FORECASTING CANADIAN MARKET RISK

By Ryan Grosz

Table of Contents

INTRODUCTION **1**

MODEL **1**

STOCK VOLATILITY 2
LAGGED STOCK VOLATILITY 2
LONG TERM INTEREST RATE 3
SHORT TERM INTEREST RATE 3
REAL GDP GROWTH 4
DUMMY VARIABLE FOR LARGE EXTERNAL SHOCKS 4
UNEMPLOYMENT RATE 5
MISSING DATA 5

DATA **6**

STOCK VOLATILITY 6
LONG TERM INTEREST RATE 9
SHORT TERM INTEREST RATE 9
UNEMPLOYMENT RATE 10
REAL GDP GROWTH 10
EXTERNAL SHOCKS 11

RESULTS **11**

STATIONARITY 11
INITIAL REGRESSION 12
MULTICOLLINEARITY 13
OMITTED VARIABLE BIAS 13
WRONG FUNCTIONAL FORM 14
AUTOCORRELATION AND HETEROSKADICITY 14
COMPARISON 15

BEST FORECAST MODEL **16**

CONCLUSION **18**

REFERENCES **20**

TABLE OF FIGURES

Figure 1: Summary Statistics (prepared in E-Views) ______ *7*
Figure 2: TSE Volatility (prepared in E-Views) ______ *7*
Figure 3: Forecast Confidence Interval with Market Risk ______ *18*

Ryan Grosz

INTRODUCTION

The volatility of the stock market shows us the minimum amount we should expect to lose or maximum amount to gain when investing into a stock. Volatility in the financial markets may also be referred to as risk. When investing into a stock we want to know how much risk we will be taking. There are two different types of risk in a stock, diversifiable risk and non-diversifiable risk. Diversifiable risk is firm or stock specific risk, while non-diversifiable risk is the risk of the entire market. We can eliminate some of the risk in the diversifiable risk by investing in many different stocks, but we cannot reduce the non-diversifiable risk.

This paper will try to predict what the next quarter's volatility will be. This is very useful for in banking firms, large firms, investment firms, and other large investors. A financial analyst could use the model to predict the expected volatility of non-diversifiable risk for the next quarter, which will help them in making a decision as to which stock(s) they wish to invest into to maximize return based on the maximum level of risk they wish to take.

The reason I have chosen to forecast stock volatility is because I wish to know how the volatility in the stock market changes and to better understand the non-diversifiable risk in the market.

MODEL

The model that will be used in this study includes six independent variables, where one model will be used using a seasonal dummy. Each of these independent variables will be explained and show how they relate to the dependent variable. Since this model is intended to forecast, the model will be a lagged model.

Stock Volatility

The non-diversifiable risk or stock volatility is measured by the TSE 300 index quarterly volatility. The reason is that it contains 300 stocks and should not have any diversifiable risk in its measure, so all the risk is non-diversifiable. I took the daily index and found the daily percentage return by taking the index at time t and subtracting index time t-1 and dividing this by index t-1; $r = (TSE_t - TSE_{t-1})/TSE_{t-1}$ where TSE is the TSE 300 index, t is the time period, and r is the percentage return. After this was calculated then I took the sample variance of these percentage returns for each quarter by using the following formula: $VAR(r) = \sum (r - \bar{r})^2 /(n-1)$ where $\bar{r}$ is the sample's mean and n is the total number of observations. Since it is a sample variance and I have estimated what the mean is, one degree of freedom from the number of observations was subtracted. The risk is basically the fluctuations of the returns compared to the expected return (mean return). What determines the returns on stocks is the change in their prices.

This non-diversifiable[1] risk is important because it shows us how much risk that is in the market. This is important for financial analysts who must decide on which stocks to invest into based on their risk tolerance and for mutual fund companies.

Lagged Stock Volatility

In Appendix 2, we can see that the last period's market risk has an affect on today's market risk. Therefore we can conclude that this periods' expected volatility should be affected by last periods. This is a rational expectation because many people that interact in the markets are assumed to base their expectations of the future on the past. This past volatility would have a positive affect on the current periods' volatility because of the rational expectation that last periods volatility will dictate this period's.

Long Term Interest Rate

We make the assumption that people investing into the stock market are making long term investments and that their alternate options for the long term are long term bonds. The will only invest in the stock market if they believe that they can make more in the stock market compared to the long term bond, while being compensated for the risk they are taking. Therefore, as the long-term interest rate increases investors will be more willing to sell their stocks and invest into bonds, causing the prices, and thus returns, to fluctuate. This fluctuation is the risk or volatility of the stocks. The opposite also holds for this theory. For the long term interest rate I have chosen to use the 30 year government bond because it should not have a default risk premium on it, so it is the risk free asset. Investor will be less likely to buy or sell stocks when the long term interest rate is at a level where investors are indifferent to holding assets in the stock market or in long term government bonds.

Short Term Interest Rate

Some investors invest in the stock market for only a short term and they will judge their willingness to invest based on the short term interest rate. When there is an increase in the short term interest rate, investors demand for investments will fall causing

[1] Note, Non-Diversifiable Risk, Market Risk, and TSE volatility will be used interchangeably in this paper.

the stock prices to fluctuate. The opposite will also hold true. Keeping in mind the long term interest rate is peoples expectations based on the short term interest rate. Therefore, there might be a high correlation between the short term and long term interest rate. The short term interest rate is the average rate of a government 90-day T-bill over a quarter or four months.

Real GDP Growth

When the real GDP growth is positive we expect that there is growth in our economy. Therefore, this growth should promote companies to grow so they will earn more income and declare more dividends. This may also have an affect on investors' confidence in the economy, making them more willing to invest in the market if there is positive real GDP growth or less likely to sell the stocks they hold. I believe a positive increase in GDP will have a negative effect of volatility because people will perceive the growth as good and will be less likely to sell shares that they hold.

Dummy Variable for Large External Shocks

When there are random, but noticeable, external shocks that are large, there will be affects on the volatility of the stock market. There are a few years where they have been very large external shocks. In 1987, there was a stock market crash on one Monday, known as black Monday. As of yet there is no conclusive agreement to what happened that day, but regardless it caused the stock volatility to dramatically increase for that fourth quarter. In 1998 in the third and fourth quarters, the Russian government defaulted on their loans and the developing Asian countries also defaulted on their loans. This causes a lot of companies to lose the money they invested in these countries, so their net incomes go down and investors sold their stock because they believed it is was overvalued. This causes the stock prices to fluctuate during this process and thus the stock volatility will increase. This dummy is interacted with the volatility of the specific quarter to see the positive effect a large external shock will have on the stock volatility.

