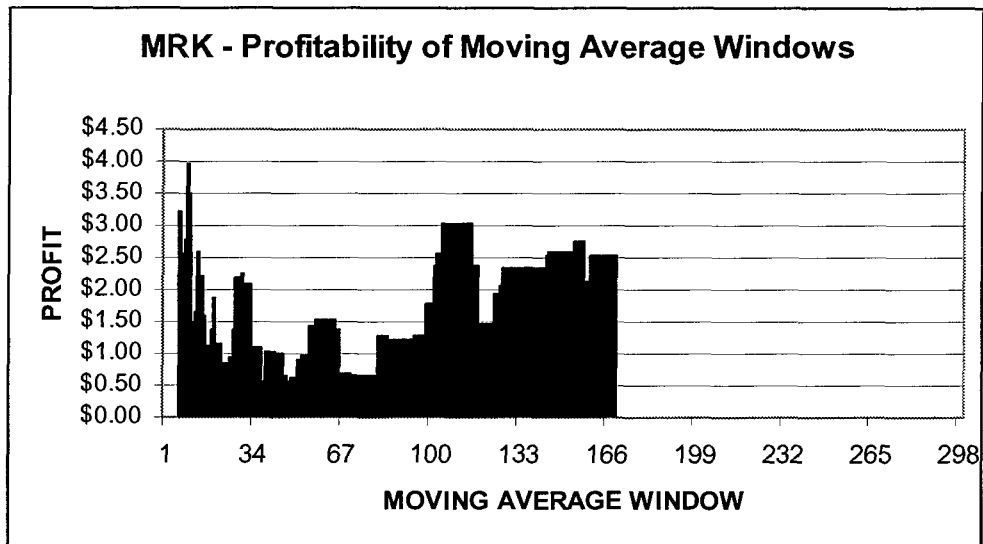
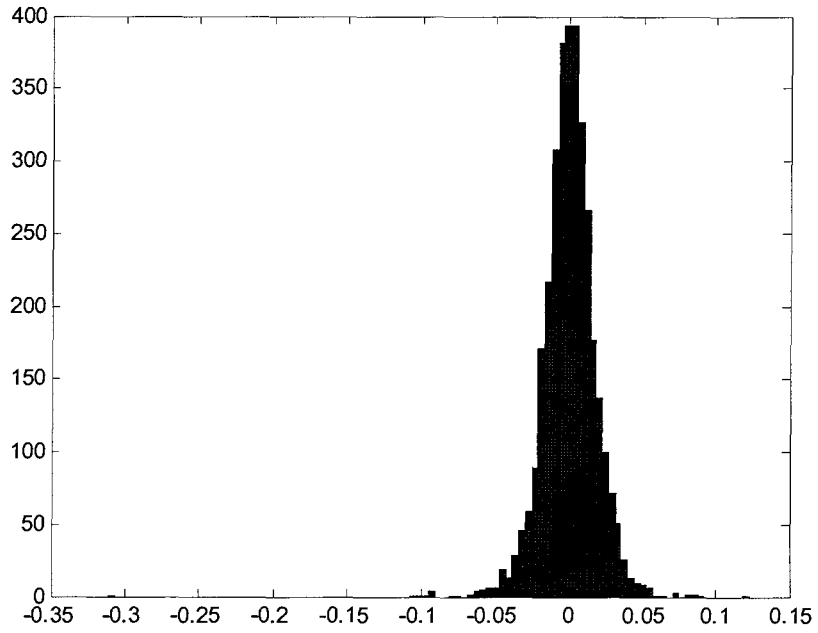


