UNIVERSITÉ DU QUÉBEC À MONTRÉAL

# L'EFFET DES VARIABLES MACROÉCONOMIQUES SUR LA VOLATILITÉ DES MARCHÉS BOURSIERS

MÉMOIRE PRÉSENTÉ
COMME EXIGENCE PARTIELLE
DE LA MAÎTRISE EN ÉCONOMIQUE AVEC
CONCENTRATION EN ÉCONOMIE FINANCIÈRE

PAR

SALIM LAHMIRI

Juin 2006

UNIVERSITÉ DU QUÉBEC À MONTRÉAL

# ON THE EFFECT OF MACROECONOMIC VARIABLES ON STOCK MARKET VOLATILITY

MÉMOIRE PRÉSENTÉ
COMME EXIGENCE PARTIELLE
DE LA MAÎTRISE EN ÉCONOMIQUE AVEC
CONCENTRATION EN ÉCONOMIE FINANCIÈRE

PAR

SALIM LAHMIRI

Juin 2006

## Acknowledgments

I would like to acknowledge and thank my supervisor, Professor André Kurmann for his patience, help and expert guidance in writing this thesis during this past year.

I would like to express my gratitude to my other committee members for their time in reviewing this thesis.

I would like to thank my father for encouraging me in all my endeavours and for his moral support during all this years. God bless you.

Finally, and by no means least, my thesis would not have been possible without the support of my wife. Thank you.

I would like to dedicate this work to my daughters Aya and Amani. Love you.

**Table of contents**

# List of Tables

## List of Figures

## Abstract

This paper seeks to better understand the distribution of realized stock return volatility and to determine how this volatility reacts to past and expected changes in monetary and other macro aggregates. I follow Schwert's (1989) methodology to investigate the relationship between stock market volatility and the level of the economy. While Schwert (1989) uses daily returns to estimate monthly variance, I use the former to compute quarterly volatility; therefore my estimates have less error. Furthermore, my model corrects for potential endogeneity and serial correlation problems that are evident in Schwert (1989). In addition, I extend my study to NYSE and NASDAQ stock markets data.

In sum, my study supports Schwert's (1989) findings. Money supply and industrial production shocks are predictors of market volatility variations; while short term interest rates do not affect equity market volatility. Nevertheless, my empirical results don't support Schwert (1989) finding that market volatility is not linked to inflation variations. Finally, to some extent, my findings suggest that the efficient market hypothesis is rejected. The actual federal fund rate, money supply, inflation and industrial capacity utilization rate help to predict future equity market volatility.

Keywords: Volatility, macro aggregates, monetary policy, endogeneity, serial correlation, efficient market hypothesis.

**Résumé**

Nous étudions l'effet des variables macroéconomiques sur la volatilité du marché des actions en utilisant des données américaines pour la période allant de janvier 1959 à décembre 2004. Nous essayons de mieux comprendre la volatilité des rendements réalisés et de déterminer comment cette volatilité réagit aux changements de la politique monétaire et de l'économie passés et futurs.

Nous adoptons la méthodologie de Schwert (1989) pour examiner la relation entre la volatilité et le niveau de l'économie. Cependant, nous utilisons des données quotidiennes pour le calcul des estimés de la volatilité, lesquels sont moins baisés. En plus, nous corrigeons notre modèle pour tenir compte du problème d'endogénéité et de l'autocorrélation des résidus qui sont évidents dans Schwert (1989). Enfin, non seulement nous étudions l'effet des variables macro économiques sur la volatilité du S&P ; mais aussi sur celles du NYSE et du NASDAQ.

Nos résultats confirment les conclusions de Schwert (1989) que les chocs de l'offre de monnaie et de la production industrielle expliquent les variations dans la volatilité. Cependant, nos résultats ne confirment pas les conclusions de Schwert (1989) que la volatilité n'est pas reliée aux variations de l'inflation.

Nos résultats suggèrent aussi que l'hypothèse d'efficience des marchés financiers est rejetée. Les taux de discount, de l'offre de monnaie, de l'inflation et d'utilisation de la capacité industrielle anticipés expliquent la volatilité future des marchés des actions. Cette dernière conclusion est soumise à l'appréciation du lecteur.

Mots clés: Volatilité, agrégats macroéconomiques, politique monétaire, endogénéité, autocorrélation, hypothèse des marchés efficients.

# INTRODUCTION

Financial market volatility is central for asset pricing, asset allocation, and risk management. It is widely recognized among financial economists that volatility varies over time. If the markets simply rose steadily upward every day, investing would be a much easier proposition: one without risk. But in reality, the market is volatile, with ups and downs that affect investments. Understanding volatility is important when developing an investment strategy: one that manages the inherent risk associated with investing. There is a broad range of factors that influence the price of securities from companies (stocks) and other issuers, such as government agencies or municipalities (bonds). These factors include financial fundamentals, market psychology, economic indicators and some major political events.

The effect of economic variables on stock market volatility has received large attention in the literature. For instance, Schwert (1989) finds weak evidence that macroeconomic volatility helps to predict stock and bond return volatility. However, when he examines the relationship between macro aggregates and market volatility he finds that monetary base growth rates and industrial production growth rates are statistically related to stock market volatility. Furthermore, inflation, high-grade long-term bond returns and short-term interest rates are not significantly related to market volatility. By contrast, Baillie and DeGennaro (1990) show evidence that changes in federal fund rates (FFR) affect highly and significantly both mean and variance of the stock market returns. In fact, they conclude that the traditional mean-variance model is not appropriate to explain asset price volatility. Therefore, they suggest conducting further research to explain risk.

Most of the aforementioned studies follow Schwert's (1989) methodology. He employs a two-stage estimation process that first consists of estimating conditional volatilities and then regressing these volatilities on current and lagged macro variables. There are two potential problems with this approach. First, computing conditional monthly volatilities from daily data introduces a bias. Second, regressing these volatilities on current macro variables is subject to a simultaneous equation bias because both stock market volatility and macro variables may be jointly determined by the same shocks (thus violating the regularity condition that explanatory variables are uncorrelated with the error term of the regression). As a result, the point estimates are biased and lead to potentially invalid statistical inference.

This paper extends Schwert's study of how stock market volatility can be explained by macroeconomic variables in two ways. First, while Schwert uses daily data to compute monthly variances, I use daily data to estimate quarterly volatility. Second, my study attempts to determine how this volatility reacts to past and expected changes in macro variables rather than contemporaneous changes. In addition, my methodology allows testing for market efficiency. If the stock market is efficient, then the information set at $t\text{-}1$should not help explain equity market volatility at time $t$. In other words, since the market efficiency theory concerns predictability of means, then one could test market efficiency also by examining the predictability of variances.

To conduct my study, I use an extended data sample and three stock market indices over the period from January 1959 to December 2004. These indices are the NYSE, the S&P500 and the NASDAQ. The macro variables I employ as regressors are the gross domestic product, the federal fund rate, inflation, the money supply, the three month T-bill rate, the interest rate spread defined as the difference between the three month T-bill rate and the five year treasury note, and industrial capacity utilization.

In addition, I also assess the robustness to using market expectations of different macro aggregates as reported in the Survey of Professional Forecasters.

The results are as follows. First, the evidence of volatility clustering in all markets is very strong. It is found that the stock returns are well characterized by year-long episodes of high volatility, separated by longer quiet periods. Second, when I investigate the effects of monetary policy and economy shifts jointly, my results suggest that increased volatility (uncertainty) is predicted by increases in the growth rates of the federal fund rates, the money supply and inflation, while higher growth rates of the gross domestic product and industrial capacity utilization are significant negative predictors of stock market volatility. In addition, the influence of both the risk free rate and the interest rate spread on stock price volatility is insignificant.

In sum, my paper support Schwert's (1989) findings. Money supply and industrial production help predict the market volatility variations. In addition, short-term interest rates do not affect equity market volatility. At the same time, my empirical results don't support Schwert (1989) findings that market volatility is unrelated to inflation variations.

To check for robustness, I use the Wald test and find that all monetary variables coefficients are statistically different from zero. When only the effect of economy changes is considered, I find evidence that the industrial capacity utilization rate becomes highly and positively related to the equity price volatility in 1963-1983 period. Furthermore, the Wald test rejects the null hypothesis that all macro variables coefficients are equal to zero. In addition, I conclude that, the expected GDP, the unemployment rate, and industrial capacity utilization capture variations in the volatility of the NYSE. Nonetheless, only the expected gross domestic product can explain significantly the S&P500 and NASDAQ volatility.

To some extent, my findings suggest that the efficient market hypothesis is rejected. The actual federal fund rate, the money supply, inflation and industrial capacity utilization help to predict future equity market volatility.

The plan of the rest of the paper is as follows. In section 1, I present the general theoretical framework. In section 2, I briefly survey the literature on testing the efficiency of stock markets volatility with respect to macroeconomic data variables. In section 3, I present the methodology. Section 4 deals with data and specification. In section 5, I analyze my results. Section 6 deals with the response of equity market volatility to expected changes in monetary policy and economy respectively. Finally, I conclude and suggest some future directions to research.

## 1. Theoretical Framework

Consider the following expected stock price of a firm:

$$E[P_t \mid V_{t-1}] = \sum_{i=0}^{\infty} E[\frac{D_{t+i}}{1+r_{t+i}} \mid V_{t-1}] \tag{1}$$

Where $D_{t+i}$ is the cash flows to shareholders, $r_{t+i}$ is the discount rate, and $P_t$ is the share price. All these variables are conditional on available information V at time t-1. It is clear that the actual stock price is determined by expected dividends and discount rates. Then, the conditional variance of share price at time t-1, $Var_{t-1}(P_t)$, will depend on both the conditional variance of expected cash flows and discount rates as well as conditional covariances between them. Clearly, macroeconomic variables reflecting real economic activity affect asset's cash flow. Consider the actual return on asset *j* at time *t* is $q_t^j$ :

$$q_t^j = \frac{p_{t+1}^j + D_{t+1}^j - p_t^j}{p_t^j} \tag{2}$$

The expected return conditional on the available information set V at time *t-1* is,

$$R_{t-1}^j = E\left[q_t^j / V_{t-1}\right] \tag{3}$$

The unconditional standard deviation of $q_t^j$ is:

$$\sigma_q^j = \tfrac{1}{n-1} \sum_{i=1}^{n} \left(q_{t+i}^j - \mu\right), \tag{4}$$

where n and μ are respectively the number of observations and the mean of the stock returns.

Hence, the expected standard deviation of return conditional on information set at time t can be written as:

$$E\left(\sigma_q \mid V_{t-1}\right)=\frac{1}{n-1}\sum_{j=1}^{n}\left[E\left[q_{t+i}^{j} \mid V_{t-1}\right]-\mu\right] \tag{5}$$

The formulas in (2), (3), (4) and (5) are all function of the price $P_t$ of the asset. The conditional standard deviation of the asset is therefore a function of the expected dividends and the interest rates and can be expressed as follows:

$$E\left[\sigma_q \mid V_{t-1}\right]=f\left[\left\{D_{t+i}\right\}_{i=1}^{\infty},\left\{r_{t+i}\right\}_{i=1}^{\infty} \mid V_{t-1}\right] \tag{6}$$

In this paper, I postulate that changes in monetary policy and economic activity play a major role in the determination of equity market volatility since stock prices depend on future profits of firms and expected discount rates.

Economic theory suggests a negative relationship between monetary policy and stock market returns. Particularly, when the discount rate increases (decreases) the present value of future cash flows decreases (increases) and its stock price decreases (increases) too. Furthermore, discount rate[1] movements would change expectations of future cash flows. Clearly, an increase (decrease) in discount rate decreases (increases) real economic activity, and consequently cash flow expectations decrease (increase). Therefore, discount rate changes alter both interest rates and cash flow expectations that are useful for firm valuation.

[1] Investment rates by FED.

Table 1 lists the expected response of equity price to monetary instruments and aggregate variables.

**Table 1: The expected effect of the macroeconomic variables on stock price volatility.**

| | GDP | ICUR | CPI | FFR | MS | TB | IRD |
|---|---|---|---|---|---|---|---|
| Expected effect | - | - | + | + | + | + | + |

GDP is gross domestic product, ICUR is industrial capacity utilization rate, FFR is federal fund rate, MS money supply, TB is three months treasury bills, and IRD is interest rate spread measured by the difference between five-year treasury notes and the three-month t-bills.

I suggest that an increase in firm output leads to a decrease in uncertainty about its economic and financial health. Also, an increase in the inflation rate will reduce individual consumption and increase firm costs, and consequently firm profits will decrease. Given this scenario, I expect an increase in firm financial uncertainty.

Similarly, an increase in interest rates indicates that economic and business conditions are or becoming worse. In fact, investment and profits are expected to fall, and investors will sell stocks and buy bonds that offer; actually; higher returns. Overall, uncertainty about firm economic conditions will be higher. My reasoning would be valid at the aggregate level.

## 2. Literature Review

In his article, Schwert (1989) investigates the changes in US stock market volatility. For instance, daily data observations were used to estimate monthly stock price variance. The author argues that stock volatility is highly persistent and possibly not stationary. Indeed, lagged stock volatility is the most important variable in predicting current stock volatility. Furthermore, he concludes that volatility is higher during recessions. On the other hand, Schwert's study shows that monetary base growth rates and industrial production growth rates (on level) are statistically related to stock market volatility. By contrast, the evidence that macroeconomic volatility helps to predict stock and bond return volatility is weak. In fact, the author finds that between 2.2% and 5% of the variability of the stock market volatility is explained by macroeconomic volatilities.

Furthermore, in his study, the author investigates the linkage between financial variables and the stock market volatility. The findings are interesting: the relationship between the market volatility, and dividend and earnings yields is not stable. Nonetheless, the former is directly related to the difference between the yields on bonds of different quality. In addition, an increase in the debt/equity ratio leads to an increase in stock return volatility. Moreover, financial leverage affects stock market volatility, but only a small proportion of its changes are explained. Finally, the results show evidence of a relationship between trading activity and stock returns volatility. Both the number of trading days in the month and share trading volume growth are positively related to stock returns volatility.