Unemployment Rate

The unemployment rate can be used as a proxy for how an economy is moving. If the unemployment rate is very high then we can see that people are losing their jobs and have less income. People will not invest if they have less income and may have to sell their assets to consume today, so they will sell stocks that they own. If the unemployment rate is low then more people will have more jobs, increasing their wealth. When they have more wealth their savings will increase and therefore be more likely to save by purchasing stocks. I expect that this will have a non linear relationship, and that their will be an 'equilibrium' unemployment rate that will not affect the market risk by a large amount.

Missing Data

It would be nice to have the consumers' confidence in the economy but this data is not feasible to collect. One proxy could be consumer spending in Canada, but this does not show how they will purchase stocks because stocks are more like saving than consuming. This is why I do not believe consumer spending is a good proxy for confidence in the market.

I would have also liked to have included the personal savings rate in this study. Unfortunately, the personal savings rate is published annually so it could not be included in this study. Personal disposable income would be a good indicator of financial wealth, but this data is in annual number and we need quarterly for this study.

DATA

All the data was collected from Statistics Canada via CANSIM II database, except the TSE300 index, which was collected from the tri university data sources website. All the data was transformed into quarterly data from the first quarter in 1977 to the last quarter of 2002; thus, there are 104 observations. However, for the purposes of forecasting I will only use the data from 1977 to the end of 1997 to regress a model. From 1998 to the end of 2002 will be used for out of sample forecasting.

Stock Volatility

The TSE300 index was collected from the tri university data source website via its web retrieval service. It is under the heading *Financial and Business,* the database is the *Canada-TSX Daily Index-Common* Equities. The data series is daily from the first trading day in 1977 to the final trading day in 2002. The quarterly volatility was calculated from this data set and thus there are 104 observations. The quarterly volatility is measured as the sample standard deviation of total returns of the TSE300 index. The reason for using the standard deviation is because it is easier to interpret the results of the model. The graph and summary statistics for the stock volatility are shown below in Figure 1 and 2.

Figure 1: Summary Statistics (prepared in E-Views)

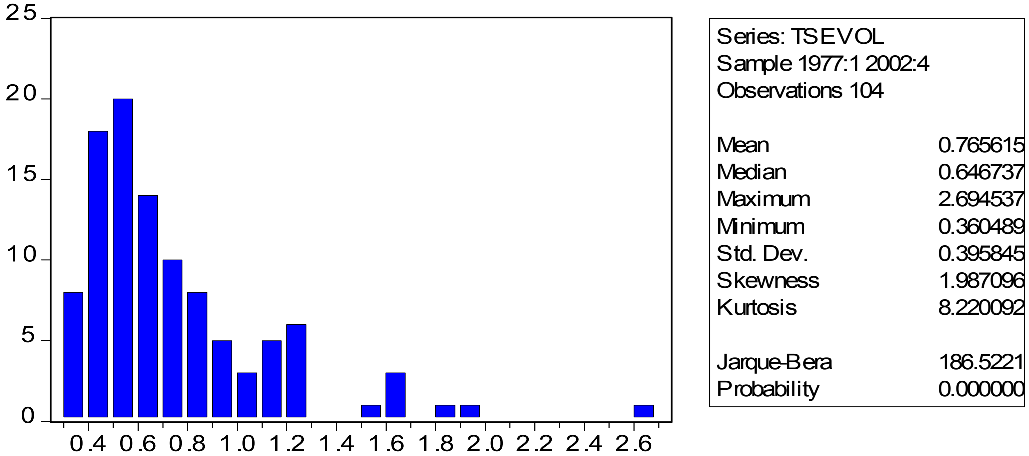
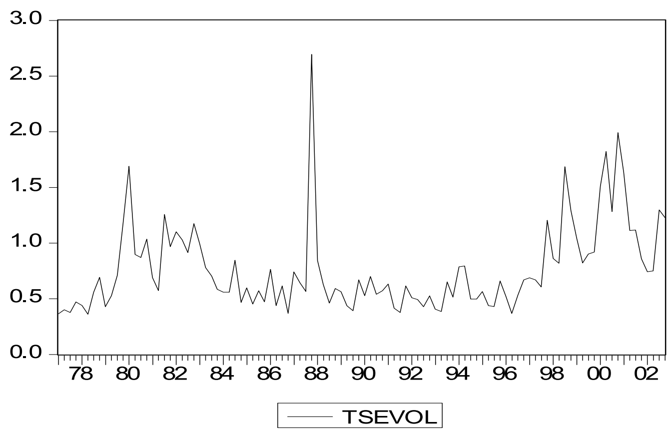


Figure 2: TSE Volatility (prepared in E-Views)



From Figure 2 we can see about three extreme outliers. The largest one occurred in the fourth quarter of 1998. This is the quarter that black Monday had happened, to which there is no explanation to why it happened. In the early 1980's there was a period of very high interest rates, shown later, and from 1998 and on there were many things going on in Canada's markets. In 1998, Russia and emerging Asian governments defaulted on their loans, which caused a lot of price volatility in our stock markets. The reason is because our companies lost a lot of money on this and therefore their expected earnings went down. Also, from 1998-2001 was when the technology stock bubble had 'burst'. A bubble is when people purchase stocks because they believe someone will pay more for it later, even though the stock doesn't pay any dividends. Like all good bubbles, it had burst causing a long period price volatility because technology stock prices were very volatile due to people overreacting in the market. In the third quarter in 2001, United States had become a victim of a terrorist attack destroying the World Trade Center, this had caused some panic in the people so they might have less confidence in the markets so they may have sold stocks, but this is hard to quantify. In the later part of 2002 there was a run-up to the war in Iraq, which may have caused people to lose confidence in the economy causing them to sell stocks that they held, but I do not believe it would have a large affect on the market volatility at that point in time. We can see that between 1984 and 1997 there was a long period of a stable economy, except the one quarter mentioned above. The mean of the TSE300 volatility is 0.76, the minimum is 0.36, and the maximum is 2.69. This shows us there were some periods of high volatility in this market but on average were steady around 0.76, which is to be expected. We must note that the mean in from 1977 to the end of 1997 is 0.67 and the mean from 1998 to the end of 2002 is 1.18. As shown in Appendix 7, the standard deviation for the out-of-sample and the in-sample are not very different from each other. This indicates to us that we can use the in-sample data to forecast the out-of-sample, since their volatility is about the same.