Figure 29 Merck & Company, Incorporated



**Figure 30** Microsoft Corporation

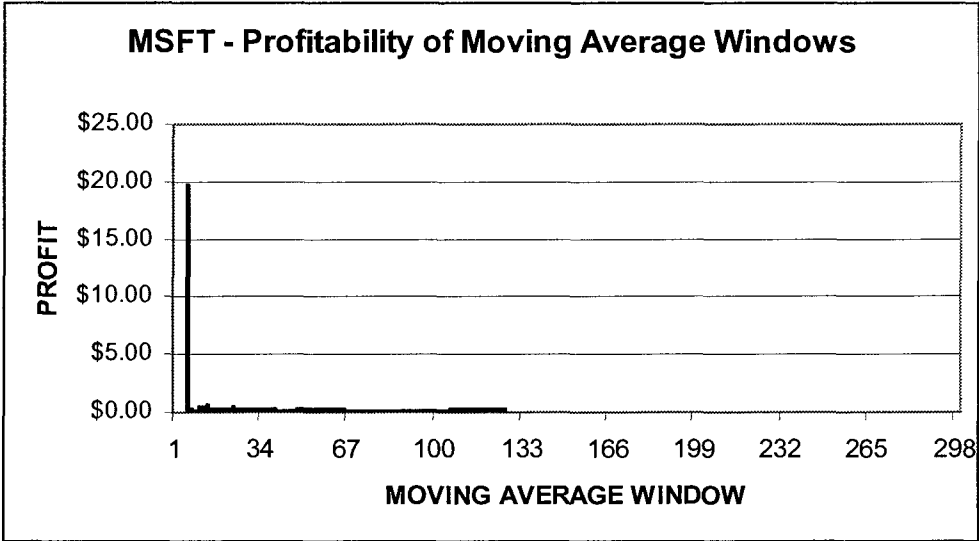
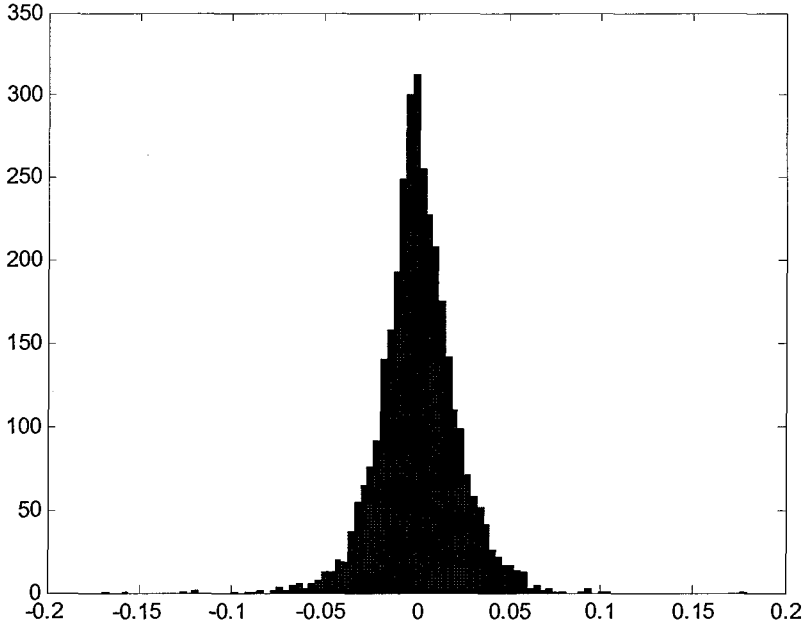