The Federal Fund Rate (FFR) was used as a proxy to the rate of compensation. The results from daily and monthly data show evidence that changes in the FFR affect highly and significantly both mean and variance of stock market returns. In sum, Baillie and DeGennaro's (1990) finding is not consistent with Schwert' (1989) conclusions.

Other studies have also modeled the relation between asset prices and real activity. For instance, Campbell, Lettau, Malkiel, and Xu (2001) use a disaggregated approach[3] to study the volatility of common stocks at the market, industry and firm levels. The results provide strong evidence that market industry and firm-level volatility are all higher in economic downturns. Particularly, industry-level and firm-level variances roughly double in recessions. Bomfim (2003) concludes that policy surprises induce greater volatility in US stock market. Particularly, positive policy surprise induces highly stock market volatility than negative surprises in the short run. Jones, Lin, and Masih (2005) conclude that announcements of changes in domestic monetary policy affect significantly UK stock market volatility. Furthermore, FTSE100 volatility reacts swiftly to industrial production, inflation rate, and changes in domestic interest rate.

I conclude that the literature provides evidence that stock return volatility is dependant on the macro factors variations and volatilities. However, all these previous studies suffer from one major problem. The estimates of the relationship between the volatility of equity market and macroeconomic variables are potentially biased because of an endogeneity problem: actual conditional volatility of stock returns is regressed on actual volatility of macroeconomic variables. If macroeconomic variables are endogenously determined with stock market volatility then we have a problem of endogeneity that leads to biased estimates.

[3] The authors use a statistical decomposition rather than a structural economic model in their 1962 to 1997 sample period. They decompose stock return into three components: the market-wide return, an industry –specific residual, and a firm-specific residual. Then, they construct time series of volatility measures of the three components.

The existing literature has not addressed this issue. Hence, my study attempts to bridge the gap in the relationship between the stock market volatility and macroeconomic variables with a different methodology that allows overcoming this major shortcoming. To address the problem of endogeneity and serial correlation, I use lagged macroeconomic variables and some autoregressive orders of the dependent variable to explain actual stock market volatility. Finally, since I use daily-frequency returns to measure the quarterly equity volatility, my estimates of volatility have less error than the estimates from monthly data.

3. Methodology

All of the daily price data was converted to daily returns data for stock market index by assuming continuous compounding.

$$q_t = log(P_t/P_{t-1}) \qquad (7)$$

Where $q$ is the asset rate of return at time $t$[4]. Then, for each quarter I compute standard deviation of stock returns $\sigma$ using three-month daily returns as follow.

$$\sigma = \frac{1}{n-1}\sum_{i=1}^{n}\left(q_{t+i} - \mu\right), \qquad (8)$$

where $n$ is the number of observations for the quarter in question and $\mu$ is the mean of the series. I have also estimated stock prices volatility using a TARCH[5] specification, but obtained very similar estimated volatilities compared to the estimation with equation (8). Because a TARCH model requires a rigorous routine to identify the stock returns process and it is not in itself a statistical estimation of the variance, I adopt equation (8) that is a simple statistical estimation of the population variance.

Once the volatilities computed, for each of the three data series I commence my analysis with a general model of the form,

$$\sigma_t = \alpha_0 + \sum_{t=1}^{T-1}\theta_i X_{t-i} + \sum_{t=1}^{T-1}\varphi_i \sigma_{t-i} + \eta_t \qquad (9)$$

Where $\sigma_t$ is standard deviation of the stock market and $t$ now stands for the quarter in question; $X_{t-i}$ is a vector of lagged growth rates of macro variables, $\sigma_{t-i}$ are lagged standard deviations capturing the autoregressive structure, and $\eta_t$ is the error term.

[4] Since we are working with stock market indices, there are no dividends to be considered.
[5] Glosten, L. R., R. Jaganathan, and D. Runkle (1993). "On the Relation between the Expected Value and the Volatility of the Normal Excess Return on Stocks," Journal of Finance, 48, 1779-1801.

Note that equation (9) is estimated by ordinary least squares routine under the hypothesis that:

$$E[\eta_t, X_{t-i}] = 0,$$

The information criteria are used as a guide in model selection. Specifically, I use both Akaike (AIC) and Schwarz (SC) information criterion to identify the best regression model. They are defined as follow.

$$AIC = -2\Phi/n + 2s/n \qquad (10)$$

$$SC = -2\Phi/n + 2s*log(n)/n \qquad (11)$$

Where $s$ is the number of estimated parameters, $n$ is the number of observations, and $\Phi$ is the value of the log likelihood function using the $s$ estimated parameters.

The various information criteria are all based on minus 2 times the average log likelihood function, adjusted by a penalty function. Once regression models are specified, I test their robustness using Wald test.

## 4. Data and Specification

The CRSP[6] database is being used to obtain daily nominal share price data for a selection of stock market indices over the 1959-2004 period. In particular, the stock market indices are the S&P500, NYSE and NASDAQ. To test the impact of changes in monetary policy and economy on stock market volatility, my paper analyses a broad spectrum of aggregate variables that are often cited as having some relationship with equity prices.

Macro data are gathered from FRED database of the Federal Reserve Bank of St.Louis. As a proxy of monetary authority instruments I select growth rates of the federal funds rate (FFR) and the money supply (M2). Also, I use five macroeconomic variables. Namely, the growth rates of gross domestic product (GDP), consumer price index (CPI), the industrial capacity utilization rate (ICUR), the three month T-bill rate (TB) and the difference (interest rate spread) between 5-year treasury note and the three month T-bill interest rate (IRS).

Before investigating the relationship between the stock returns volatility and macroeconomic variables, I illustrate the stock returns behaviour through time of the NYSE and S&P indices from July 1962 to December 2004 and from December 1972 to December 2004 for the NASDAQ index. Growths of equity price indices are presented in figure 4.1. One important feature stands out. In some periods, the stock returns variability is consistently higher. Particularly, the variability of stock returns is higher from 1973 to 1976, is low in the mid 1990s and, then, increases dramatically in late 1990s and early 2000s, especially for the NASDAQ volatility.

Note that the biggest spikes in price returns happened in the financial crash of October 1987 and in the bubble burst that occurred in 2000. I conclude that the equity prices are characterized by their respective volatility clustering. Table 4.1 provides further evidence that support my conclusion.

---

[6] The Center for Research in Security Prices.

The NASDAQ has the highest return but is more volatile than the NYSE and S&P price index. Standard deviations are slightly higher in 1990s. The Kurtosis statistics indicate that all the distributions of stock returns have a fat tail, especially for the full sample.

This means that all the distributions have pronounced extreme values. Figure 4.2 illustrates graphically this latter conclusion. It plots the quantiles ($Q_s$) of each market index returns series against the quantiles ($Q_t$) of the normal distribution. If the two distributions are the same, the $Q_sQ_t$-plot should lie on a straight line. If the $Q_sQ_t$-plot does not lie on a straight line, the two distributions differ along some dimensions. Figure 4.2 also shows that the pattern of deviation from linearity provides an indication of differences between all returns series and the normal distribution. In other words, the S-shape nature of all three curves provides strong evidence that the NYSE, S&P and NASDAQ index volatility are clustering in post 1990 period. In the next section, I review some of the important empirical literature.

In this section, I also examine how the volatility of stock returns varies over time. In fact, to provide a general understanding of the properties of stock market volatilities and to compare the distinct properties across the different market indices, I present summary statistics for the volatilities of the three equity markets for the period[7] from the first quarter of 1973 to first quarter of 2003 in table 4.2. The statistics include the average quarterly standard deviation, median, maximum, minimum, standard deviation, skewness, kurtosis, Jarque-Bera statistic, autocorrelations, and the Ljung-Box (Q) statistic[8].

---

[7] This is common sample. NASDAQ standard deviation data start on the first quarter of 1973.

[8] The formula for the Ljung-Box (Q) statistic is: $Q_k = T(T+2)\sum_{k}^{T} \rho_j^2 (T-j)$. Where $\rho_j$ is the $j$th lag autocorrelation, $k$ is the number of autocorrelations, and $T$ is the sample size. The null hypothesis is: $H_0: \rho_1 = \rho_2 = \ldots = \rho_k = 0$. Rejection of the null hypothesis indicates the presence of serial correlation in standard deviations. For more details see Ljung and Box (1978).

The sample means of all market volatilities range from 0.8% to 1%. The NYSE market index has the lowest average volatility with the lowest standard deviation, and the technology market has the highest average volatility with the highest standard deviation. The maximum volatility is achieved at 3.7% for both the NASDAQ and S&P500 stock indices. Note that volatility of technology sector has the lowest minimum level at 0.3% while the S&P500 has the highest minimum level at 3.7%.

If the volatilities are normally distributed, then the coefficients of skewness and kurtosis are respectively zero and three. All the three market volatilities have a long right tail and are leptokurtic relative to the normal distribution. In sum, all the volatilities depart from normality. The Jarque-Bera statistics are all significant; hence all volatilities are not normally distributed. Calculating autocorrelation coefficients tests the independence assumption of $T$ observations in each time series. The statistics of all the volatilities cannot reject the null hypothesis of the absence of first order autocorrelation at 5% significance level.

Table 4.2 also reports the Ljung-Box, Portmanteau, ($Q_k$) statistic, which is designed to test whether the series correlations up to order $k$ are all equal to zero. The evidence shows that all the equity market volatilities reject the null hypothesis of absent dependency[9]. Hence, when running OLS, I should correct for serial correlation in the dependent variable which is the stock market volatility in our estimation. Otherwise, all inferences will be not valid.

In a comparison of the means and standard deviations for these three volatilities I find that (1) the volatility of the technology market is relatively larger, whereas that of the NYSE and S&P500 is relatively smaller, and (2) the standard deviation of volatility of the technology market is relatively larger compared to those of the NYSE and S&P500.

---

[9] All reported p-values, in parentheses, are equal to zero.

Figure 4.3 plots the standard deviation of the NYSE, S&P, and NASDAQ stock market returns for 1962-2003 period. There are many similarities between volatility series. In particular, the latter were high from 1973 to 1974. This could be related to the OPEC oil shock.

They also were high from 1979 to 1982. In 1987, the October crash caused an increase in the volatility series. The 80s are characterized by periods when volatility series rose for brief periods. In recent times, from 1996 to 2002, all volatility series were rising and achieved their peaks in 2000 for the NASDAQ and 2002 for the NYSE and S&P stock indices respectively.

Overall, it is found that the stock returns are well characterized by year-long episodes of high volatility, separated by longer quiet periods. I conclude that even though the volatility series have similar pattern, the levels of standard deviations are quite different. To show that volatility clustering is evident in my case[10], I compute the autocorrelation function for each market squared returns and its associated Ljung-Box statistic. I present graphically the autocorrelation functions of the NYSE, S&P, and NASDAQ squared returns up to order 36 in figure 4.4. I find that all markets squared returns have positive and significant autocorrelations. Hence, empirical results provide strong evidence for volatility clustering.

---

[10] This is an indirect procedure to test constancy of volatility.

## 5. Results and Analysis

In this section, I first discuss the results of unit root tests and the selection of lag order for the regressions. Second, I report the results of the regressions.

### 5.1 The Dickey-Fuller Test for Stationarity

I conduct the Augmented Dickey-Fuller procedure to test for the presence of unit root in all the financial and aggregate data. The test results show that all of the market volatilities and growth rates of macroeconomic variables are stationary[11] (see appendix A for results of unit root tests).

### 5.2 Model Selection

Before estimating equation (9), I conduct the model selection procedure to determine both the autoregressive process of the endogenous variable and the optimal number of lagged exogenous variables. The model selection procedure is based on the minimization of the Akaike and Schwarz information criterion. Table 5.1 shows that all the three stock returns volatilities follow an autoregressive process of order three with only one period lagged growth rates of macro factors.

Equation (9) is estimated by ordinary least square. If I assume that standard errors of equation (9) are heteroskedastic and the form of heteroskedasticity is not known, it may not be possible to obtain efficient estimates of the parameters using Weighted Least Squares.

---

[11] Running a regression with non stationary variables leads to a spurious regressions; and therefore; all inferences are not valid.

Ordinary least square provides consistent parameter estimates in the presence of heteroskedasticity but it should be noted that the usual OLS standard errors may be incorrect.

I use simple OLS for estimation and add lagged dependent variable to correct for serial correlation, however.

### 5.3 Results

Table 5 reports regression results for volatility of the three market indices following equation (9) and using information criterion in (16) and (17) in appendix. Table 5.2 generally shows that lagged volatilities of order one and three are found to be highly significant at the 1% significance level, and the R squared ranges from 35% to 63% which is much higher than Schwert's findings. I find that lagged growth rate of gross domestic product is significant at the 10% significance level in the three financial markets. I also find that lagged growth rate of the consumer price index; the money supply, the federal fund rate, and industrial capacity utilization are all highly significant for the NYSE and S&P, but not the NASDAQ index. By contrast, for the lagged growth rate of treasury bills and the growth rate of the spread, they were found not to be statistically significant at any level.

In fact, the lagged growth rate of gross domestic product has a negative effect on the NYSE and S&P500 volatility: an increase in output reduces future uncertainty, and then asset prices volatility diminishes. However, the response of the NASDAQ volatility to an increase in lagged growth rate of gross domestic product is positive. The impact of the lagged growth rate of consumer price index, the money supply, and the federal fund rate on all three markets volatilities is positive, except that the money supply affects negatively NASDAQ volatility. Indeed, lower inflation and interest rates reduce future uncertainty.

On the other hand, the lagged growth rate of treasury bills and the growth rate of the interest rate spread have a negative and a positive effect on all volatilities respectively, except that the spread affects negatively NASDAQ volatility. Finally, the response of all the volatilities to an increase in the growth rate of industrial capacity utilization is negative. The p-values of both F and $\chi2$ statistics indicate that we can decisively reject the null hypothesis that all monetary and economy factors are equal to zero except for the volatility of NASDAQ returns.