In Appendix 2, we can see that the partial autocorrelation and autocorrelation exists for one lag, which is concurrent with theory. Therefore, we should include a lagged on period of the TSE volatility ($TSEVOL_{t-1}$).

Long Term Interest Rate

The data for the long term interest rate (lint) was found at Statistics Canada via CANSIM II in series V122487 (government of Canada marketable bonds, average yield: over 10 years). This was presented in monthly data and had to be converted into quarterly averages. In Appendix 1, we can see that since 1982 there has clearly been a downward trend in the long term interest rate until 1999, where it flattens out. The mean of the long term interest rate is 9.3%, the minimum is 5.2%, the maximum is 17.16%, and the standard deviation is 2.67%. This shows that there is quite a large range in the long term interest rate, which can come from the downward trend seen in the graph. Thus, this trend should be modeled in some way; the functional form will be discussed later.

Short Term Interest Rate

The data for the short term interest rate (sint) was found at Statistics Canada via CANSIM II in series V122484 (Canada; Treasury Bill Auction – average yields: 3 month, average at values). This was presented in monthly data and had to be converted to quarterly averages. In Appendix 1, we can see that is moves very closely with the long term interest rate and is a bit more volatile than the long term interest rate. The mean of the short term interest rate is 8.25%, the minimum is 2.07%, the maximum is 19.94%, and the standard deviation is 3.78%. We can see from these numbers that the short term interest rate seems to fluctuate more than the long term interest rate, which may not be good for the forecasting model. We must keep this in mind when choosing the appropriate model.

Unemployment Rate

The data for the unemployment rate (urate) was obtained from Statistics Canada series V159752 (Canada; Unemployment Rate; both sexes; 15 years and over; seasonally adjusted). It is presented as a seasonally adjusted monthly dataset and had to be converted to quarterly averages. In Appendix 1, we can see that the unemployment rate from 1977 to 2002 has had some cyclical behaviour. This is because in 1983 and in 1993 there were recessions causing higher unemployment rates. The average or mean rate of unemployment during this period is 9.02%, the minimum is 6.7%, the maximum is 12.87%, and the standard deviation is 1.59%. We can see that the unemployment rate isn't too volatile, so it can be used to help forecast the non-diversifiable risk.

One problem with this dataset is that when the government changes the unemployment benefits then people will enter the workforce to collect these benefits or may choose not to work and become unemployed. This does cause some biasness in the unemployment rates that Statistics Canada publishes. Unfortunately, this biasness is very hard to control for and the estimates that Statistics Canada publishes is the best indicator of unemployment available.

Real GDP Growth

The data for real GDP growth was obtained from Statistics Canada, series V1997736 (Canada; Contributions to Percent Change; Seasonally Adjusted; Gross Domestic Product (GDP) at Market Prices). It is presented as a seasonally adjusted quarterly dataset. I chose to use seasonally adjusted because I do not wish to model the seasonal affects of the real GDP growth and wish the dataset to be stationary. In Appendix 1, we can see that the GDP growth is pretty volatile and there is clearly two recessions. These recessions took place around 1981-1983 and 1990-1991. The mean of the GDP growth is 0.73%, the minimum is -1.5%, the maximum is 2.5%, and the standard deviation is 0.78%. This shows us that the GDP growth rate is stable and there are no extremely large fluctuations.

External Shocks

Since the regression is only being estimated on the data from the first quarter in 1977 to the last quarter of 1997, there is only external shock. This point is the third quarter in 1987, where 'Black Monday' occurred, as described in the model section.

RESULTS

Stationarity

Non-stationarity can cause a very large problem in the model. This is because the variable would only dependant on previous periods or observations. We must make sure that all of the variables are stationary to ensure that any models that are run are efficient and unbiased. I will use the Augmented Dickey- Fuller Unit Root Test to see if there is any non-stationarity.

The TSE300 volatility's unit root test statistic[2] is -2.84 while the critical value at the 10% level is -2.58 so we reject the null hypothesis that the TSE300 volatility is non-stationary at this level. There is some autocorrelation that the lagged term will capture so we can consider the non-diversifiable risk to be stationary.

The long term interest rate has a unit root test statistic of -3.57 and the critical value at the 5% level is -3.46, so we can see that this variable is stationary. The unit root

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[2] All unit root tests are calculated with four lags

test was calculated with at trend and intercept, so the regression must model this trend. This can be modelled by modelling the long term interest rate as a polynomial. The unemployment rate's unit root test statistic is -2.13, while the critical value at the 10% level is -2.58. Therefore we fail to reject the null hypothesis that the unemployment rate is stationary. However, in Appendix 1, we can see that the unemployment rate is stationary. The reason is that it has a quadratic trend and the Augmented Dickey-Fuller test does not test a quadratic trend. Therefore, after looking at the line graph for the unemployment, we can see that it is stationary and the quadratic trend must be captured in the model.

Initial Regression

I will start with a simple regression with the TSE300 volatility as the dependent variable run on TSE volatility lagged one period, long term interest rate, short term interest rate, unemployment rate, real GDP growth, and a dummy variable for the extreme shock in the third quarter in 1987. For purposes of forecasting, all of the variables will have one lagged value and the regression will be using the data from first quarter in 1977 to the last quarter in 1997 so we can conduct an out-of-sample forecast. The model looks like the following:

$$TSEVOL_t = \beta_0 + \beta_1 TSEVOL_{t-1} + \beta_2 LINT_{t-1} + \beta_3 SINT_{t-1} + \beta_4 URATE_{t-1} + \beta_5 GDPGROWTH_{t-1} + \beta_6 EXSHOCK_{t-1} * TSEVOL_t + \varepsilon_t$$

The estimated regression is[3]:

[3] All of the regression results can be seen in Appendix 3.

$$TSEVOL_t = 0.32180 + 0.244084\,\mathrm{TSEVOL}_{t-1} + 0.047568\,\mathrm{LINT}_{t-1} - 0.011600\,\mathrm{SINT}_{t-1} - 0.021611\,\mathrm{URATE}_{t-1} - 0.02149\mathrm{GDPGROWTH}_{t-1} + 0.761834\,\mathrm{EXSHOCK}_t * TSEVOL_t$$

R^2= 0.625625 and Adj. R^2= 0.596069 $\hat{\sigma}$ =0.210610

Only the TSEVOL_{t-1} and $\mathrm{EXSHOCK}_t * TSEVOL_t$ is statistically significant at the 95% level in this regression, using the t-test[4]. The estimates can be off due to various reasons. Thus, the model must be tested for various statistical problems.