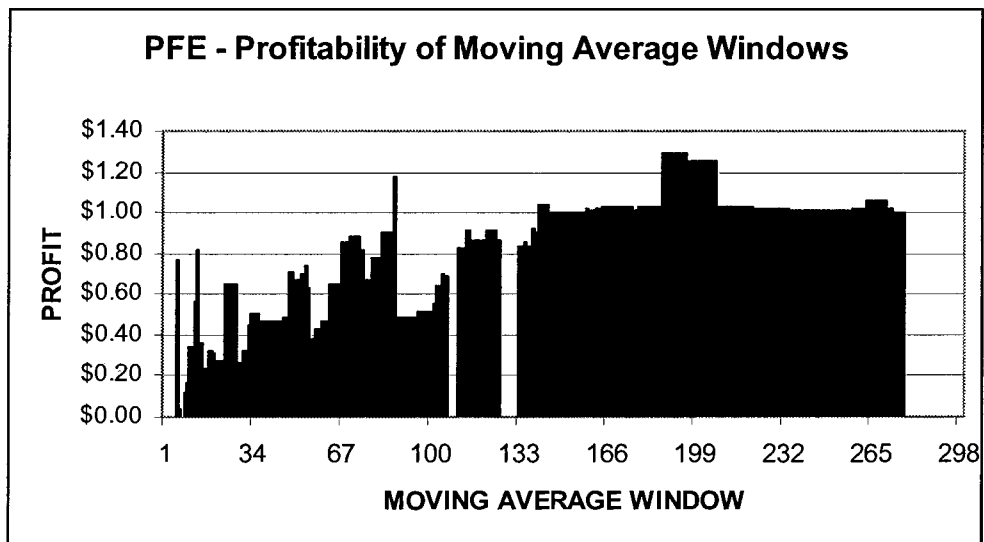
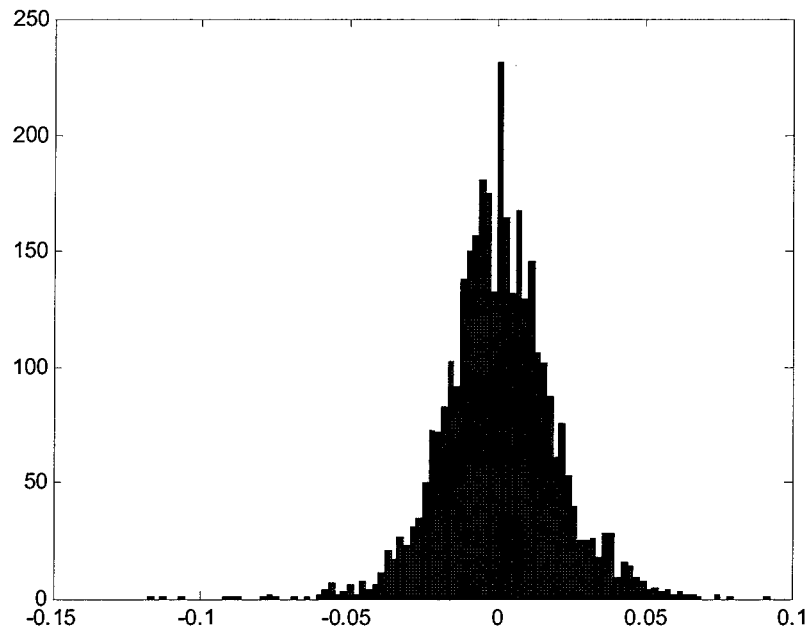
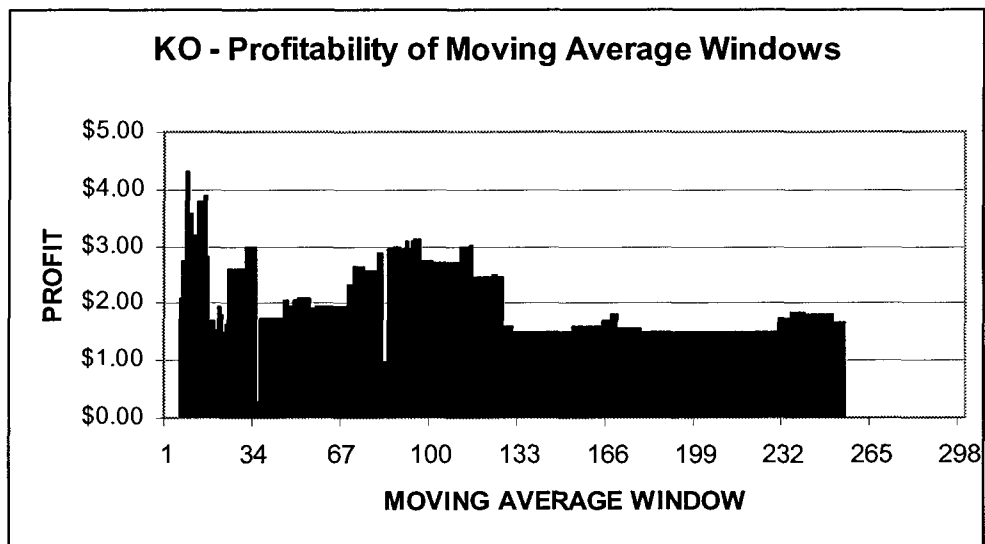
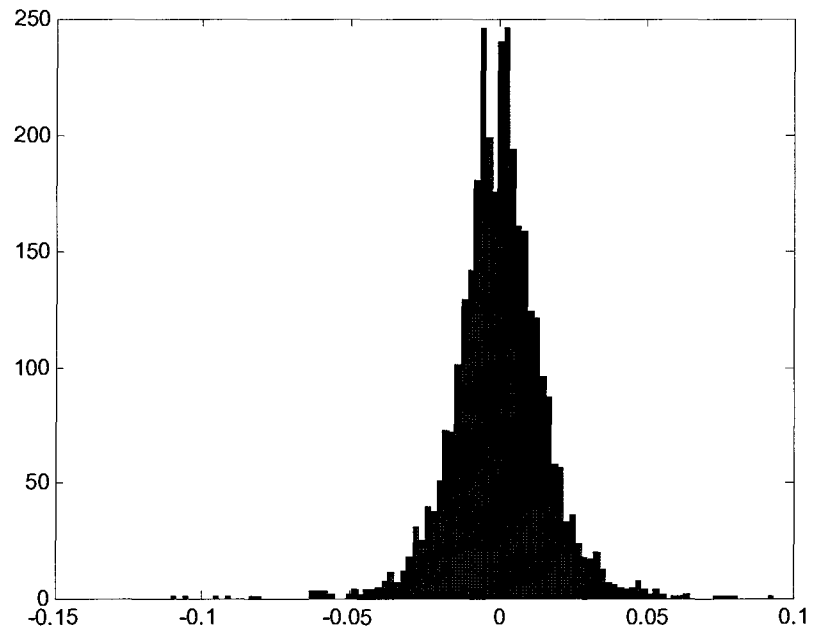