Overall, the NYSE volatility regression results show that for the full sample, the effect of lagged growth of GDP is negative and statistically significant at the 5% level. The effect of the money supply, inflation, and the FFR growth is positive and highly significant at the 5% level. The volatility is negatively and significantly related to growth of ICUR at the 5% level. The effect of the risk free rate and interest rate spread on volatility is negative and positive respectively. However, these effects are not consistently significant.

Finally, for the S&P500 volatility, the regression results show that for the full sample, the effect of lagged growth of GDP is negative and statistically significant at the 10% level. The effect of the money supply, inflation, and the FFR is positive and highly significant at the 5% level. The effect of the TB and interest rate spread growth on volatility is negative and positive respectively, however they are not consistently significant. The volatility is negatively related to ICUR and the relationship is highly significant. For the full sample, results from the NASDAQ volatility regression show that only gross domestic product is positively related to volatility and it is statistically significant at the 10% level.

In sum, my empirical findings support Schwert's (1989) findings that both the output and the money supply are significantly related to the stock market volatility. By opposition, I find a significant relationship between inflation and the stock market volatility.

Indeed, my empirical findings support Baillie and DeGinnaro (1990), Li (1998), Chian and Doong (1999), Beltratti and Morana[12], and Jones, Lin, and Masih (2005) that the federal fund rate, the gross domestic product; inflation and the money supply are significantly related to the stock market volatility.

### 5.4 Robustness of Results

#### 5.4.1 The Effect Before and After 1983

Now, I want to compare the effect of monetary policy and economy shifts on the stock market volatility before and after the second quarter of 1982. I choose the split date to coincide with the reduction in the volatility of the growth rate of several macro variables. As usual, I identify equation (5) using Akaike and Schwarz information criterion.

Tables 5.3, 5.4 and 5.5 report summary of regressions statistics for the NYSE, S&P500, and NASDAQ volatility respectively. For each stock market, I compare ordinary least squares estimates before and after 1982:2.

Results from regression of the NYSE market volatility show that the sign of lagged growth in the gross domestic product is negative in the two periods and is not statistically significant.

Table 5.3 shows that the lagged gross domestic product effect on the NYSE volatility is negative and not statistically significant in all sub samples. In the first sub period, the sign of lagged coefficient of inflation is positive, larger and not significant.

---

[12] Beltratti .A and Morana .C, "Breaks and Persistency: Macroeconomic Causes of Stock Market Volatility", Journal of Econometrics, forthcoming.

For example, an increase in lagged inflation by 1% causes an increase in the NYSE volatility by 0.14% in next period. It does become smaller and statistically not significant at any level in the second sub period.

The coefficient of lagged growth in the money supply is negative, smaller in absolute value, and not statistically significant before second quarter of 1983. In second sub period, the money supply shows high economic significance.

For example, the quarterly effect of money growth is positive and highly significant at the 1% level. Particularly, an increase of 1% in the money supply leads to 0.12% increase in the NYSE volatility in next period. The effect of the federal fund rate is positive in all sub periods. It is small and not significant before second quarter of 1983, but the effect is relatively larger and highly significant in the second sub period. In all sub periods, the impact of the risk free rate is negative, small, and insignificant at any level. The effect of interest rate spread is small and statistically insignificant in all sub periods. The sign of the spread variable is positive in all periods.

In all sub periods, the impact of industrial capacity utilization is negative and is statistically highly significant in the full and first sample only. The p-values of both F and $\chi 2$ statistics indicate that we can decisively reject the null hypothesis that all monetary and economy factors are equal to zero in the two sub periods.

For the volatility of S&P500, results from table 9 show that the sign of lagged growth in the gross domestic product is negative in the two sub periods and it is not statistically significant.

In the first sub period, the sign of lagged coefficient of inflation is positive, relatively larger and highly significant. For example, an increase in lagged inflation by 1% causes an increase in the S&P500 volatility by 0.14% in next period. It is positive and statistically not significant at any level in the second sub period. Note that the impact of inflation on the volatility of NYSE and S&P500 is the same. The coefficient of lagged growth in the money supply is negative, smaller in absolute value, and not statistically significant before second quarter of 1983.

In second sub period, the effect of the money supply becomes positive and shows high economic significance.

For example, an increase of 1% in the money supply leads to 0.13% increase in the S&P500 volatility in next period. The federal fund rate has smaller and statistically insignificant effect on future volatility of the S&P500 before second quarter of 1983. Its effect is sizable and highly significant at the 1% level in second sub period. Again, the impact of the risk free rate on future volatility is negative, extremely small, and insignificant at any level in all sub periods.

The sign of the interest rate spread variable is negative and positive in first and second period respectively and is not significant. Note that the effects of interest rate spread on the volatility of NYSE and S&P500 are quietly similar.

Industrial capacity utilization has a small, negative and statistically significant effect on the S&P500 volatility in first sub period. Nevertheless, its effect is insignificant in second sub period. Again, the Wald test rejects the null hypothesis that all monetary and economy factors are equal to zero in the two time period.

For the volatility of NASDAQ, regression results in table 5.5 differ largely from those of the NYSE and S&P500 stock index volatility. The gross domestic product has a positive but insignificant effect on the technology market volatility in all sub periods. This effect is small in first sub period and relatively larger in second sub period.

In addition, the coefficient of inflation growth is positive and only significant at the 10% level before second quarter of 1983. The money supply growth is positively and negatively related to the technology stocks volatility in first and second sub period respectively. The relationship is statistically insignificant, nevertheless.

The federal fund rate affects positively and negatively the NASDAQ volatility in first and second sub period respectively. The effect is only statistically significant at the 10% level in first time period.

Note that the federal fund rate coefficient has a small size in the two periods. The risk free interest rate is negatively related to the technology stocks volatility in two sub periods and the relationship is statistically significant at the 10% level in first period.

The coefficient of the interest rate spread is positive and negative in first and second sub period respectively. However, its size is extremely small and insignificant. The industrial capacity utilization rate is negatively related to the volatility of technology stocks in first time period. Although the relationship is highly significant at the 5% level its size is small. The effect of industrial capacity utilization is relatively sizable, negative and highly significant at the 10% level in first sample.

In addition, F and $\chi 2$ statistics indicate that the null hypothesis that all monetary and economy factors are equal to zero is rejected in first sub sample and accepted in second time period.

### 5.4.2 The Effect of Monetary Variables on Stock Market Volatility

Since combining macro factors and monetary instruments in one-model specification leads to a few unexpected effects, I investigate separately the effect of monetary policy and economy on market volatility. Section 5.4 provides the empirical relationship between monetary policy changes and stock market volatility and section 5.5 provides the empirical relationship between economy shifts and stock returns volatility.

In this section, I study how stock returns volatility responds to monetary variables changes. I use 1963:3-2002:1, 1963:3-1983:1, and 1983:2-2002:1 time period to investigate the effect of lagged growth of the money supply, the federal fund rate, the three month treasury bills, and the interest rate spread on stock returns volatility. Tables from 5.6 to 5.8 report regressions summary statistics for the NYSE, S&P, and NASDAQ volatility.

For the NYSE, the Wald statistic indicates that the null hypothesis that all monetary variables coefficients are jointly equal to zero is highly rejected for the two sub samples. From table 5.6, the coefficient on lagged money supply growth is negative and positive in first and second time period respectively. It is consistently significant at the 10% level in first time period and highly significant at the 1% level in second time period. From 1963:3 to 2002:1, the money supply growth coefficient is positive and statistically significant. The coefficient on lagged growth of the federal fund rate is positive in all periods and has small size. It is highly significant at the 1% level in the full and second time period. The coefficient on lagged growth of the risk free rate is negative in all periods and has small size. It is highly significant at the 1% level in the full time period.

This concludes that there is very strong evidence that the NYSE volatility is related to the federal fund rate, the risk free rate, and the money supply for the full sample.

The association between the NYSE volatility and the money supply and the interest rate spread is strong from 1963 through 1983. The money supply and the federal fund rate are found to be highly associated with the NYSE volatility from 1983 through 2002.

When only monetary policy is considered, the effects of the T-bill rate and the interest rate spread on the NYSE volatility become highly significant. They respectively affect negatively and positively market volatility.

For the S&P, table 5.7 shows that the coefficient of lagged money supply growth is very small and consistently significant at the 10% in full time period (positive) and first time period (negative). In second time period, it is positive and highly significant at the 1% level. The lagged growth of the treasury bill rate is negative in all periods and highly significant in full sample only. In first period, the lagged growth of interest rate spread is small, positive and not significant at any level. The Wald statistics highly reject the joint hypothesis that all monetary variables coefficients are equal to zero for all periods.

In sum, for 1963-2002 period, all monetary variables are highly related to market volatility, except the interest rate spread. The effect of the T-bill rate becomes significant and affects negatively the S&P volatility. From 1963 through 1983, the interest rate spread becomes highly significant and negative.

For the NASDAQ, table 5.8 shows that the coefficient of lagged money supply growth is very small and not consistently significant. The coefficient of lagged federal fund rate growth is positive in all periods, very small and is only consistently significant at the 10% in first sub sample. The risk free rate affects negatively the NASDAQ volatility in all samples, and the effect is only significant in first sub sample at the 10% level. The effect of lagged growth of interest rate spread is extremely small, negative and not statistically significant. Again, the Wald statistics highly reject the joint hypothesis that all monetary variables coefficients are equal to zero for all periods. We conclude that from 1963 through 1983, the federal fund rate and T-bill rate become highly related to NASDAQ volatility. Their effects are found to be positive and negative respectively.

In conclusion, the effect of money supply on the volatility of NYSE and NASDAQ is positive. Since an increase in the money supply causes higher inflation, then market uncertainty goes up. However, the volatility of S&P responds negatively to the money supply variations. All the volatilities are positively related to the variations in the federal fund rate, and the risk free rate is negatively linked to all markets. In fact, higher interest rates (FFR) cause higher uncertainty in markets. Finally, the interest rate spread has no effect on all market volatilities.

### 5.4.3 The Effect of Real Macro Aggregates on Stock Market Volatility

In this section, I study how stock returns volatility responds to the economy changes over time. I use 1963:3-2002:1, 1963:3-1983:1, and 1983:2-2002:1 time period to investigate the effect of lagged growth of gross domestic product, consumer price index, and industrial capacity utilization on stock returns volatility. Tables 5.9, 5.10, and 5.11 report regressions summary statistics for the NYSE, S&P, and NASDAQ volatility respectively.

For the NYSE market, the Wald statistics highly reject the joint hypothesis that all macro variables coefficients are equal to zero, except for second time period.

Table 5.9 shows that the NYSE volatility is negatively related to the lagged growth rate of gross domestic product and is not statistically significant at any level in all samples. The inflation rate affects positively NYSE volatility and is consistently significant except in second sub period. The effect of ICUR is negative and highly significant in all samples. The industrial capacity utilization rate affects negatively NYSE volatility and the effect is significant at the 5% level in second sample.

This concludes that for the entire sample, only inflation is strongly related to NYSE volatility and that the relationship is negative. An increase in the inflation rate leads to an increase in uncertainty, thus in the stock market volatility. Furthermore, the volatility is negatively related to the GDP and industrial capacity utilization rate. Finally, the explanatory power of macro variables is 30.65% that it is lower than explanatory power of the combined effect of real aggregates and monetary variables, 35.04%, and is as much as the explanatory power of monetary policy, 30.66%.

For the S&P market, the lagged gross domestic product of order one has a negative impact on future volatility of S&P500 stock returns. The impact is not significant in all samples at any level. Future volatility of S&P500 is positively associated with inflation.

The linkage is highly significant at all levels in full and first sub period, and is statistically significant at the 10% significance level in second sample. The industrial capacity utilization rate is negatively related to future S&P volatility and is significant at the 5% level in 1963-2002 period. Indeed, the Wald statistics highly reject the joint hypothesis that all macro variables coefficients are equal to zero, except for 1983-2002 time period.

In short, the S&P500 volatility negatively reacts to an increase in the gross domestic product and industrial capacity utilization rate, but it responds positively to an increase in inflation. I do not find significant change in macro variables effects when monetary factors are isolated. Finally, the explanatory power of macro variables is 35.14% that it is lower than explanatory power of combined effect, 39.44%, and is higher than that of monetary policy, 35.32%.

For the full sample, the empirical results from table 5.11 show that the gross domestic product and inflation affect positively future NASDAQ volatility. The relationship between the gross domestic product and technology sector volatility is only significant in 1983-2002 period, and the relationship between inflation and market volatility is only significant in 1963-1983 period. The ICUR affects negatively NASDAQ volatility, and the effect is only significant at the 5% level in first sub sample.

In fact, the joint hypothesis that all macro variables coefficients are equal to zero is only rejected in first sub period. Finally, the explanatory power of macro variables is 62.13% that it is much higher than explanatory power of combined effect, 62.98%, and monetary policy, 61.63%.

In conclusion, the gross domestic product affects positively the NYSE and NASDAQ volatility. This result was not expected because higher output would lead to lower uncertainty. However, it is negatively related to S&P volatility.

Finally, the volatility in the three markets responds negatively to the industrial capacity utilization rate as expected.

## 6. The Effect of Expectations on Stock Market Volatility

Given the hypothesis of informational efficiency, equity markets must react only to unanticipated announcements. To investigate this issue, one would regress the actual variable of interest on expectations of current variables. This is exactly the procedure I am following in this section. Particularly, I measure total returns volatility explained by expected variation in the output (EGDP), industrial production (EIP), and the unemployment rate (EUNEMP). The expected GDP, industrial production, and the unemployment rate are used to proxy the impact of business conditions and global real activity shocks on expected cash flows. These variables were considered in this section because of large sample availability. Forecasted data were taken from the Survey of Professional Forecasters website[13] which is maintained by The Federal Reserve Bank of Philadelphia.

The model says that, if information about the production of a given quarter is spread across several past quarters, then the production of a given month will affect stock returns volatility. To estimate the relationship between expected economy changes and stock market volatility, I regress contemporaneous volatility on lagged expected growth of the GDP, industrial production, and the unemployment rate from 1970:1 to 2003:4.