Multicollinearity

To check for multicollinearity we look at the correlation matrix (Appendix 4) for the independent variables. We can see that the long term interest rate and short term interest rate are highly correlated with each other, and that the long term interest rate has a higher correlation with the dependent variable than the short term interest rate. Therefore, we should drop the short term interest from the model since it is being modelled by the long term interest rate.

Omitted Variable Bias

As seen in Figure 1, the non-diversifiable risk is not normally distributed and has a very large kurtosis. Running an OLS regression assumes that the dependent variable is normally distributed, so we should model the excess kurtosis. Thus, I will add the term of $TSEVOL^4_{t-1}$ to model the affects of the excess kurtosis. This difference will be shown as a separate regression in Appendix 3.

The opposite of omitting a variable that has an affect on the dependent variable is to include an independent variable that has no affect on the dependent variable. As seen

[4] All of the t-tests are calculated in EViews output

in Appendix 4, the real GDP growth per capita has a very low correlation to the dependent variable and therefore, will be dropped from further regressions.

Wrong Functional Form

In Appendix 5, we can see that the relationship between the long term interest rate and the TSE300 volatility is clearly not linear. After testing the relationship from a fourth power polynomial, the significant relationship is a third power polynomial. But, if we are to put this term in then we would have to drop the excess kurtosis term. If we wish to keep this in then we should use only a second power polynomial. I will regress both of these models to compare them.

We can also see from Appendix 5, that the relationship between the unemployment rate and TSE300 volatility is not linear. After testing the relationship from a sixth power polynomial, it reduced to a fourth power polynomial. If we regress the model with the long term interest rate as a third level polynomial and the unemployment rate as a fourth level polynomial, then the excess kurtosis term would definitely be modeled model and maybe model too much. If it models too much in sample then it would become a poor forecasting model. Therefore, I will compare a model that regress's the long term interest rate as a second power polynomial and the unemployment rate as a fourth power polynomial, for comparison.

Autocorrelation and Heteroskadicity

Since the model is a lagged model, there should be no autocorrelation. This means that the Durbin-Watson test statistic would show that the model is in the wrong functional form. Also, there cannot be any heteroskadicity because the model chosen is a time series model and heteroskadicity only exists in a cross-sectional model.

Comparison

To test to see if which model is a better forecasting model we must compare the models including benchmark models. I am going to use the ARMA, seasonal, trend model, and a naive model as benchmark models. If my model is no better at forecasting than these, then my model would not be as efficient as the benchmark models. I will use the SC, AIC, RMSE, MAE, the Durbin-Watson statistic and the standard error as the criterions for choosing the best forecasting model. As noticed, I am not using the R^2 as a criterion. This is because it is rather unimportant when looking at predicting the future or forecasting. I could have the R^2 equal to one but it will have a terrible forecast, since it would be modelling the errors. These errors are unknown in the forecast so it cannot model them, which causes a large forecast error. However, I will be concerned if the R^2 is very low and take that into consideration when deciding on the most efficient forecasting model.

I will use the Root Mean Squared Error as the main criterion for comparison. The reason is because it shows the average error we can expect from the forecast. This number should also be compared to the mean of the dependant variable because we want to see if it is a large or small error in comparison to the dependant variable. I am also using the Mean Absolute Error because it may happen that a model predicted one quarter very poorly but the rest quite well, and this would cause the RMSE to increase even though it could be a good model. The SC and AIC are good criterion to see if the model is asymptotically efficient; we will want these to be as low as possible. The standard error of the model ($\hat{\sigma}$) will show if the model has a good in sample forecast and we want this to be as low as possible. I will look at the Durbin Watson statistic because if it shows there is autocorrelation then the model must be in the wrong functional form, since all models are lagged one period. All criterions, except the standard error of the regression and Durbin-Watson statistic, are calculated using the out of sample forecast.

The naive model is just that next quarters non-diversifiable risk is this periods. This is considered to be a poor forecast model since it does not take into account other factors. The seasonal model shows the affects of each season on the non-diversifiable risk. In Appendix 3, we can see that the seasons do not have a significant affect on the non-diversifiable risk at the 95% confidence level, using the t-tests. There was no linear trend in the TSE300 volatility, since the coefficients were insignificant. The coefficients for a quadratic trend were significant and as shown in Appendix 3.

Appendix 2 shows the correlogram for the dependant variable (TSE300 volatility). This will help us determine the Autoregressive Moving Average (ARMA) model. The partial autocorrelation function is only significant at two lagged periods, and the autocorrelation is an exponential decay. This shows that the ARMA model can be depicted by an autoregressive model to two lags. The residuals correlogram is shown in Appendix 6 and we can see that there is no significant autocorrelation or partial autocorrelation.

BEST FORECAST MODEL

Appendix 3 shows all of the estimated models that were run, including the benchmark models. After looking at all the criterion, I have chosen model 5 as the most efficient forecasting model. The reason is because it has the lowest RMSE and MAE, it has a low standard error and has a pretty low AIC and SC. Other models have lower AIC and SC scores because they have less independent variables. Model 6 was not chosen because it seems to be modeling the error as well, due to the fact that it has a higher RMSE and MAE even though it has a higher R^2 and lower standard error. Model 5 is estimated as follows:

$$TSEVOL_t = \beta_0 + \beta_1 TSEVOL_{t-1} + \beta_2 LINT_{t-1} + \beta_3 LINT^2_{t-1} + \beta_4 URATE_{t-1} +$$

$$\beta_5 URATE^2_{t-1} + \beta_6 URATE^3_{t-1} + \beta_7 URATE^4_{t-1} + \beta_8 EXSHOCK_t * TSEVOL_t + \varepsilon_t$$