Figure 31 Pfizer Incorporated

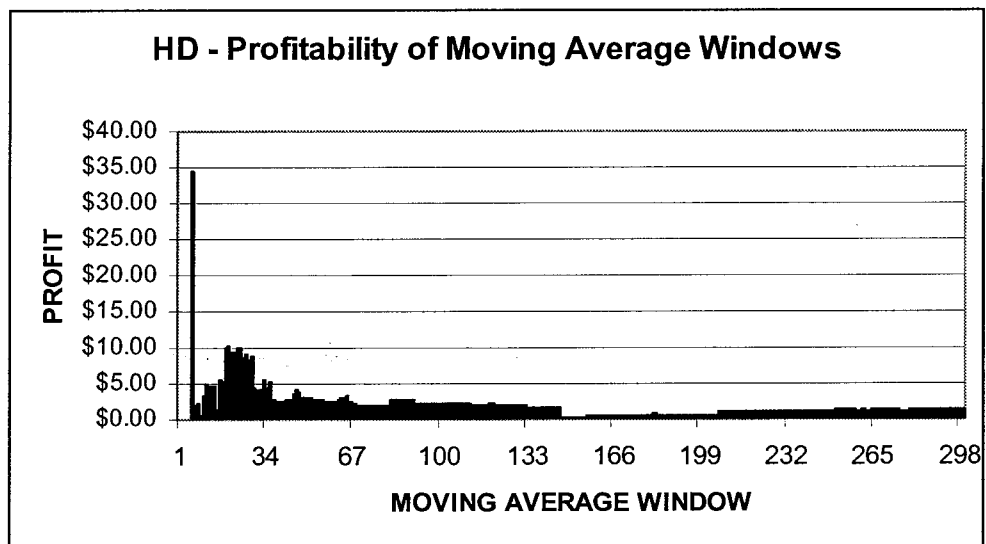
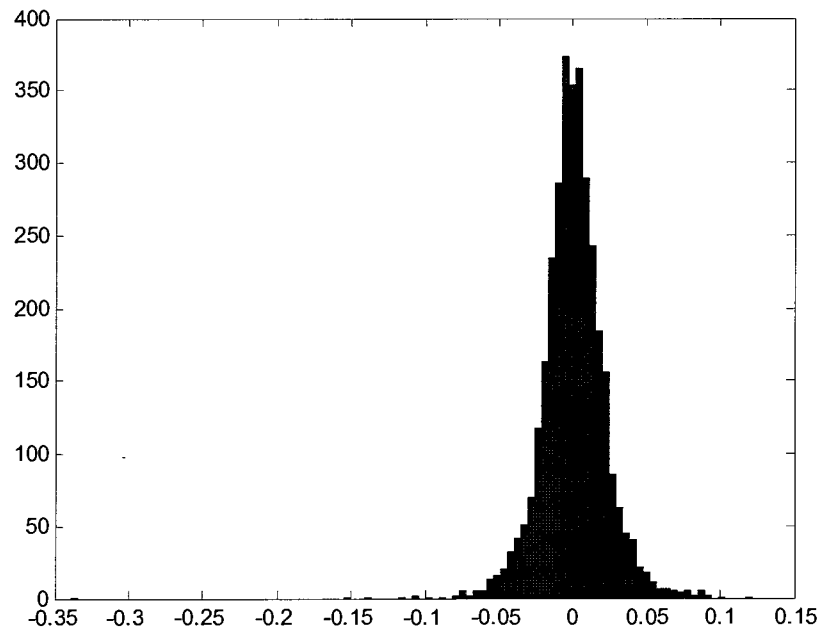