In fact, for the NYSE market, lagged expected quarterly unemployment rate, the GDP and industrial production up to two to three lags help to explain quarterly volatility. Their coefficients are significant at six, two and eight percent significance level. The model explains 25% of its variability. The expected unemployment rate, the GDP, and industrial production have positive, negative, and positive effect on NYSE volatility respectively.

---

[13] The *Survey of Professional Forecasters* is gathering data from a diverse set of participants who forecast some economic variables on a regular basis. Go to www.phil.frb.org/econ/spf/ for more details.

For the S&P500 index, only the lagged expected GDP growth of order three has a negative and strongly significant effect at the 2% level. The model explains 30% of S&P500 index variability. Similarly, the lagged expected GDP growth of order three is negatively related to NASDAQ volatility.

The relationship is statistically significant at the 8% level and the explanatory power of the model is about 64%. Indeed, the joint hypothesis that all expected macro variables coefficients are equal to zero is not rejected in all stock markets. Note that the null hypothesis is highly accepted in the NASDAQ volatility regression. Hence, I conclude that the effect of expectations on the stock market volatility is generally insignificant. This conclusion would support the hypothesis of market efficiency. However, lagged expected quarterly unemployment rate, the GDP and industrial production help to explain quarterly NYSE volatility.

## CONCLUSION

In this paper I document the effect of monetary and real macro variables on the volatility of NYSE, S&P500 and NASDAQ market. I mainly follow Schwert's (1989) methodology. The major feature is to use a different approach to overcome the endogeneity problem evident in Schwert (1989) and document the effect of macroeconomic variables on the technology stock price volatility. In fact, this topic has received a very little attention in the academic literature. For instance, rather than using daily returns to estimate monthly volatility as Schwert (1989) does, I use daily returns to compute quarterly market volatility. Furthermore, I use an extended data sample and three stock market indices to conduct my study. Finally, I document the effect of expectations on future market volatility. This is a one way to test the rationality of stock prices.

Allowing for various data transformations and lags, econometric models are built over the period January 1959 to December 2004. The US gross domestic product (GDP) and industrial capacity utilization rate (ICUR) are strong indicators of real output and current economic conditions. Interest rates are measured by the federal fund rate denoted by FFR. Since 1983, the Federal Reserve Bank has targeted the federal fund rate. This new targeting strategy indicates the importance of using the FFR as a measure of monetary policy. The consumer price index denoted by CPI is included as a general indicator of inflationary conditions. Three month T-bill rate and interest rate spread are also used as business conditions indicators in my basic model.

The main findings of my work can be summarized as follows. First, I conclude that the evidence of volatility clustering in all markets is very strong. Second, empirical results show that; when combined; some monetary and macroeconomic variables can explain a substantial fraction of stock price volatility.

In fact, I document a significant effect of the gross domestic product, inflation, the federal fund rate, and industrial capacity utilization on NYSE volatility.

The response of these markets to effect of the three month T-bill and the interest rate spread is not consistently significant.

However, these finding are very similar to results for S&P500 volatility except that industrial capacity utilization effect is not statistically significant.

For NASDAQ volatility, the only statistically significant predictor is the gross domestic product changes. Third, when the effect of economy variables is excluded, the effects of three month T-bill rate and the interest rate spread on NYSE volatility become highly significant. Particularly, they affect negatively market volatility. In 1963-2002 period, all monetary variables are highly related to S&P volatility, except the interest rate spread.

The effect of T-bill rate becomes significant[14] and affects negatively S&P500 volatility. From 1963 through 1983, the interest rate spread becomes highly significant and negative[15]. From 1963 through 1983, the federal fund rate and T-bill rate become highly related to the NASDAQ volatility. Their effects are found to be positive and negative respectively. Fourth, when the effect of monetary factors is excluded, the effects of the output, inflation, and industrial capacity utilization on the NYSE volatility are significant. I do not find significant change in macro variables effects on S&P500 volatility when monetary factors are isolated. Finally, results show that the NASDAQ volatility is significantly related to industrial capacity utilization, the output and inflation. In addition, using an extended sample compared to Schwert's paper and doing the subsample splits gives us more information on how some real variables affect the stock market volatility. For example, the association between NYSE volatility and the money supply and interest rate spread is strong in first period.

In the second subsample, the effect of money supply on S&P500 is positive (negative in first period) and highly significant. The effect of inflation is positive and

[14] For entire sample, the effect of T-bills was not significant.
[15] For entire sample, the effect of interest rate spread was not significant.

only significant before second quarter of 1983. Industrial capacity utilization affects negatively and significantly the S&P500 volatility in first sub period.

Furthermore, I find evidence of strong relationship between expected GDP, the unemployment rate, and industrial capacity utilization and NYSE volatility. However, only the expected gross domestic product can explain significantly S&P500 and NASDAQ volatility.

These findings suggest that some of lagged and expected macro economic variables help to explain future stock market volatility. Therefore, I conclude that the efficient market hypothesis is not accepted[16] in my study. However, the answer to the basic market-rationality question is left to the reader.

In sum, this research supports Schwert (1989) findings. The money supply and industrial production shocks explain market volatility variations. And, short-term interest rates do not affect equity market volatility. Nevertheless, my empirical results don't support Schwert (1989) findings that market volatility is not linked to inflation variations.

To overcome the problem associated with the procedure of employing a two-stage estimation process[17] to first estimate conditional volatilities, one can jointly estimate the equation for the conditional volatility of stock market returns together with the equations determining the conditional volatilities of all variables included in the model using the generalized least squares (GLS) estimation procedure together.

---

[16] Since the statistical significance of some explanatory variables is weak.

[17] This problem is inherent in Schwert (1989), Liljeblom and Stenius (1997), Morelli (2002) to name a few.

In addition, volatilities can be estimated by a simple and powerful GARCH (1,1) process. Finally, I suggest investigating the effect of asymmetry in macro variables on stock price volatility using a TARCH model that accounts for the fact that investors react differently to positive and negative increments of a given factor.

## Appendix A: Unit Root Test Results

To illustrate the use of Dickey-Fuller tests, consider first an AR (1) process:

$$Y_t = \mu + \rho y_{t-1} + \varepsilon_t,\ \varepsilon_t \sim N(0,\sigma_\varepsilon^2) \qquad (12)$$

Where $\mu$ and $\rho$ are parameters. The basic Dickey-Fuller (DF) test (Dickey and Fuller 1979, 1981) examines whether $\rho<1$ in equation (12), which, after subtracting $y_{t-1}$ from both sides, can be written as:

$$\Delta y_t = \mu + (\rho-1)y_{t-1} + \varepsilon_t = \mu + \theta y_{t-1} + \varepsilon_t \qquad (13)$$

The null hypothesis is that there is a unit root in $y_t$, or $H_0$: $\theta = 0$, against the alternative $H_1$: $\theta < 0$, or there is no unit root in $y_t$. Dickey and Fuller (1979) showed that the distribution under the null hypothesis is non-standard, and simulated the critical values for selected sample sizes. More recently, MacKinnon (1991) has implemented a much larger set of simulations than those tabulated by Dickey and Fuller. In addition, MacKinnon estimates the response surface using the simulation results, permitting the calculation of Dickey-Fuller critical values for any sample size and for any number of right-hand variables.

Equations (12) and (13) are the simplest case where the residual $\varepsilon_t$ is white noise. In general, there is serial correlation in the residual and $\Delta y_t$ can be represented as an autoregressive process:

$$\Delta y_t = \mu + \theta y_{t-1} + \sum_{t=1}^{T-1} \phi_i \ \Delta y_{t-1} + \varepsilon_t \qquad (14)$$

Corresponding to equation (14), DF's procedure becomes the Augmented Dickey-Fuller (ADF) test. We can also include a deterministic trend in equation (14). Altogether, there are four test specifications with regard to the combinations of an intercept and a deterministic trend.

| Variables on level | Dickey-Fuller t-statistic | MacKinnon Critical Values 1% critical value | 5% critical value | 10% critical value |
|---|---|---|---|---|
| NASDAQ Volatility | -2.7911 | -3.4847 | -2.8851 | -2.5792 |
| NYSE Volatility | -5.2739 | -3.472 | -2.8794 | -2.5762 |
| S&P500 Volatility | -4.8402 | -3.472 | -2.8794 | -2.5762 |
| Inflation | -3.2591 | -3.4684 | -2.8778 | -2.5754 |
| Federal Fund Rate | -9.0093 | -3.4684 | -2.8778 | -2.5754 |
| Gross domestic product | -6.2122 | -3.4684 | -2.8778 | -2.5754 |
| Industrial capacity utilization rate | -6.8170 | -3.4735 | -2.8801 | -2.5766 |
| Money Supply | -5.1555 | -3.4684 | -2.8778 | -2.5754 |
| Spread | -8.8862 | -3.4701 | -2.8786 | -2.5758 |
| T-bills | -8.6178 | -3.4684 | -2.8778 | -2.5754 |

| Variables on first difference | Dickey-Fuller t-statistic | MacKinnon Critical Values 1% critical value | 5% critical value | 10% critical value |
|---|---|---|---|---|
| NASDAQ Volatility | -3.6243 | -4.0355 | -3.4469 | -3.1482 |
| NYSE Volatility | -5.7393 | -4.0175 | -3.4384 | -3.1432 |
| S&P500 Volatility | -5.6198 | -4.0175 | -3.4384 | -3.1432 |
| Inflation | -3.2961 | -4.0125 | -3.436 | -3.1418 |
| Federal Fund Rate | -9.1911 | -4.0125 | -3.436 | -3.1418 |
| Gross domestic product | -6.5851 | -4.0125 | -3.436 | -3.1418 |
| Industrial capacity utilization rate | -6.7976 | -4.0197 | -3.4394 | -3.1438 |
| Money Supply | -5.1699 | -4.0125 | -3.436 | -3.1418 |
| Spread | -8.9400 | -4.0149 | -3.4371 | -3.1425 |
| T-bills | -8.6178 | -3.4684 | -2.8778 | -2.5754 |

## Appendix B: Tables

**Table 4.1: Summary statistics of stock returns from July 1962 to December 2004 for NYSE and S&P and from December 1972 to December 2004 for NASDAQ index.**

| | From 1962 to 2004 | | | From 1990 to 2004 | | |
|---|---|---|---|---|---|---|
| | NASDAQ | NYSE | S&P | NASDAQ | NYSE | S&P |
| Mean | 0.0005 | 0.0005 | 0.0005 | 0.0006 | 0.0005 | 0.0005 |
| Median | 0.0011 | 0.0006 | 0.0005 | 0.0013 | 0.0006 | 0.0005 |
| Maximum | 0.1427 | 0.0879 | 0.0881 | 0.1427 | 0.0531 | 0.0575 |
| Minimum | -0.1131 | -0.1835 | -0.1946 | -0.0981 | -0.0639 | -0.0679 |
| Std. Dev. | 0.0123 | 0.0087 | 0.0094 | 0.0162 | 0.0091 | 0.0103 |
| Skewness | -0.0826 | -0.9368 | -0.8231 | 0.1545 | -0.1508 | -0.0178 |
| Kurtosis | 13.6270 | 26.6943 | 24.9947 | 8.5986 | 7.3182 | 6.7623 |
| Jarque-Bera | 38071.99 | 251817.80 | 216847.30 | 4616.35 | 2751.30 | 2078.57 |
| Probability | 0 | 0 | 0 | 0 | 0 | 0 |
| Observations | 8089 | 10698 | 10698 | 3524 | 3524 | 3524 |

**Table 4.2: Summary statistics of stock markets volatilities**

| | NYSE | S&P | NASDAQ |
|---|---|---|---|
| Mean | 0.0086 | 0.0094 | 0.0101 |
| Median | 0.0078 | 0.0086 | 0.0076 |
| Maximum | 0.0336 | 0.0370 | 0.0374 |
| Minimum | 0.0039 | 0.0043 | 0.0033 |
| Std. Dev. | 0.0038 | 0.0042 | 0.0070 |
| Skewness | 2.9178 | 2.8613 | 2.0366 |
| Kurtosis | 18.1423 | 17.5285 | 7.1203 |
| Jarque-Bera | 1327.692 | 1229.288 | 169.2402 |
| Probability | 0.000 | 0.000 | 0.000 |
| Autocorrelation function | | | |
| 1 | 0.48(0.0) | 0.528(0.0) | 0.75(0.0) |
| 2 | 0.376(0.0) | 0.442(0.0) | 0.697(0.0) |
| 3 | 0.282(0.0) | 0.355(0.0) | 0.676(0.0) |
| 4 | 0.209(0.0) | 0.281(0.0) | 0.603(0.0) |
| 5 | 0.219(0.0) | 0.289(0.0) | 0.579(0.0) |
| 12 | 0.051(0.0) | 0.108(0.0) | 0.263(0.0) |
| 18 | 0.037(0.0) | 0.052(0.0) | 0.109(0.0) |
| Ljung-Box | | | |
| 1 | 38.309(0.0) | 46.298(0.0) | 71.446(0.0) |
| 2 | 61.906(0.0) | 78.958(0.0) | 133.74(0.0) |
| 3 | 75.28(0.0) | 100.17(0.0) | 192.77(0.0) |
| 4 | 82.659(0.0) | 113.56(0.0) | 240.1(0.0) |
| 5 | 90.838(0.0) | 127.77(0.0) | 284.13(0.0) |
| 12 | 99.135(0.0) | 156.72(0.0) | 458.32(0.0) |
| 18 | 103.27(0.0) | 163.94(0.0) | 483.26(0.0) |
| Observations | 121 | 121 | 121 |

**Table 5.1: Models selection for 1962-2001 period**

AR(p) is the order of autoregressive process and L(k) is the order of lagged exogenous variables.