The estimated regression is:

$$TSEVOL_t = 108.7281 + 0.195\, TSEVOL_{t-1} - 0.2352\, LINT_{t-1} + 0.0115\, LINT^2_{t-1} -$$

$$43.866\, URATE_{t-1} + 6.684\, URATE^2_{t-1} - 0.4492\, URATE^3_{t-1} + 0.0112\, URATE^4_{t-1} + 0.8182$$

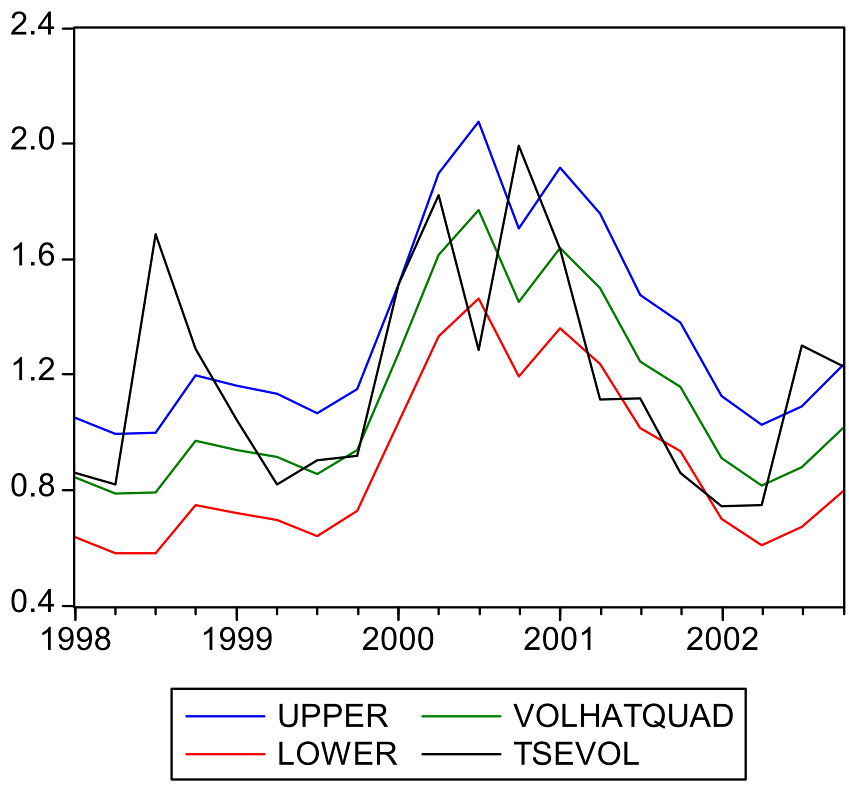
$$EXSHOCK_t * TSEVOL_t$$

$$R^2 = 0.7271 \text{ and Adj. } R^2 = 0.6976 \quad \hat{\sigma} = 0.1822$$

We can see that the coefficients are concurrent with the theory. By observation and inputting values while holding everything else constant, we can see the marginal affects. The marginal affect of unemployment on the market risk is negative when the unemployment rate around 7%-10%, and has a positive if below or above this range. This is concurrent with the theory that was described in the model section. When we look at the net affects of the long-term interest rate on the market risk we can see that around a 7% long-term interest rate have a negative affect, but if it gets smaller it will have a positive affect and if it gets larger (around 11%) it will have a positive affect. This is concurrent with the theory that was described in the model section.

Figure 3 compares the confidence level of our forecast with the actual market risk of the out of sample period. We can see that in the third quarter of 1998, in the fourth quarter of 2000, and in the third quarter of 2002 the market risk was not in our forecasted confidence interval. In 1998 Russia and some Asian countries had defaulted on loans, as described in the model section, in 2001 there was a terrorist attack in the US which shocked consumer confidence, and from 1998 to about 2002 there was the technology stock bubble. We cannot model for these affects because we cannot predict that they will happen, which is why they are shocks. This may not seem to be a good forecast, but it is the best forecast out of all the models that were run. We can see that there are no structural breaks by looking at the CUSUM test in Appendix 8. It is interesting to see that the mean percentage error for the out-of-sample forecast is 1.96% but a better measure is the mean absolute percentage error, which is 18.34%.

Figure 3: Forecast Confidence Interval with Market Risk



CONCLUSION

This study has examined many different models to do a one-step ahead forecast on the non-diversifiable risk in the Canadian financial markets, using the TSE300 index's returns standard deviation as a proxy. This is proven to be a good proxy because it should eliminate diversifiable risk and the remaining risk must be non-diversifiable risk.

The quarterly data from 1977 to 1997 was used for the in sample modeling and from 1998 to 2002 was used for the out-of sample forecast.

The study showed that the real GDP growth has no affect on the non-diversifiable risk and that there was a problem of multicolinearity between the short term interest rate and the long term interest rate. It also showed that the relation between the long term interest rate and the non-diversifiable risk is non-linear. This relation also holds for the unemployment rate and the non-diversifiable risk. Model 5 was chosen because it had a better forecast than all the other models, including the ARMA model. We can see it is not a great forecast of the market risk in the out-of-sample forecast but it is better then the other models that were regressed. The reason it is not a great forecast in the out-of-sample forecast is because it cannot predict large shocks that happened during this time. I believe the model will do a very good job at predicting a stable period’s market risk. For further study, we can compare the model by obtaining the GARCH models’ conditional volatility for the forecast period.

This information would be very useful to the finance industry because they will have a better prediction of the market risk. We care about risk because we want to reduce the risk we are exposed to when we invest into stocks. Having a good prediction of the next period’s non diversifiable risk will help investors decide which stock(s) they will invest into.

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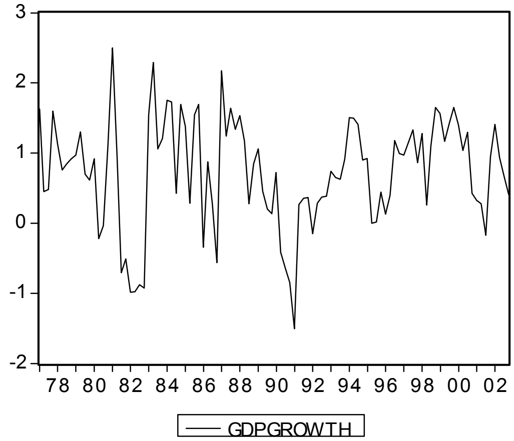
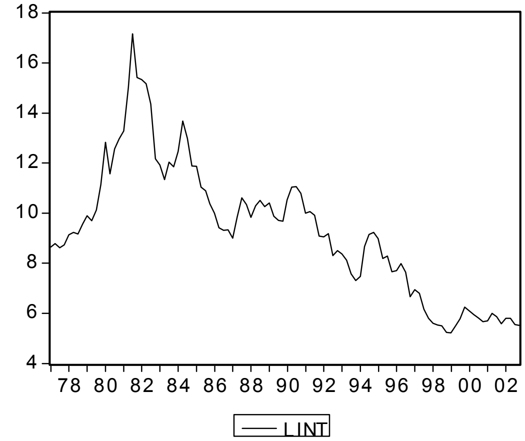
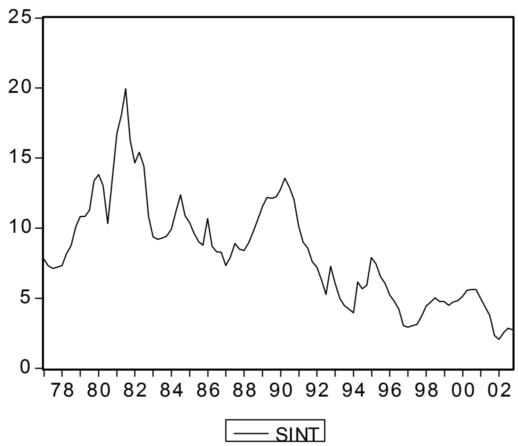
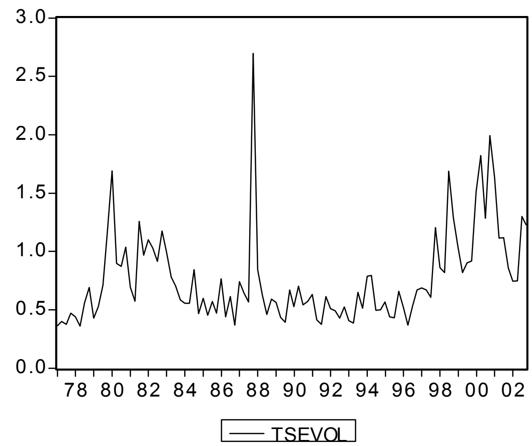
APPENDIX 1