**Figure 32 The Coca-Cola Company**





**Figure 33**    **The Home Depot Incorporated**



**Figure 34**    **The Proctor & Gamble Company**

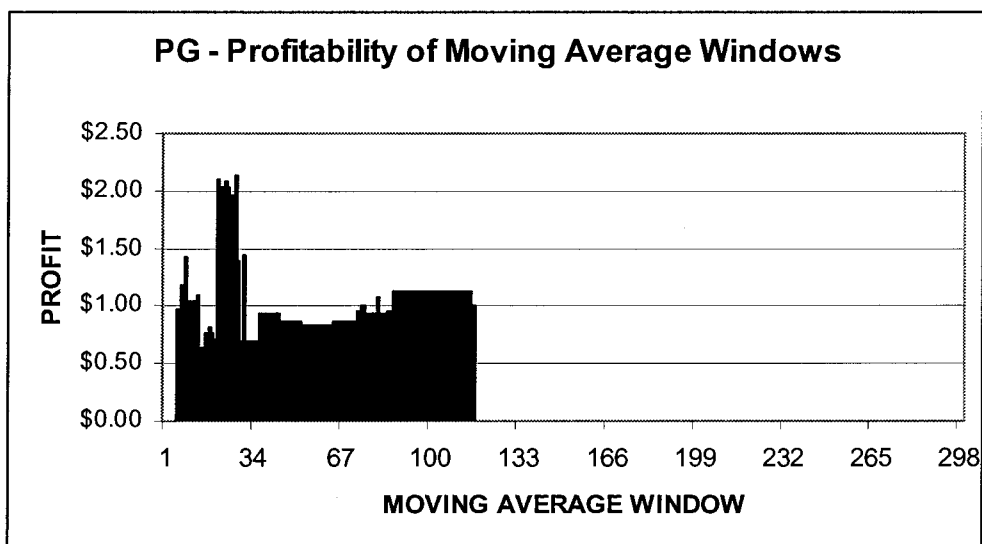
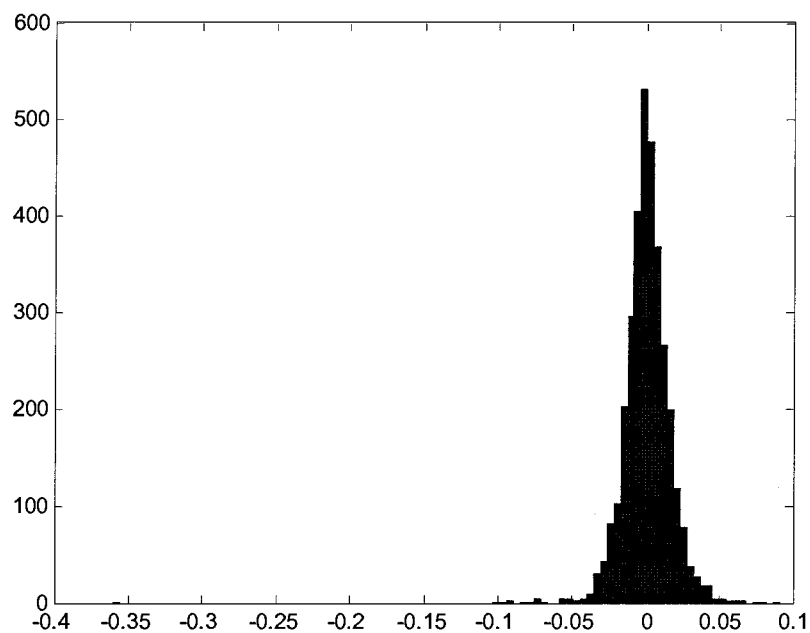
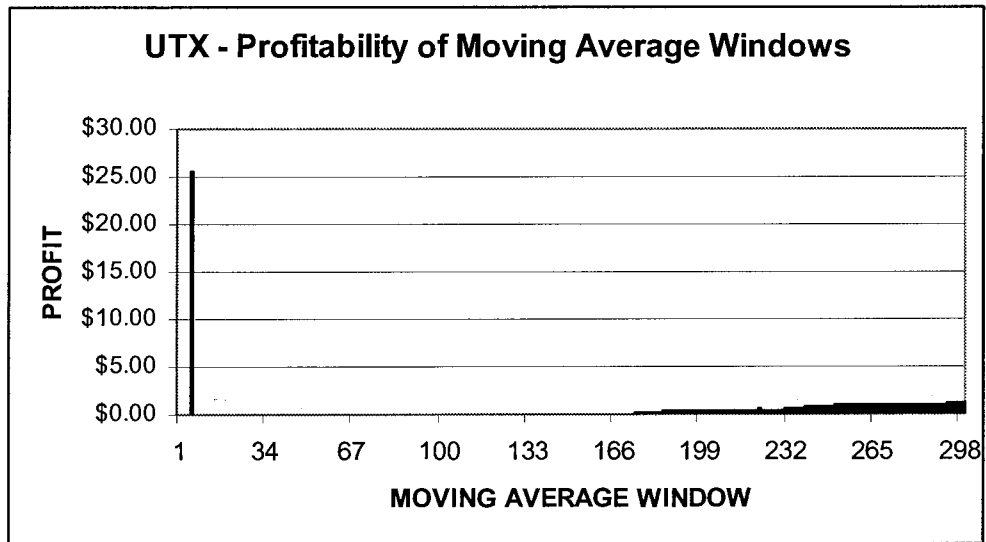
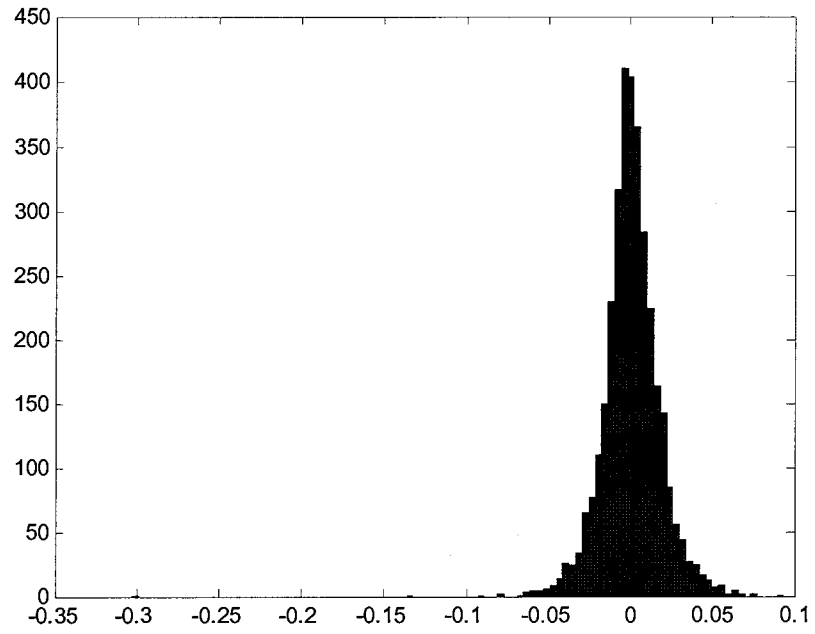