Model selection from regression of NYSE standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -8.7212 | -8.7277 | -8.7581 | -8.7496 | -8.7324 | -8.7356 | -8.9027 |
| Schwarz | -8.5452 | -8.5314 | -8.5411 | -8.5119 | -8.3759 | -8.2382 | -8.2633 |

Model selection from regression of S&P500 standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -8.5383 | -8.5622 | -8.6006 | -8.5917 | -8.5764 | -8.5848 | -8.7421 |
| Schwarz | -8.3623 | -8.3658 | -8.3836 | -8.3540 | -8.2199 | -8.0875 | -8.1027 |

Model selection from regression of NASDAQ standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -7.8122 | -7.8926 | -7.9650 | -7.9388 | -7.8967 | -7.8786 | -7.9346 |
| Schwarz | -7.5962 | -7.6513 | -7.6980 | -7.6459 | -7.4598 | -7.2718 | -7.1579 |

**Table 5.2: Regressions summary for NYSE, S&P500, and NASDAQ volatility.**

Estimated equation is: $\sigma_t = \theta_0 + \theta_1 GDP_{t-1} + \theta_2 CPI_{t-1} + \theta_3 ICUR_{t-1} + \theta_4 MS_{t-1} + \theta_5 FFR_{t-1} + \theta_6 TB_{t-1} + \theta_7 Spread_{t-1} + \varphi_1 \sigma_{t-1} + \varphi_2 \sigma_{t-2} + \varphi_3 \sigma_{t-3} + \eta_t$. *All exogenous variables are in growth rates.* Estimation period for volatility of NYSE and S&P500 market index is from 1963:2 to 2001:3. For technology sector, estimation period is from 1973:4 to 2001:3. P-values are between brackets. * Parameter estimates are significantly different from zero at 5% significance level. ** Parameter estimates are significantly different from zero at 10% significance level.

| *Dependent variable* | *NYSE Volatility* | *S&P500 Volatility* | *NASDAQ Volatility* |
|---|---|---|---|
| Intercept | 0.0068 | 0.0073 | 0.0184 |
| | [0.000] | [0.000] | [0.4994] |
| Gross domestic product | -0.0572 | -0.0594 | 0.0931 |
| | [0.0546]* | [0.0625]** | [0.0649]** |
| Inflation | 0.1204 | 0.1262 | 0.0720 |
| | [0.0148]* | [0.022]* | [0.3816] |
| Industrial capacity | -0.0436 | -0.0454 | -0.0181 |
| | [0.0209]* | [0.0239]* | [0.5335] |
| Money Supply | 0.0529 | 0.0599 | -0.0381 |
| | [0.0496]* | [0.0415]* | [0.3653] |
| Federal Fund Rate | 0.0070 | 0.0076 | 0.0026 |
| | [0.0061]* | [0.0053]* | [0.5182] |
| Treasury Bills | -0.0031 | -0.0032 | -0.0024 |
| | [0.233] | [0.2405] | [0.5642] |
| Interest rate spread | 0.0000 | 0.0000 | -0.0002 |
| | [0.8529] | [0.9022] | [0.2216] |
| AR(1) | 0.3403 | 0.3636 | 0.3987 |
| | [0.0001] | [0.000] | [0.0001] |
| AR(2) | 0.0923 | 0.1259 | 0.1978 |
| | [0.3025] | [0.1628] | [0.0576] |
| AR(3) | 0.2209 | 0.2424 | 0.3698 |
| | [0.0099] | [0.0046] | [0.0005] |
| R squared | 0.3504 | 0.3944 | 0.6298 |
| Number of observations | 154 | 154 | 112 |

| Wald test | $H_0: \theta_1=\theta_2=\theta_3=\theta_4=\theta_5=\theta_6=\theta_7=0$, | | |
|---|---|---|---|
| F-statistic | 3.5035 | 3.3708 | 1.1212 |
| Probability | 0.0017 | 0.0023 | 0.3558 |
| Chi-square | 24.5246 | 23.5954 | 7.8481 |
| Probability | 0.0009 | 0.0013 | 0.3462 |

| Wald test | $H_0: \theta_1=\theta_2=\theta_3=0$, | | |
|---|---|---|---|
| F-statistic | 5.5863 | 5.1426 | 1.6105 |
| Probability | 0.0012 | 0.0021 | 0.1916 |
| Chi-square | 16.7588 | 15.4279 | 4.8316 |
| Probability | 0.0008 | 0.0015 | 0.1846 |

| Wald test | $H_0$: $\theta_4=\theta_5=\theta_6=\theta_7=0$, | | |
|---|---|---|---|
| F-statistic | 2.3883 | 2.5096 | 0.7497 |
| Probability | 0.0538 | 0.0445 | 0.5605 |
| Chi-square | 9.5531 | 10.0385 | 2.9989 |
| Probability | 0.0487 | 0.0398 | 0.5580 |

**Table 5.3: Regressions summary for NYSE volatility.**

Estimated equation is:

$\sigma_t = \theta_0 + \theta_1\ GDP_{t-1} + \theta_2\ CPI_{t-1} + \theta_3\ ICUR_{t-1} + \theta_4\ MS_{t-1} + \theta_5\ FFR_{t-1} + \theta_6\ TB_{t-1} + \theta_7\ Spread_{t-1} + \varphi_1\ \sigma_{t-1} + \varphi_2\ \sigma_{t-2} + \varphi_3\ \sigma_{t-3} + \eta_t$. *All exogenous variables are in growth rates.* P-values are between brackets. * Parameter estimates are significantly different from zero at 5% significance level. ** Parameter estimates are significantly different from zero at 10% significance level.

| *Dependent variable* | *NYSE Volatility* | | |
|---|---|---|---|
| *Sample* | 1963:2-2002:1 | 1963:2-1983:1 | 1983:2-2002:1 |
| Intercept | 0.0068 | 0.0061 | 0.0084 |
| | [0.000] | [0.000] | [0.0001] |
| Gross domestic product | -0.0572 | -0.0306 | -0.1161 |
| | [0.0546]* | [0.2347] | [0.171] |
| Inflation | 0.1204 | 0.1434 | 0.0629 |
| | [0.0148]* | [0.0003]* | [0.6] |
| Industrial capacity | -0.0436 | -0.0399 | -0.0395 |
| | [0.0209]* | [0.0421]* | [0.3067] |
| Money Supply | 0.0529 | -0.0240 | 0.1285 |
| | [0.0496]* | [0.4364] | [0.0052]* |
| Federal Fund Rate | 0.0070 | 0.0029 | 0.0144 |
| | [0.0061]* | [0.2594] | [0.0136]* |
| Treasury Bills | -0.0031 | -0.0027 | -0.0001 |
| | [0.233] | [0.2538] | [0.9791] |
| Interest rate spread | 0.0000 | 0.0000 | 0.0000 |
| | [0.8529] | [0.5099] | [0.8701] |
| AR(1) | 0.3403 | 0.3618 | 0.4152 |
| | [0.0001] | [0.009] | [0.0028] |
| AR(2) | 0.0923 | -0.0248 | 0.0939 |
| | [0.3025] | [0.8564] | [0.5077] |
| AR(3) | 0.2209 | 0.0971 | 0.2007 |
| | [0.0099] | [0.4783] | [0.1174] |
| R squared | 0.3504 | 0.5468 | 0.3273 |
| Number of observations | 154 | 80 | 74 |

| Wald test | $H_0$: $\theta_1=\theta_2=\theta_3=\theta_4=\theta_5=\theta_6=\theta_7=0$, | | |
|---|---|---|---|
| F-statistic | 3.5035 | 4.0395 | 2.5653 |
| Probability | 0.0017 | 0.0009 | 0.0217 |
| Chi-square | 24.5246 | 28.2764 | 17.9573 |
| Probability | 0.0009 | 0.0002 | 0.0122 |

| Wald test | $H_0$: $\theta_1=\theta_2=\theta_3=0$, | | |
|---|---|---|---|
| F-statistic | 5.5863 | 7.1660 | 1.3217 |
| Probability | 0.0012 | 0.0003 | 0.2752 |
| Chi-square | 16.7588 | 21.4979 | 3.9651 |
| Probability | 0.0008 | 0.0001 | 0.2653 |

| Wald test | $H_0$: $\theta_4=\theta_5=\theta_6=\theta_7=0$, | | |
|---|---|---|---|
| F-statistic | 2.3883 | 1.0811 | 3.4715 |
| Probability | 0.0538 | 0.3727 | 0.0126 |
| Chi-square | 9.5531 | 4.3246 | 13.8861 |
| Probability | 0.0487 | 0.3639 | 0.0077 |

**Table 5.4: Regressions summary for S&P500 volatility.**

Estimated equation is:

$\sigma_t = \theta_0 + \theta_1\ GDP_{t-1} + \theta_2\ CPI_{t-1} + \theta_3\ ICUR_{t-1} + \theta_4\ MS_{t-1} + \theta_5\ FFR_{t-1} + \theta_6\ TB_{t-1} + \theta_7\ Spread_{t-1} + \varphi_1\ \sigma_{t-1} + \varphi_2\ \sigma_{t-2} + \varphi_3\ \sigma_{t-3} + \eta_t$. *All exogenous variables are in growth rates.* P-values are between brackets. * Parameter estimates are significantly different from zero at 5% significance level. ** Parameter estimates are significantly different from zero at 10% significance level.

| *Dependent variable* | *S&P500 Volatility* | | |
|---|---|---|---|
| *Sample* | 1963:2-2002:1 | 1963:2-1983:1 | 1983:2-2002:1 |
| Intercept | 0.0073 | 0.0065 | 0.0093 |
| | [0.000] | [0] | [0.0004] |
| Gross domestic product | -0.0594 | -0.0294 | -0.1270 |
| | [0.0625]* | [0.2419] | [0.1752] |
| Inflation | 0.1262 | 0.1273 | 0.0997 |
| | [0.022]* | [0.0021]* | [0.4536] |
| Industrial capacity | -0.0454 | -0.0399 | -0.0402 |
| | [0.0239]* | [0.0403]* | [0.3387] |
| Money Supply | 0.0599 | -0.0277 | 0.1419 |
| | [0.0415]* | [0.3593] | [0.0056]** |
| Federal Fund Rate | 0.0076 | 0.0033 | 0.0152 |
| | [0.0053]* | [0.1972] | [0.0186]* |
| Treasury Bills | -0.0032 | -0.0028 | -0.0002 |
| | [0.2405] | [0.2153] | [0.9801] |
| Interest rate spread | 0.0000 | -0.0001 | 0.0001 |
| | [0.9022] | [0.4093] | [0.8422] |
| AR(1) | 0.3636 | 0.4197 | 0.4095 |
| | [0.000] | [0.0026] | [0.0031] |
| AR(2) | 0.1259 | -0.0001 | 0.1233 |
| | [0.1628] | [0.9995] | [0.3826] |
| AR(3) | 0.2424 | 0.1114 | 0.2237 |
| | [0.0046] | [0.4133] | [0.0815] |
| R squared | 0.3944 | 0.5656 | 0.3633 |
| Number of observations | 154 | 80 | 74 |

| Wald test | $H_0$: $\theta_1=\theta_2=\theta_3=\theta_4=\theta_5=\theta_6=\theta_7=0$, | | |
|---|---|---|---|
| F-statistic | 3.3708 | 3.6735 | 2.5406 |
| Probability | 0.0023 | 0.0020 | 0.0228 |
| Chi-square | 23.5954 | 25.7144 | 17.7839 |
| Probability | 0.0013 | 0.0006 | 0.0130 |

| Wald test | $H_0$: $\theta_1=\theta_2=\theta_3=0$, | | |
|---|---|---|---|
| F-statistic | 5.1426 | 5.6434 | 1.3441 |
| Probability | 0.0021 | 0.0016 | 0.2681 |
| Chi-square | 15.4279 | 16.9301 | 4.0324 |
| Probability | 0.0015 | 0.0007 | 0.2580 |

| Wald test | $H_0$: $\theta_4=\theta_5=\theta_6=\theta_7=0$, | | |
|---|---|---|---|
| F-statistic | 2.5096 | 1.4093 | 3.3139 |
| Probability | 0.0445 | 0.2401 | 0.0158 |
| Chi-square | 10.0385 | 5.6371 | 13.2554 |
| Probability | 0.0398 | 0.2279 | 0.0101 |

**Table 5.5: Regressions summary for NASDAQ volatility.**

Estimated equation is: $\sigma_t = \theta_0 + \theta_1\, GDP_{t-1} + \theta_2\, CPI_{t-1} + \theta_3\, ICUR_{t-1} + \theta_4\, MS_{t-1} + \theta_5\, FFR_{t-1} + \theta_6\, TB_{t-1} + \theta_7\, Spread_{t-1} + \varphi_1\, \sigma_{t-1} + \varphi_2\, \sigma_{t-2} + \varphi_3\, \sigma_{t-3} + \eta_t$. *All exogenous variables are in growth rates*. P-values are between brackets. * Parameter estimates are significantly different from zero at 5% significance level. ** Parameter estimates are significantly different from zero at 10% significance level.