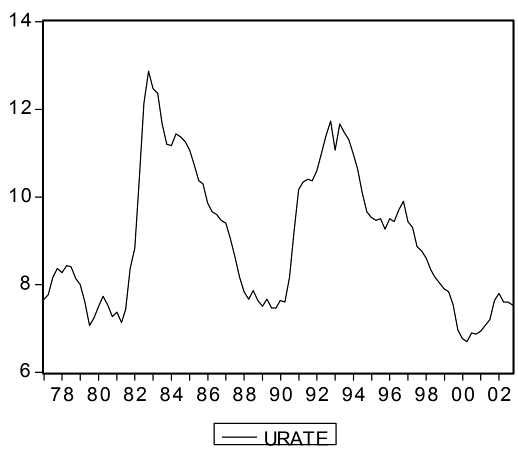
Line graphs of all variables plotted against time





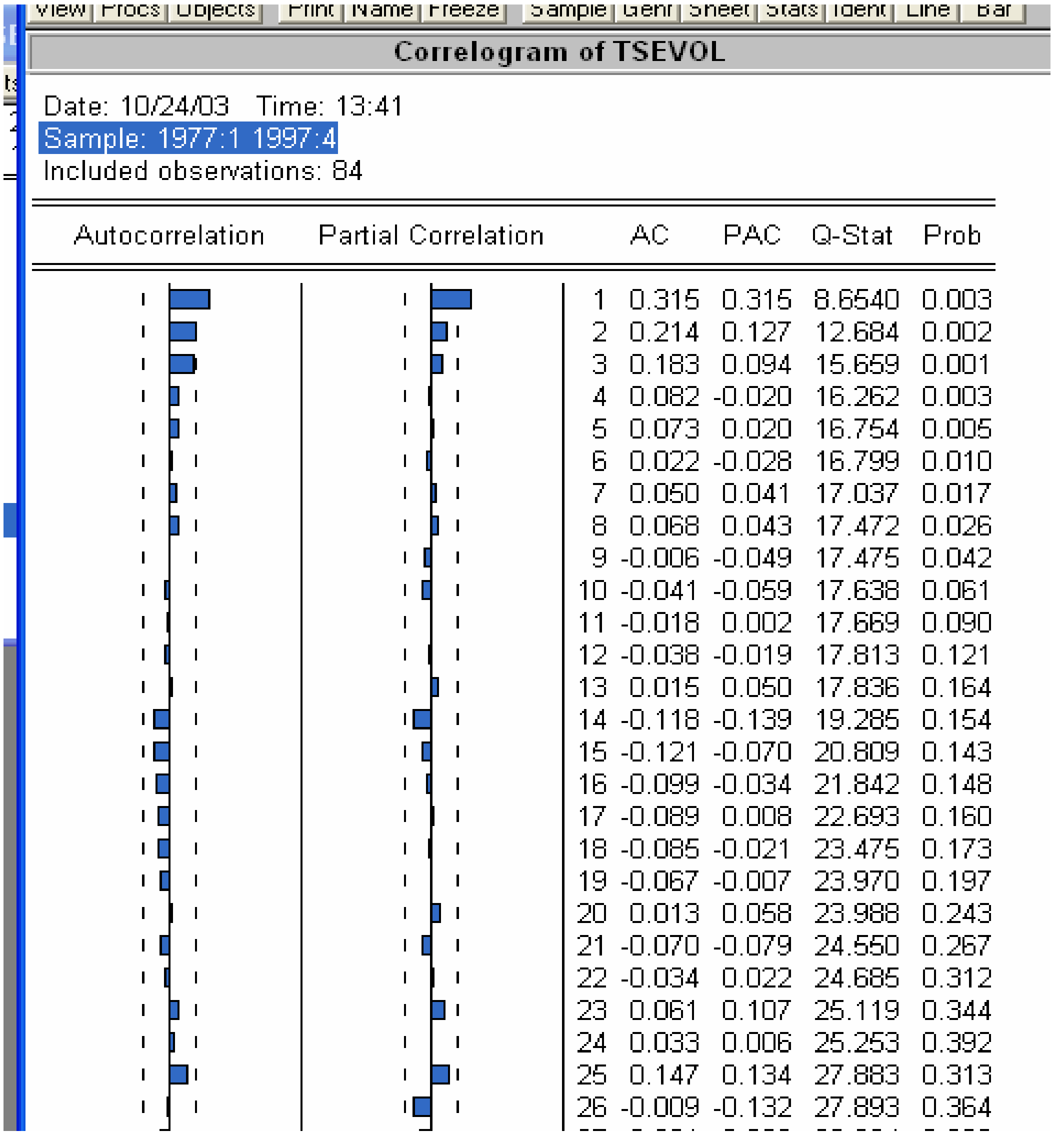






APPENDIX 2

Correlogram of TSE 300 volatility



Correlogram of TSEVOL

Date: 10/24/03 Time: 13:41
Sample: 1977:1 1997:4
Included observations: 84

	AC	PAC	Q-Stat	Prob
1	0.315	0.315	8.6540	0.003
2	0.214	0.127	12.684	0.002
3	0.183	0.094	15.659	0.001
4	0.082	-0.020	16.262	0.003
5	0.073	0.020	16.754	0.005
6	0.022	-0.028	16.799	0.010
7	0.050	0.041	17.037	0.017
8	0.068	0.043	17.472	0.026
9	-0.006	-0.049	17.475	0.042
10	-0.041	-0.059	17.638	0.061
11	-0.018	0.002	17.669	0.090
12	-0.038	-0.019	17.813	0.121
13	0.015	0.050	17.836	0.164
14	-0.118	-0.139	19.285	0.154
15	-0.121	-0.070	20.809	0.143
16	-0.099	-0.034	21.842	0.148
17	-0.089	0.008	22.693	0.160
18	-0.085	-0.021	23.475	0.173
19	-0.067	-0.007	23.970	0.197
20	0.013	0.058	23.988	0.243
21	-0.070	-0.079	24.550	0.267
22	-0.034	0.022	24.685	0.312
23	0.061	0.107	25.119	0.344
24	0.033	0.006	25.253	0.392
25	0.147	0.134	27.883	0.313
26	-0.009	-0.132	27.893	0.364