Figure 35 United Technologies Corporation



**Figure 36 Verizon Communications**

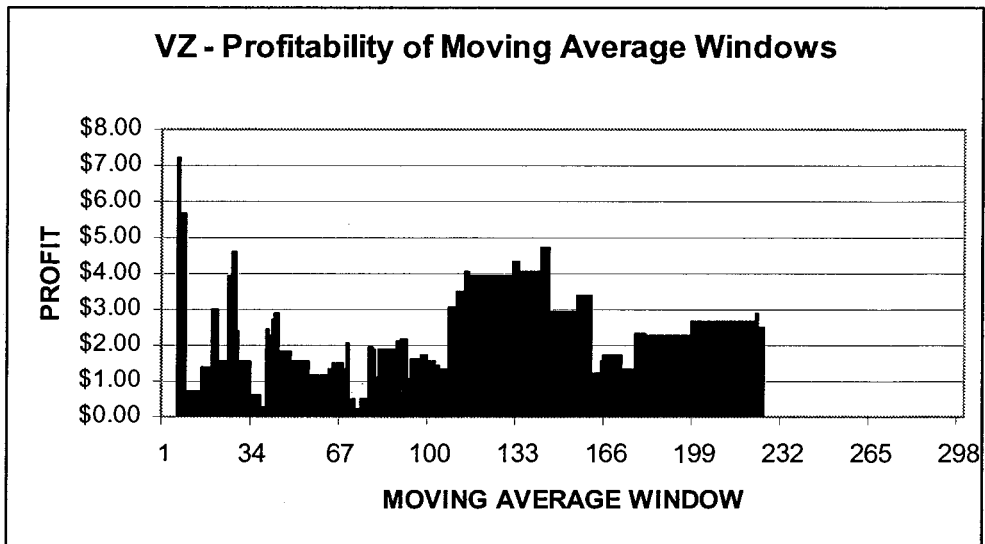
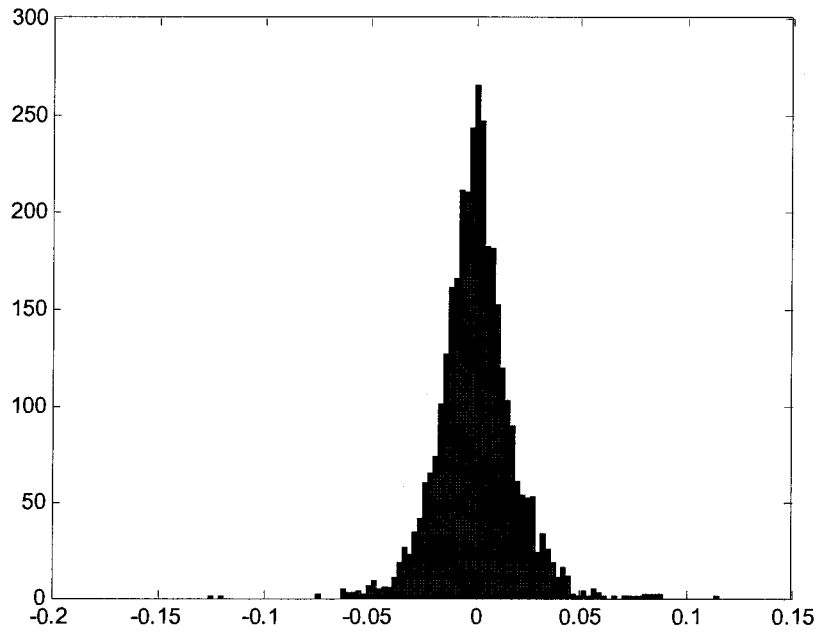