| *Dependent variable* | *NASDAQ Volatility* | | |
|---|---|---|---|
| *Sample* | 1963:2-2002:1 | 1963:2-1983:1 | 1983:2-2002:1 |
| Intercept | 0.0184 | 0.0035 | 0.0241 |
| | [0.4994] | [0.0404] | [0.6397] |
| Gross domestic product | 0.0931 | 0.0389 | 0.1848 |
| | [0.0649]* | [0.2472] | [0.1097] |
| Inflation | 0.0720 | 0.1055 | 0.0754 |
| | [0.3816] | [0.053]* | [0.6494] |
| Industrial capacity | -0.0181 | -0.0553 | -0.0150 |
| | [0.5335] | [0.0341]* | [0.7598] |
| Money Supply | -0.0381 | 0.0218 | -0.0592 |
| | [0.3653] | [0.5949] | [0.3326] |
| Federal Fund Rate | 0.0026 | 0.0062 | -0.0036 |
| | [0.5182] | [0.054]* | [0.6474] |
| Treasury Bills | -0.0024 | -0.0048 | -0.0019 |
| | [0.5642] | [0.082]** | [0.8205] |
| Interest rate spread | -0.0002 | 0.0000 | -0.0003 |
| | [0.2216] | [0.8254] | [0.3517] |
| AR(1) | 0.3987 | 0.5012 | 0.3892 |
| | [0.0001] | [0.0141] | [0.0041] |
| AR(2) | 0.1978 | -0.3563 | 0.1575 |
| | [0.0576] | [0.1309] | [0.2482] |
| AR(3) | 0.3698 | 0.4157 | 0.4199 |
| | [0.0005] | [0.0433] | [0.0018] |
| R squared | 0.6298 | 0.5302 | 0.6366 |
| Number of observations | 112 | 38 | 74 |

| <u>Wald test</u> | $H_0$: $\theta_1=\theta_2=\theta_3=\theta_4=\theta_5=\theta_6=\theta_7=0$, | | |
|---|---|---|---|
| F-statistic | 1.1212 | 3.2704 | 0.8230 |
| Probability | 0.3558 | 0.0120 | 0.5719 |
| Chi-square | 7.8481 | 22.8926 | 5.7612 |
| Probability | 0.3462 | 0.0018 | 0.5679 |

| <u>Wald test</u> | $H_0$: $\theta_1=\theta_2=\theta_3=0$, | | |
|---|---|---|---|
| F-statistic | 1.6105 | 4.7241 | 1.0287 |
| Probability | 0.1916 | 0.0089 | 0.3860 |
| Chi-square | 4.8316 | 14.1724 | 3.0860 |
| Probability | 0.1846 | 0.0027 | 0.3786 |

| Wald test | $H_0: \theta_4=\theta_5=\theta_6=\theta_7=0,$ | | |
|---|---|---|---|
| F-statistic | 0.7497 | 1.3530 | 0.5916 |
| Probability | 0.5605 | 0.2763 | 0.6699 |
| Chi-square | 2.9989 | 5.4121 | 2.3665 |
| Probability | 0.5580 | 0.2476 | 0.6687 |

**Table 5.6: The effect of monetary policy: Regression summary from volatility of NYSE stock returns.**
Estimated equation is:

$\sigma_t = \theta_0 + \theta_1 \, GDP_{t-1} + \theta_2 \, CPI_{t-1} + \theta_3 \, ICUR_{t-1} + \theta_4 \, MS_{t-1} + \theta_5 \, FFR_{t-1} + \theta_6 \, TB_{t-1} + \theta_7 \, Spread_{t-1} + \varphi_1 \, \sigma_{t-1} + \varphi_2 \, \sigma_{t-2} + \varphi_3 \, \sigma_{t-3} + \varphi_4 \, \sigma_{t-4} + \eta_t$. *All exogenous variables are in growth rates*. P-values are between brackets. * Parameter estimates are significantly different from zero at 5% significance level. ** Parameter estimates are significantly different from zero at 10% significance level.

| *Dependent variable* | *NYSE Volatility* | | |
|---|---|---|---|
| *Sample* | 1963:2-2002:1 | 1963:2-1983:1 | 1983:2-2002:1 |
| Intercept | 0.0075 | 0.0085 | 0.0078 |
| | [0] | [0] | [0.0022] |
| Money Supply | 0.0544 | -0.0557 | 0.1492 |
| | [0.053]* | [0.0575]* | [0.0014]* |
| Federal Fund Rate | 0.0070 | 0.0020 | 0.0137 |
| | [0.0036]* | [0.3652] | [0.0069]* |
| Treasury Bills | -0.0062 | -0.0031 | -0.0064 |
| | [0.0144]* | [0.1608] | [0.1884] |
| Interest rate spread | 0.0000 | -0.0001 | 0.0002 |
| | [0.8223] | [0.0977]** | [0.3489] |
| AR(1) | 0.4217 | 0.5582 | 0.4729 |
| | [0] | [0] | [0.0005] |
| AR(2) | 0.1395 | 0.0728 | 0.1505 |
| | [0.13] | [0.6007] | [0.2819] |
| AR(3) | 0.0758 | -0.0436 | 0.0483 |
| | [0.4139] | [0.7586] | [0.7235] |
| AR(4) | 0.0576 | 0.1811 | 0.1399 |
| | [0.5014] | [0.1502] | [0.2798] |
| R squared | 0.3066 | 0.4770 | 0.3165 |
| Number of observations | 155 | 79 | 76 |

| <u>Wald test</u> | $H_0$: $\theta_2=\theta_3=\theta_4=\theta_5=0$, | | |
|---|---|---|---|
| F-statistic | 2.5340 | 2.7745 | 4.1058 |
| Probability | 0.0427 | 0.0336 | 0.0049 |
| Chi-square | 10.1360 | 11.0979 | 16.4234 |
| Probability | 0.0382 | 0.0255 | 0.0025 |

**Table 5.7: The effect of monetary policy: Regression summary from volatility of S&P500 stock returns.**

Estimated equation is:

$\sigma_t = \theta_0 + \theta_1\, GDP_{t-1} + \theta_2\, CPI_{t-1} + \theta_3\, ICUR_{t-1} + \theta_4\, MS_{t-1} + \theta_5 FFR_{t-1} + \theta_6\, TB_{t-1} + \theta_7 Spread_{t-1} + \varphi_1\, \sigma_{t-1} + \varphi_2\, \sigma_{t-2} + \eta_t.$

*All exogenous variables are in growth rates.* P-values are between brackets. * Parameter estimates are significantly different from zero at 5% significance level. ** Parameter estimates are significantly different from zero at 10% significance level.

| *Dependent variable S&P500 volatility* | | | |
|---|---|---|---|
| Sample period | 1963:3-2002:1 | 1963:3-1983:1 | 1983:2-2002:1 |
| Exogenous variables | coefficient | coefficient | coefficient |
| Intercept | 0.0079 | 0.0081 | 0.0087 |
| | 0.0000 | 0.0000 | 0.0001 |
| Money supply | 0.0554 | -0.0507 | 0.1555 |
| | 0.0640** | 0.0728** | 0.0029* |
| Federal Fund Rate | 0.0076 | 0.0027 | 0.0155 |
| | 0.0022* | 0.1729 | 0.0049* |
| Risk free | -0.0065 | -0.0033 | -0.0068 |
| | 0.0147* | 0.1087 | 0.1976 |
| Interest rate spread | 0.0000 | -0.0001 | 0.0002 |
| | 0.7447 | 0.0446* | 0.4750 |
| AR(1) | 0.4710 | 0.6857 | 0.5204 |
| | 0.0000 | 0.0000 | 0.0001 |
| AR(2) | 0.2209 | | 0.2440 |
| | 0.0084 | | 0.0534 |
| R squared | 0.3532 | 0.4777 | 0.3393 |
| Observations | 157 | 82 | 76 |

| Wald test | $H_0$: $\theta_2=\theta_3=\theta_4=\theta_5=\theta 6=0$ | | |
|---|---|---|---|
| F-statistic | 2.6193 | 2.8447 | 3.7536 |
| Probability | 0.0373 | 0.0299 | 0.0080 |
| Chi-square | 10.4770 | 11.3788 | 15.0143 |
| Probability | 0.0331 | 0.0226 | 0.0047 |

**Table 5.8: The effect of monetary policy: Regression summary from volatility of NASDAQ stock returns.**

Estimated equation is:

$\sigma_t = \theta_0 + \theta_4 MS_{t-1} + \theta_5 FFR_{t-1} + \theta_6 TB_{t-1} + \theta_7 Spread_{t-1} + \varphi_1 \sigma_{t-1} + \varphi_2 \sigma_{t-2} + \varphi_3 \sigma_{t-3} + \eta_t.$

*All exogenous variables are in growth rates.* P-values are between brackets. * Parameter estimates are significantly different from zero at 5% significance level. ** Parameter estimates are significantly different from zero at 10% significance level.

| *Dependent variable* | *NASDAQ Volatility* | | |
|---|---|---|---|
| *Sample* | 1963:2-2002:1 | 1963:2-1983:1 | 1983:2-2002:1 |
| Intercept | 0.0118 | 0.0072 | 0.0136 |
| | [0.0023] | [0] | [0.0121] |
| Money Supply | -0.0230 | 0.0151 | -0.0366 |
| | [0.5797] | [0.7392] | [0.5507] |
| Federal Fund Rate | 0.0044 | 0.0062 | 0.0001 |
| | [0.2258] | [0.0712]** | [0.9847] |
| Treasury Bills | -0.0025 | -0.0062 | 0.0003 |
| | [0.5248] | [0.0658]** | [0.9658] |
| Interest rate spread | -0.0001 | -0.0001 | -0.0005 |
| | [0.3241] | [0.5968] | [0.2084] |
| AR(1) | 0.3915 | 0.4721 | 0.3800 |
| | [0.0001] | [0.0161] | [0.003] |
| AR(2) | 0.2378 | -0.0509 | 0.2006 |
| | [0.0201] | [0.824] | [0.1239] |
| AR(3) | 0.2549 | 0.2182 | 0.2988 |
| | [0.0094] | [0.2535] | [0.0149] |
| R squared | 0.6163 | 0.3342 | 0.6177 |
| Number of observations | 114 | 38 | 76 |

| Wald test | $H_0$: $\theta_2=\theta_3=\theta_4=\theta_5=0$, | | |
|---|---|---|---|
| F-statistic | 0.7425 | 1.2447 | 0.5662 |
| Probability | 0.5651 | 0.3133 | 0.6880 |
| Chi-square | 2.9698 | 4.9787 | 2.2649 |
| Probability | 0.5629 | 0.2895 | 0.6872 |

**Table 5.9: The effect of economy changes: Regression summary from volatility of NYSE stock returns.**
Estimated equation is:

$$\sigma_t = \theta_0 + \theta_1\, GDP_{t-1} + \theta_2\, CPI_{t-1} + \theta_3\, ICUR_{t-1} + \varphi_1\, \sigma_{t-1} + \varphi_2\, \sigma_{t-2} + \varphi_3\, \sigma_{t-3} + \varphi_4\, \sigma_{t-4} + \eta_t.$$

*All exogenous variables are in growth rates.* P-values are between brackets. * Parameter estimates are significantly different from zero at 5% significance level. ** Parameter estimates are significantly different from zero at 10% significance level.

| *Dependent variable* | *NYSE Volatility* | | |
|---|---|---|---|
| *Sample* | 1963:2-2002:1 | 1963:2-1983:1 | 1983:2-2002:1 |
| Intercept | 0.0070 | 0.0056 | 0.0081 |
| | [0] | [0] | [0] |
| Gross domestic product | -0.0451 | -0.0325 | -0.1006 |
| | [0.1245] | [0.1895] | [0.2411] |
| Inflation | 0.1440 | 0.1595 | 0.2099 |
| | [0.0025]* | [0]* | [0.0845]** |
| Industrial capacity | -0.0267 | -0.0360 | -0.0158 |
| | [0.1288] | [0.0341]* | [0.6815] |
| AR(1) | 0.2892 | 0.3023 | 0.2471 |
| | [0.0007] | [0.0187] | [0.0572] |
| AR(2) | 0.1253 | -0.0084 | 0.1703 |
| | [0.1466] | [0.9477] | [0.1708] |
| AR(3) | 0.1973 | 0.0946 | 0.2460 |
| | [0.0217] | [0.453] | [0.0503] |
| AR(4) | -0.0077 | 0.0622 | -0.0961 |
| | [0.9269] | [0.6075] | [0.4416] |
| R squared | 0.3065 | 0.5167 | 0.1993 |
| Number of observations | 153 | 79 | 74 |

| Wald test | $H_0: \theta_1=\theta_2=\theta_3=0$, | | |
|---|---|---|---|
| F-statistic | 4.6839 | 8.3554 | 1.4575 |
| Probability | 0.0037 | 0.0001 | 0.2342 |
| Chi-square | 14.0518 | 25.0662 | 4.3724 |
| Probability | 0.0028 | 0.0000 | 0.2240 |

**Table 5.10: The effect of economy changes: Regression summary from volatility of S&P500 stock returns.**

Estimated equation is:

$\sigma_t = \theta_0 + \theta_1\, GDP_{t-1} + \theta_2\, CPI_{t-1} + \theta_3\, ICUR_{t-1} + \varphi_1\, \sigma_{t-1} + \varphi_2\, \sigma_{t-2} + \varphi_3\, \sigma_{t-3} + \varphi_4\, \sigma_{t-4} + \eta_t.$

*All exogenous variables are in growth rates.* P-values are between brackets. * Parameter estimates are significantly different from zero at 5% significance level. ** Parameter estimates are significantly different from zero at 10% significance level.

| *Dependent variable* | *S&P500 Volatility* | | |
|---|---|---|---|
| *Sample* | 1963:2-2002:1 | 1963:2-1983:1 | 1983:2-2002:1 |
| Intercept | 0.0077 | 0.0059 | 0.0091 |
| | [0] | [0] | [0] |
| Gross domestic product | -0.0462 | -0.0324 | -0.1099 |
| | [0.1428] | [0.1876] | [0.2464] |
| Inflation | 0.1504 | 0.1538 | 0.2498 |
| | [0.0047]* | [0.0001]* | [0.0626]** |
| Industrial capacity | -0.0272 | -0.0368 | -0.0175 |
| | [0.1467] | [0.0316]* | [0.6755] |
| AR(1) | 0.3093 | 0.3363 | 0.2587 |
| | [0.0003] | [0.0094] | [0.0479] |
| AR(2) | 0.1606 | 0.0067 | 0.1897 |
| | [0.0646] | [0.9585] | [0.1278] |
| AR(3) | 0.2180 | 0.1051 | 0.2668 |
| | [0.0117] | [0.4103] | [0.0336] |
| AR(4) | 0.0037 | 0.0542 | -0.0911 |
| | [0.9643] | [0.6574] | [0.4697] |
| R squared | 0.3514 | 0.5295 | 0.2452 |
| Number of observations | 153 | 79 | 74 |
| Wald test | $H_0: \theta_2=\theta_3=\theta_4=0,$ | | |
| F-statistic | 4.1534 | 7.5588 | 1.6161 |
| Probability | 0.0074 | 0.0002 | 0.1940 |
| Chi-square | 12.4603 | 22.6763 | 4.8484 |
| Probability | 0.0060 | 0.0000 | 0.1832 |

**Table 5.11: The effect of economy changes: Regression summary from volatility of NASDAQ stock returns.**

Estimated equation is:

$\sigma_t = \theta_0 + \theta_1 \, GDP_{t-1} + \theta_2 \, CPI_{t-1} + \theta_3 \, ICUR_{t-1} + \varphi_1 \, \sigma_{t-1} + \varphi_2 \, \sigma_{t-2} + \varphi_3 \, \sigma_{t-3} + \varphi_4 \, \sigma_{t-4} + \eta_t$. *All exogenous variables are in growth rates.* P-values are between brackets. * Parameter estimates are significantly different from zero at 5% significance level. ** Parameter estimates are significantly different from zero at 10% significance level.

| *Dependent variable* | *NASDAQ Volatility* | | |
|---|---|---|---|
| *Sample* | 1963:2-2002:1 | 1963:2-1983:1 | 1983:2-2002:1 |
| Intercept | 0.0263 | 0.0037 | 0.0206 |
| | [0.7472] | [0.0161] | [0.6014] |
| Gross domestic product | 0.0704 | 0.0430 | 0.1979 |
| | [0.1518] | [0.1818] | [0.0861]** |
| Inflation | 0.0985 | 0.1035 | 0.0520 |
| | [0.221] | [0.0562]* | [0.7328] |
| Industrial capacity | -0.0180 | -0.0417 | -0.0176 |
| | [0.486] | [0.0361]* | [0.7069] |
| AR(1) | 0.4106 | 0.3817 | 0.4592 |
| | [0.0001] | [0.0444] | [0.0009] |
| AR(2) | 0.1787 | -0.2658 | 0.1671 |
| | [0.0903] | [0.2086] | [0.2126] |
| AR(3) | 0.3078 | 0.2115 | 0.3264 |
| | [0.0046] | [0.3004] | [0.0183] |
| AR(4) | 0.0832 | 0.2087 | 0.0078 |
| | [0.4765] | [0.27] | [0.9576] |
| R squared | 0.6213 | 0.4524 | 0.6253 |
| Number of observations | 111 | 37 | 74 |

| Wald test | $H_0: \theta_1=\theta_2=\theta_3=0$, | | |
|---|---|---|---|
| F-statistic | 1.3255 | 3.5144 | 1.1179 |
| Probability | 0.2702 | 0.0275 | 0.3482 |
| Chi-square | 3.9766 | 10.5433 | 3.3536 |
| Probability | 0.2640 | 0.0145 | 0.3403 |

**Table 6.1: The effect of expected economy changes on stock returns volatility.**

EGDP, EIP and EUNEMP are respectively expected growth rates in gross domestic product, industrial production and unemployment rate. P-values are between brackets. * Parameter estimates are significantly different from zero at 5% significance level. ** Parameter estimates are significantly different from zero at 10% significance level. The estimation period is from 1970:1 to 2003:4.

| Dependent variable | NYSE | S&P | NASDAQ |
|---|---|---|---|
| | coefficient | coefficient | coefficient |
| Intercept | 0.0089 | 0.0109 | 0.0107 |
| | [0.0000] | [0.0000] | [0.0505] |
| EGDP(-1) | 0.1412 | 0.0933 | 0.2971 |
| | [0.3801] | [0.5876] | [0.2249] |
| EIP(-1) | -0.0165 | 0.0013 | -0.0236 |
| | [0.8007] | [0.9849] | [0.8259] |
| EUNEMP(-1) | 0.0218 | 0.0237 | 0.0075 |
| | [0.3122] | [0.3190] | [0.8136] |
| EGDP(-2) | 0.1123 | 0.1079 | -0.0009 |
| | [0.4744] | [0.5404] | [0.9971] |
| EIP(-2) | 0.0084 | 0.0203 | 0.0756 |
| | [0.9001] | [0.7840] | [0.4984] |
| EUNEMP(-2) | 0.0384 | 0.0334 | 0.0454 |
| | [0.0679**] | [0.1626] | [0.1745] |
| EGDP(-3) | -0.3637 | -0.3999 | -0.4250 |
| | [0.0245*] | [0.0211*] | [0.0817**] |
| EIP(-3) | 0.1214 | 0.1272 | 0.1617 |
| | [0.0871*] | [0.1037] | [0.1537] |
| EUNEMP(-3) | 0.0014 | 0.0046 | -0.0105 |
| | [0.9423] | [0.8321] | [0.7320] |
| AR(1) | 0.3391 | 0.3228 | 0.4720 |
| | [0.0001] | [0.0005] | [0.0000] |
| AR(2) | | 0.1250 | 0.1551 |
| | | [0.1676] | [0.1422] |
| AR(3) | | | 0.2237 |
| | | | [0.0233] |
| R squared | 0.2559 | 0.3005 | 0.6426 |
| Observations | 137 | 136 | 121 |
| | | | |
| Wald test | F-statistic | F-statistic | F-statistic |
| | 1.5553 | 1.2853 | 0.6279 |
| p-value | 0.1359 | 0.2514 | 0.7710 |

## Appendix C: Figures

**Figure 4.1: Stock returns from July 1962 to December 2004 for NYSE and S&P and from December 1972 to December 2004 for NASDAQ index.**

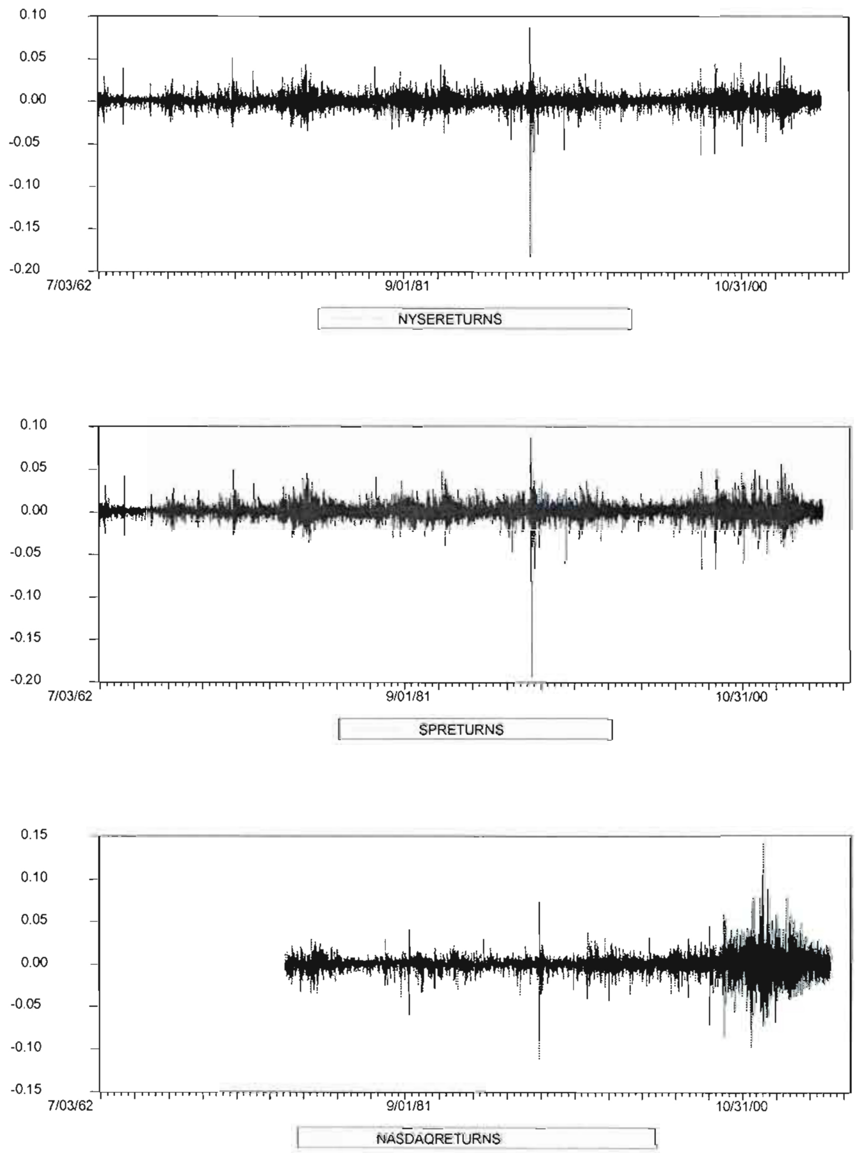


**Figure 4.2: Quantile plot of stock market returns post 1990**

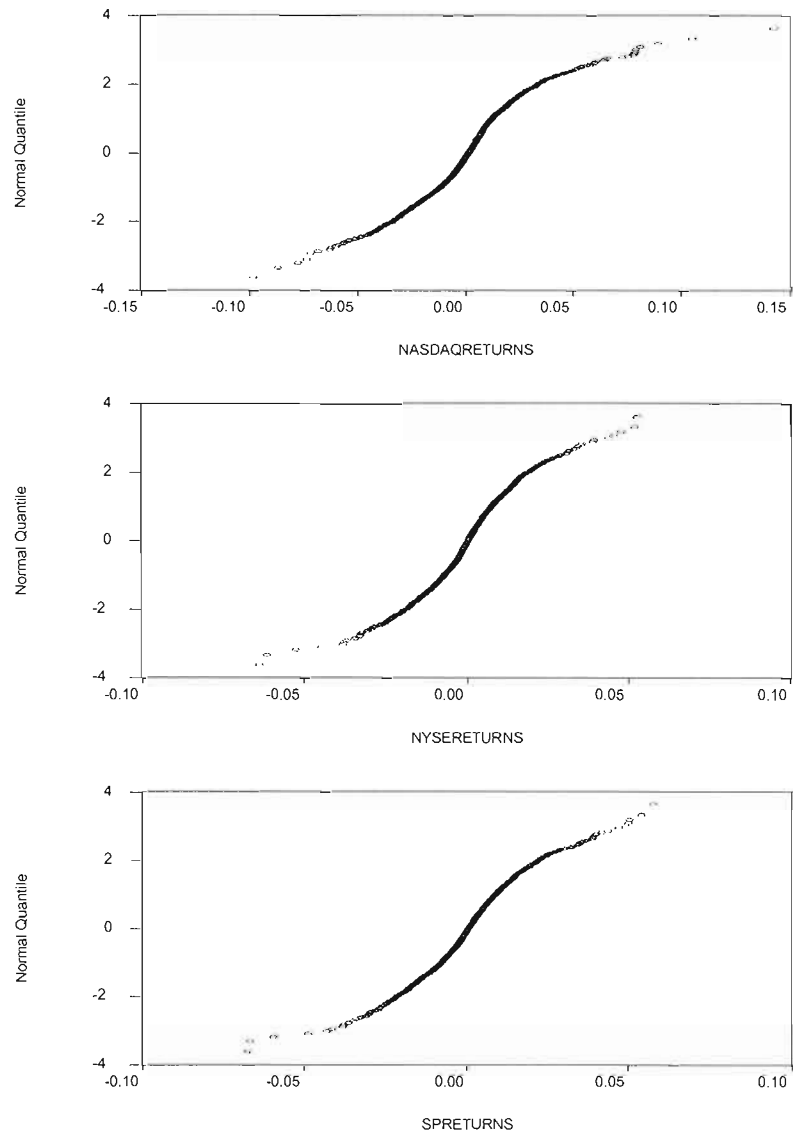


**Figure 4.3: Volatility of stock markets indices**

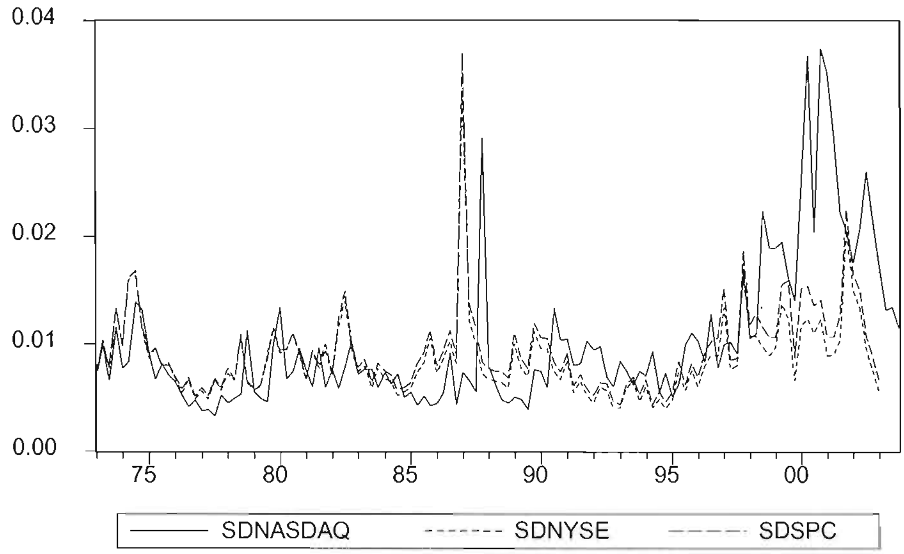
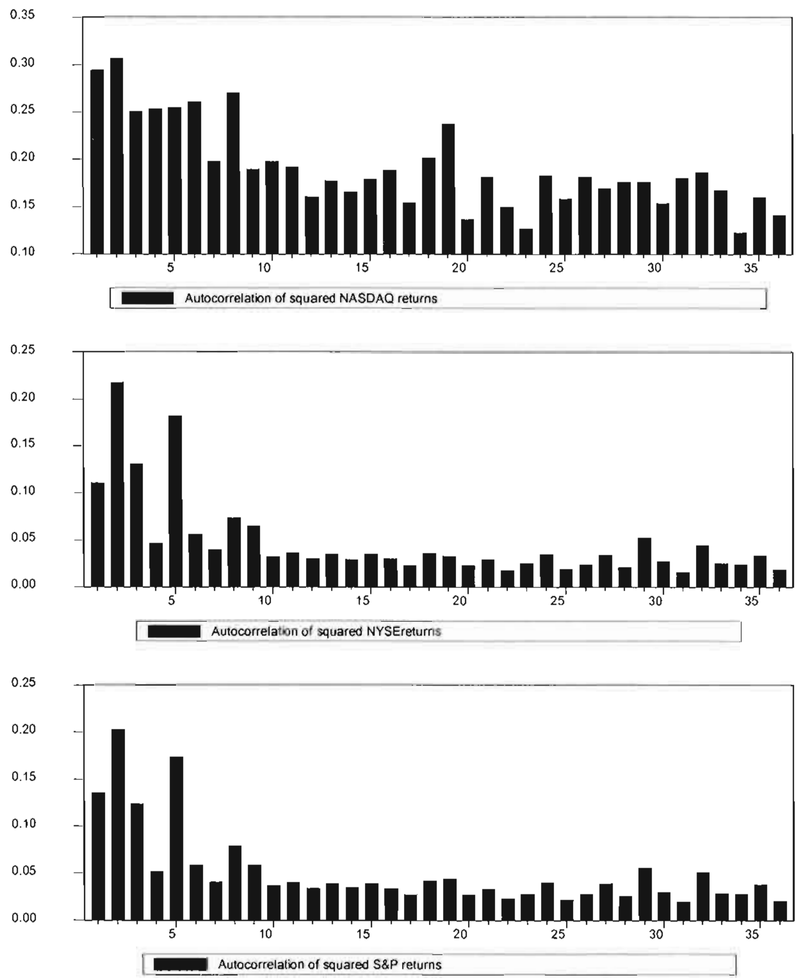


**Figure 4.4: Autocorrelation Functions of Squared Market Returns**



## Appendix D: Model Selection

### D.1: The Effect of Monetary Variables on Stock Market Volatility

**Table C.1.1: The effect of monetary policy: Models selection from 1962:4 to 2001:1**

AR(p) is the order of autoregressive process and L(k) is the order of lagged exogenous variables.