APPENDIX 3

Estimated regressions

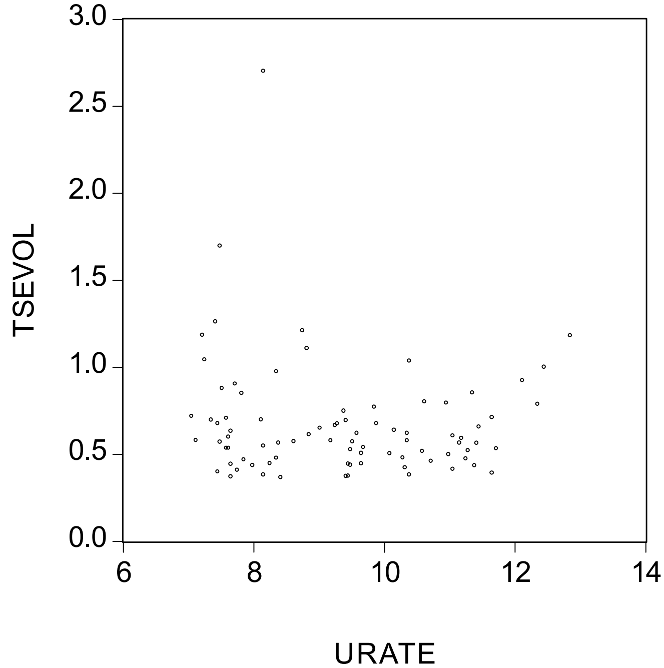
	Simple	Very Simple Model	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
C	0.3218 (0.1977)	0.4545 (0.0782)	1.3068 (0.4074)	1.0755 (0.4156)	5.2932 (1.425)	8.4471 (1.6816)	108.7281 (34.994)	109.8475 (33.071)
$TSEVOL_{t-1}$	0.2441 (0.0798)	0.3261 (0.1064)	0.2348 (0.0739)	0.4576 (0.1318)	0.2092 (0.0712)	0.1719 (0.0687)	0.195 (0.0702)	0.1677 (0.0669)
$TSEVOL^4_{t-1}$				-0.0137 (0.0068)				
$LINT_{t-1}$	0.0476 (0.0321)		-0.1855 (0.0744)	-0.1569 (0.0744)	-0.0031 (0.0011)	-1.424 (0.3901)	-0.2352 (0.071)	-1.3855 (0.3723)
$LINT^2_{t-1}$			0.0099 (0.0033)	0.0081 (0.0034)	-1.3222 (0.3973)	0.1205 (0.0354)	0.0115 (0.0031)	0.1174 (0.0338)
$LINT^3_{t-1}$					0.1142 (0.036)	-0.0032 (0.001)		-0.0031 (0.001)
$SINT_{t-1}$	-0.0116 (0.0212)							
$URATE_{t-1}$	-0.0216 (0.0212)					-0.5355 (0.1992)	-43.866 (14.568)	-42.742 (13.771)
$URATE^2_{t-1}$						0.0266 (0.0104)	6.684 (2.2494)	6.5228 (2.1262)
$URATE^3_{t-1}$							-0.4492 (0.1528)	-0.439 (0.1444)
$URATE^4_{t-1}$							0.0112 (0.0039)	0.011 (0.0036)
$GDPGROWTH_{t-1}$	-0.0201 (0.0307)							
$EXSHOCK_t * TSEVOL_t$	0.7618 (0.0801)		0.7836 (0.0746)	0.7847 (0.0732)	0.7856 (0.0713)	0.7976 (0.0682)	0.8182 (0.0697)	0.8138 (0.0659)
R^2	0.6256	0.1039	0.6575	0.6748	0.6914	0.7286	0.7271	0.7596
Adj. R^2	0.5961	0.0929	0.634	0.6537	0.6714	0.7033	0.6976	0.73
S.E.	0.2106	0.3156	0.1988	0.1950	0.19	0.1805	0.1822	0.1722
AIC		-3.073	-2.144	-2.24	-2.442	-2.416	-2.377	-1.91
SC		0.223	0.672	0.835	0.845	1.145	1.312	1.444
RMSE		0.481	0.4841	0.4212	0.3808	0.3823	0.3212	0.3849
MAE		0.3443	0.3436	0.286	0.3088	0.3465	0.2341	0.3327
DW STAT	1.5462	2.0527	1.7318	2.0542	1.6936	1.7592	2.0312	2.006