Figure 37 Wal-Mart Stores, Incorporated

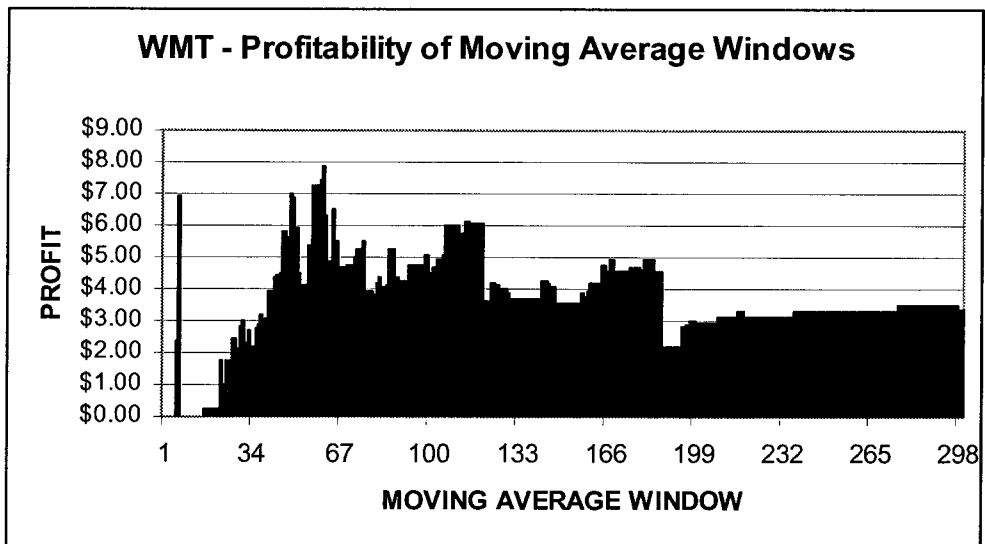
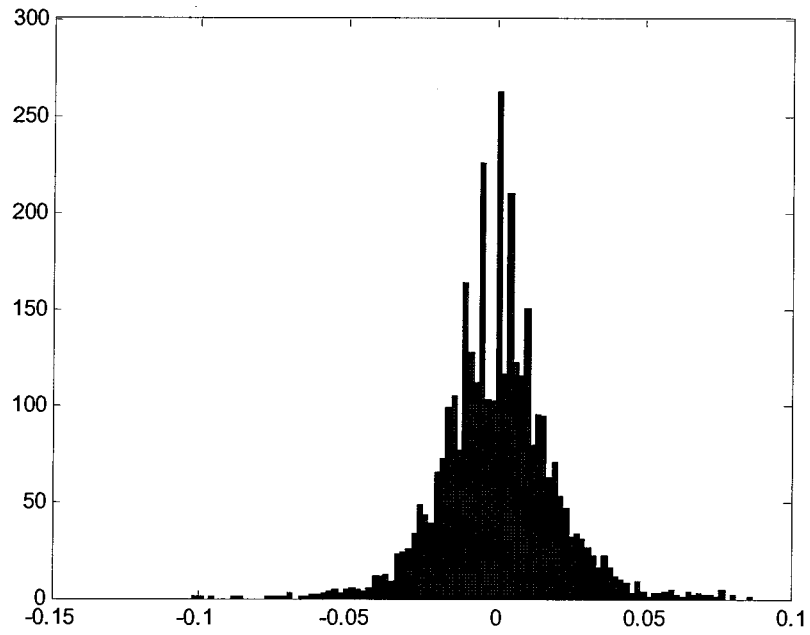
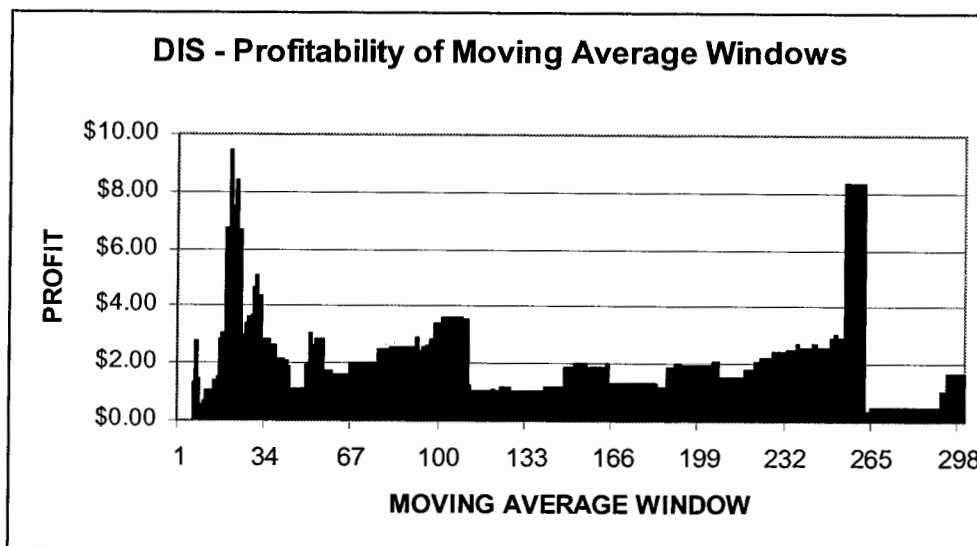
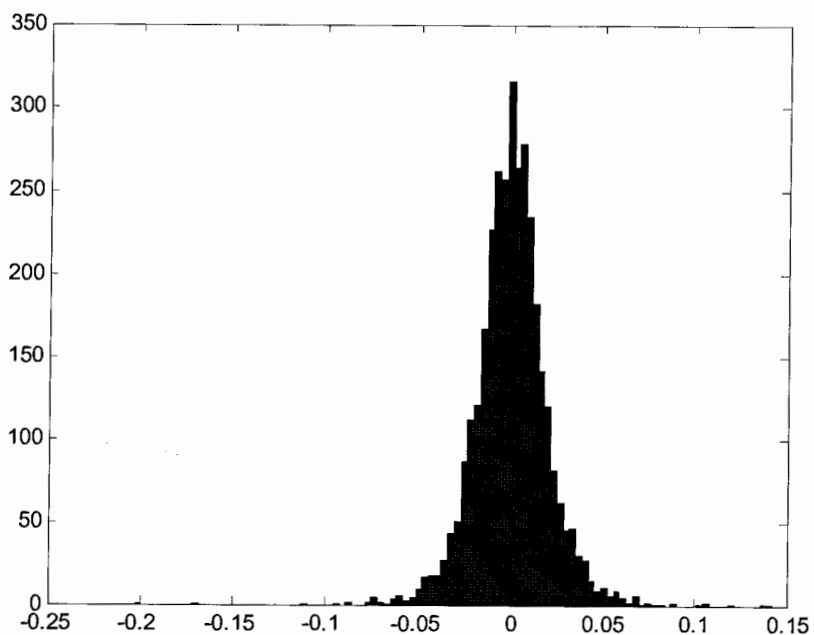


Figure 38 Walt Disney Company (The) (Holding Co.)



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