Model selection from regression of NYSE standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -8.6306 | -8.6418 | -8.6377 | -8.7342 | -8.6937 | -8.7009 | -8.8553 |
| Schwarz | -8.5143 | -8.5055 | -8.4813 | -8.5757 | -8.4749 | -8.4212 | -8.5141 |

Model selection from regression of S&P500 standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -8.4713 | -8.4978 | -8.4975 | -8.4884 | -8.4794 | -8.4651 | -8.4168 |
| Schwarz | -8.3550 | -8.3615 | -8.3411 | -8.3117 | -8.2653 | -8.1731 | -8.0469 |

Model selection from regression of NASDAQ standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -7.8406 | -7.9373 | -7.9686 | -7.9444 | -7.9243 | -7.9142 | -7.9206 |
| Schwarz | -7.6982 | -7.7702 | -7.7766 | -7.7272 | -7.6362 | -7.5301 | -7.4406 |

**Table D.1.2: The effect of monetary policy: Models selection from 1962:2 to 1983:1**

AR(p) is the order of autoregressive process and L(k) is the order of lagged exogenous variables.

Model selection from regression of NYSE standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -9.2814 | -9.2573 | -9.2442 | -9.2497 | -9.2762 | -9.2321 | -9.2363 |
| Schwarz | -9.1053 | -9.0504 | -9.0060 | -8.9797 | -8.9827 | -8.8212 | -8.7080 |

Model selection from regression of S&P500 standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -9.3060 | -9.2814 | -9.2682 | -9.2679 | -9.3053 | -9.2640 | -9.2587 |
| Schwarz | -9.1299 | -9.0745 | -9.0300 | -8.9979 | -9.0118 | -8.8531 | -8.7304 |

Model selection from regression of NASDAQ standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -9.0247 | -8.9656 | -8.9281 | -8.9362 | -8.8956 | -8.7539 | -8.7105 |
| Schwarz | -8.7714 | -8.6671 | -8.5833 | -8.5444 | -8.4734 | -8.1628 | -7.9505 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Akaike | -9.0247 | -8.9656 | -8.9281 | -8.9362 | -8.8956 | -8.7539 | -8.7105 |
| Schwarz | -8.7714 | -8.6671 | -8.5833 | -8.5444 | -8.4734 | -8.1628 | -7.9505 |

**Table D.1.3: The effect of monetary policy: Models selection from 1983:2 to 2002:4**

AR(p) is the order of autoregressive process and L(k) is the order of lagged exogenous variables.

Model selection from regression of NYSE standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -8.2631 | -8.2737 | -8.2582 | -8.2490 | -8.2723 | -8.1838 | -8.1067 |
| Schwert | -8.0791 | -8.0591 | -8.0129 | -7.9730 | -7.9349 | -7.7238 | -7.5241 |

Model selection from regression of S&P500 standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -8.0690 | -8.0936 | -8.0801 | -8.0719 | -8.0876 | -8.0066 | -7.9271 |
| Schwarz | -7.8850 | -7.8789 | -7.8348 | -7.7959 | -7.7503 | -7.5466 | -7.3444 |

Model selection from regression of NASDAQ standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -7.5079 | -7.5845 | -7.6279 | -7.6064 | -7.5713 | -7.5273 | -7.5342 |
| Schwarz | -7.3239 | -7.3698 | -7.3825 | -7.3304 | -7.2033 | -7.0366 | -6.9208 |

## D.2: The Effect of Real Macro Aggregates on Stock Market Volatility

**Table D .2.1: The effect of economy shifts: Models selection from 1962:4 to 2001:1**

AR(p) is the order of autoregressive process and L(k) is the order of lagged exogenous variables.

Model selection from regression of NYSE standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -8.7144 | -8.7267 | -8.7462 | -8.7342 | -8.7111 | -8.7157 | -8.8703 |
| Schwarz | -8.6166 | -8.6089 | -8.6081 | -8.5757 | -8.5131 | -8.4570 | -8.5506 |

Model selection from regression of S&P500 standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -8.5255 | -8.5579 | -8.5858 | -8.5728 | -8.5504 | -8.5539 | -8.7076 |
| Schwarz | -8.4278 | -8.4400 | -8.4478 | -8.4144 | -8.3523 | -8.2952 | -8.3878 |

Model selection from regression of NASDAQ standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -7.8713 | -7.9441 | -8.0087 | -7.9863 | -7.9714 | -7.9864 | -8.0110 |
| Schwarz | -7.7513 | -7.7993 | -7.8387 | -7.7910 | -7.7287 | -7.6708 | -7.6227 |

**Table D.2.2: The effect of economy shifts: Models selection from 1962:2 to 1983:1**

AR(p) is the order of autoregressive process and L(k) is the order of lagged exogenous variables.

Model selection from regression of NYSE standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -9.4236 | -9.3979 | -9.3758 | -9.3538 | -9.3665 | -9.4057 | -9.3990 |
| Schwarz | -9.2768 | -9.2205 | -9.1674 | -9.1139 | -9.1300 | -9.0782 | -8.9791 |

Model selection from regression of S&P500 standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -9.4167 | -9.3896 | -9.3719 | -9.3481 | -9.3572 | -9.4092 | -9.3839 |
| Schwarz | -9.2700 | -9.2122 | -9.1634 | -9.1082 | -9.1208 | -9.0817 | -8.9640 |

Model selection from regression of NASDAQ standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -9.1559 | -9.1370 | -9.1522 | -9.1495 | -9.0678 | -9.0278 | -8.9557 |
| Schwarz | -8.9448 | -8.8810 | -8.8505 | -8.8012 | -8.7300 | -8.5634 | -8.3646 |

**Table D.2.3: The effect of economy shifts: Models selection from 1983:2 to 2002:4**

AR(p) is the order of autoregressive process and L(k) is the order of lagged exogenous variables.

Model selection from regression of NYSE standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -8.2367 | -8.2498 | -8.2551 | -8.2361 | -8.1954 | -8.1895 | -8.5333 |
| Schwarz | -8.0810 | -8.0629 | -8.0372 | -7.9870 | -7.8841 | -7.7847 | -8.0351 |

Model selection from regression of S&P500 standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -8.0165 | -8.0425 | -8.0556 | -8.0358 | -7.9978 | -7.9859 | -8.3271 |
| Schwarz | -7.8608 | -7.8557 | -7.8376 | -7.7867 | -7.6864 | -7.5811 | -7.8289 |

Model selection from regression of NASDAQ standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -7.5525 | -7.6060 | -7.6721 | -7.6451 | -7.6527 | -7.6589 | -7.6708 |
| Schwarz | -7.3968 | -7.4192 | -7.4541 | -7.3960 | -7.3414 | -7.2541 | -7.1727 |

**Table D.2.4: The effect of expected economy shifts: Models selection from 1969:2 to 2003:4**

AR(p) is the order of autoregressive process and L(k) is the order of lagged exogenous variables.

Model selection from regression of NYSE standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -8.5515 | -8.5488 | -8.5308 | -8.5118 | -8.5344 | -8.5257 | -8.4926 |
| Schwarz | -8.4460 | -8.4215 | -8.3816 | -8.3405 | -8.3647 | -8.2912 | -8.1928 |

Model selection from regression of S&P500 standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -8.3812 | -8.3887 | -8.3729 | -8.3543 | -8.3543 | -8.3520 | -8.3330 |
| Schwarz | -8.2757 | -8.2615 | -8.2237 | -8.1829 | -8.1625 | -8.0950 | -8.0102 |

Model selection from regression of NASDAQ standard deviation

| | AR(1) | AR(2) | AR(3) | AR(4) | L(2) | L(3) | L(4) |
|---|---|---|---|---|---|---|---|
| Akaike | -7.8771 | -7.9584 | -7.9822 | -7.9671 | -7.9404 | -7.9209 | -7.9334 |
| Schwarz | -7.7627 | -7.8205 | -7.8204 | -7.7813 | -7.7093 | -7.6205 | -7.5637 |

## References


Baillie R.T and R. P DeGennaro. 1990, "Stock Returns and Volatility", Journal of Financial and Quantitative Analysis, 25, No.2, pp: 203-214.

Beltratti .A and Morana .C, "Breaks and Persistency: Macroeconomic Causes of Stock Market Volatility", Journal of Econometrics, forthcoming.

Bernanke B. S and K. N Kuttner, 2004, "What Explains The Stock Market's Reaction to Federal Reserve Policy?", National Bureau of Economic Research, working paper 10402.

Bollerslev, Tim, Robert F. Engle and Daniel B. Nelson. 1994, "ARCH Models" in Chapter 49 of Handbook of Econometrics, Volume 4, North-Holland.

Carroll .R and Davidian .M. 1987, "Variance Function Estimation", Journal of American Statistical Association. Volume 82, No 400, pp:1079-1091.

Campbell J.Y, Lettan M, Malkiel G and Xu Y. 2001,"Have Individual Stocks Become More Volatile? An Empirical Exploration of Idiosyncratic Risk", The Journal of Finance, Volume LVI, N. 1. pp:45-60.

Chiang Thomas C. and Doong Shuh-Chyi, 1999, "Empirical Analysis of Real and Financial Volatilities on Stock Excess Returns: Evidence from Taiwan Industrial Data", Global Finance Journal, 10:2, pp. 187-200.

Cutler, D. M., Poterba, J. M. and Summers, L. H, 1989, "What Moves Stock Prices", Journal of Portfolio Management, 15, pp: 4-12.

Engle Robert, 2004 "Risk and volatility: Econometric Models and Financial Practice", The American Economic Review, Volume 94, number 3, pp: 405-420.

Glosten, L.R., R. Jagannathan, and D. Runkle, 1993, "On the Relation between the Expected Value and the Volatility of the Normal Excess Return on Stocks", Journal of Finance, 48, pp: 1779–1801.

Greene, William H. 1997. Econometric Analysis, 3rd edition, Prentice-Hall.

Hamilton, James D. 1994. Time Series Analysis, Princeton University Press.

Hausman, Jerry A. 1978, "Specification Tests in Econometrics", Econometrica, 46, pp: 1251–1272.

Kearny Colm and Daly Kevin. 1998, "The Causes of Stock Market Volatility in Australia", Applied Financial Economics, 8, 597-605.

Kleidon Allan .W. 1986,"Variance Bounds Tests and Stock Price" The journal of Political Economy. Volume 94. No 5, pp:953-1001.

Maurice G. Kendall and Alan Stuart. 1969, "The Advanced Theory of Statistics'', London: Griffin.

Maurice G. Kendall and Alan Stuart. 1969, "The Advanced Theory of Statistics'', London: Griffin.

Kim Suk-Joong, McKenzie Michael .D, and Faff Robert .W. 2004, "Macroeconomic News Announcements and The Role of Expectations: Evidence from US Bonds, Stock and Foreign Exchange Markets", Journal of Multinational Financial Management, 14, pp: 217-232.

Li Yuming. 1998, "Expected Stock Returns, Risk Premiums and Volatilities of Economic Factors", Journal of Empirical Finance, 5, pp: 69-97.

Liljeblom Eva and Stenius Marianne. 1997,"Macroeconomic Volatility and Stock Market Volatility: Empirical Evidence on Finish data", Applied Financial Economics, 7, pp: 419-426.

Ljung, G. and G. Box .1979, "On a Measure of Lack of Fit in Time Series Models" Biometrika, 66, pp: 265–270.

Morelli David. 2002,"The Relationship between Conditional Stock Market Volatility and Conditional Macroeconomic Volatility: Empirical Evidence based on UK data", International Review of Financial Analysis, 11, pp: 101-110.

Pindyck, Robert S. and Daniel L. Rubinfeld, 1998. Econometric Models and Economic Forecasts, 4th edition, McGraw-Hill.

Sadorsky, Perry. 2003,"The Macroeconomic Determinants of Technology Stock Price Volatility", Review of Financial Economics, 12, pp: 191-205.

Schwert, W. G. 1989, "Why does Stock Market Volatility Change Over Time?" Journal of Finance, 44, pp: 1368-1388.

Tauchen, George. 1986, "Statistical Properties of Generalized Method-of-Moments Estimators of Structural Parameters Obtained From Financial Market Data" Journal of Business and Economic Statistics, 4, pp: 397–416.

Zakoïan, J. M. 1994, "Threshold Heteroskedastic Models", Journal of Economic Dynamics and Control, 18, pp: 931-944.