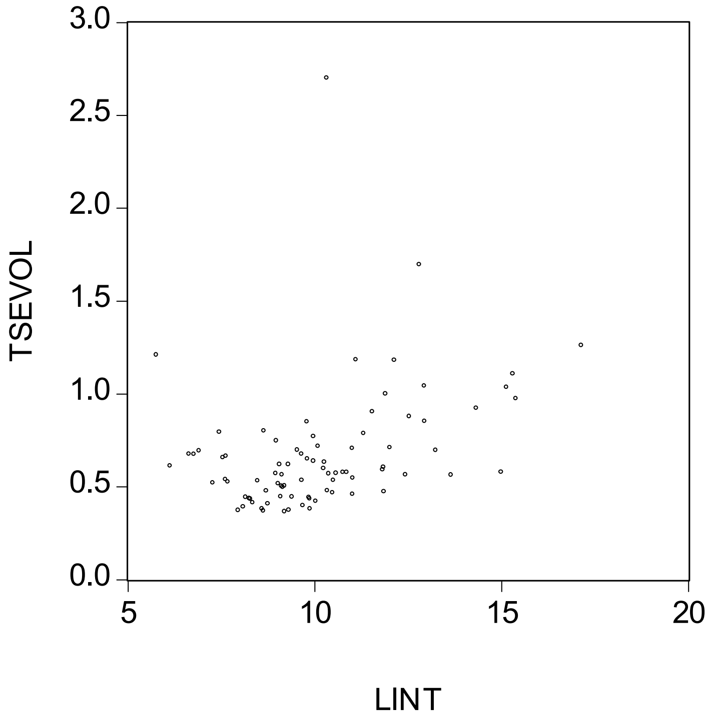
	Quadratic Trend	Seasonal	Seasonal with Constant	NAIVE MODEL	ARMA MODEL
C	0.6956 (0.1053)		0.6866 (0.0712)		.7902 (0.0858)
AR(1)					0.4232 (0.0988)
AR(2)					0.1871 (0.0992)
TIME	0.0023 (0.0059)				
TIME2	-5.45E-05 (6.84E-05)				
WINTER		0.6865 (0.0712)			
SPRING		0.5708 (0.0712)	-0.1156 (0.1007)		
SUMMER		0.6145 (0.0712)	-0.0719 (0.1007)		
AUTUMN		0.7916 (0.0712)	0.1051 (0.1007)		
R^2	0.034	0.0644	0.0644		0.2936
Adj. R^2	0.0102	0.0293	0.0293		0.2793
S.E.	0.3294	0.3262	0.3262		0.3362
AIC	-1.56	-1.826	-1.826	-4.145	-3.1371
SC	0.317	0.495	0.495	0.092	0.3962
RMSE	0.8368	0.6346	0.6346	0.398	0..3804
MAE	0.7508	0.5188	0.5188	0.3123	0.2693
DW STAT	1.375	1.296	1.296		2.055

APPENDIX 4

	URATEL	TSEVOL_LAG	TSEVOL	SINTL	LINTL	GDPL
URATEL	1.000000	-0.106657	-0.144065	-0.372372	-0.080284	0.017858
TSEVOL_LAG	-0.106657	1.000000	0.322397	0.330896	0.410563	-0.064789
TSEVOL	-0.144065	0.322397	1.000000	0.282177	0.336252	-0.012094
SINTL	-0.372372	0.330896	0.282177	1.000000	0.892647	-0.302554
LINTL	-0.080284	0.410563	0.336252	0.892647	1.000000	-0.226006
GDPL	0.017858	-0.064789	-0.012094	-0.302554	-0.226006	1.000000

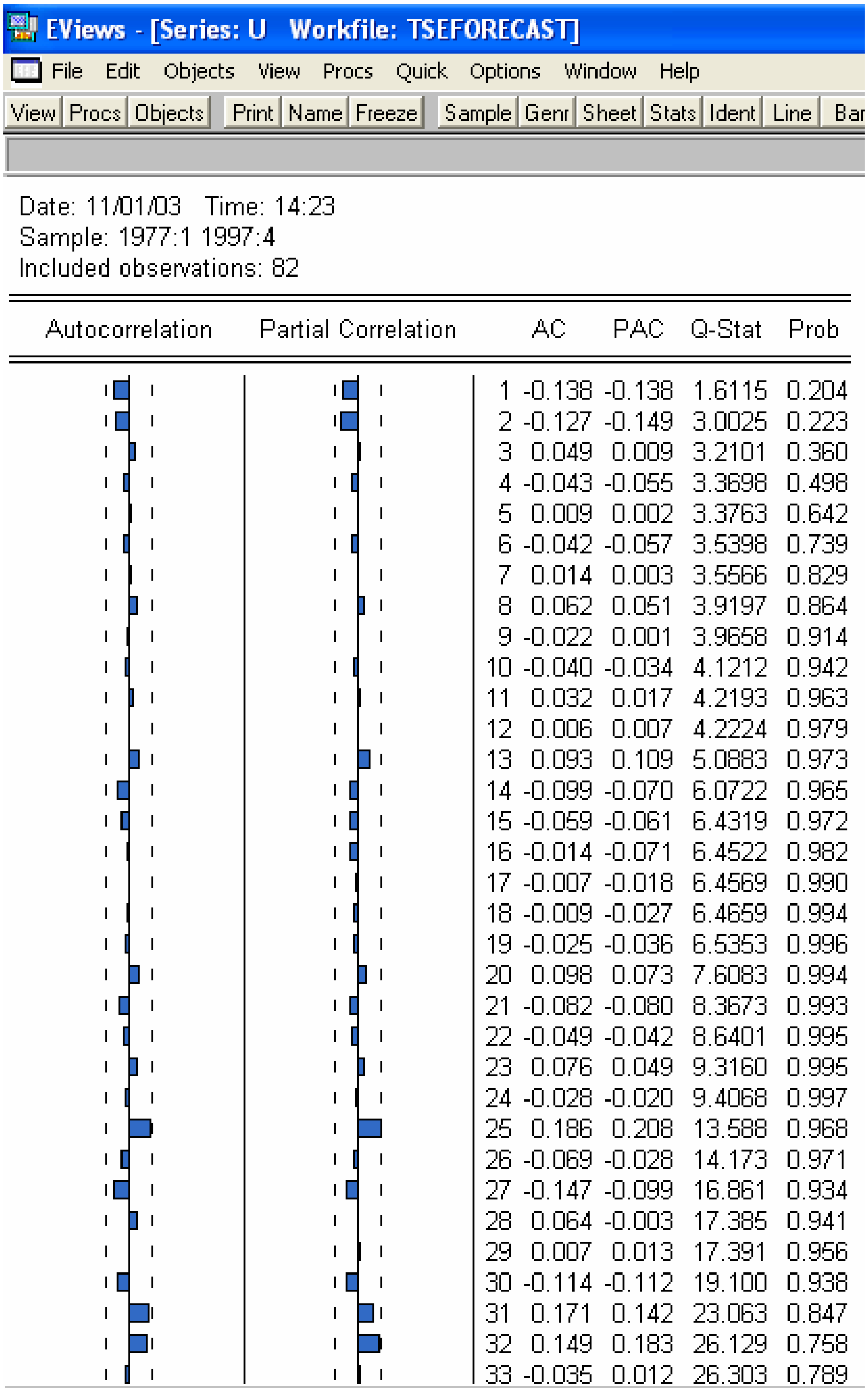
APPENDIX 5


3.0
2.5
2.0
1.5
1.0
0.5
0.0
TSEVOL
6
8
10
12
14
URATE


3.0
2.5
2.0
1.5
1.0
0.5
0.0
TSEVOL
5
10
15
20
LINT

APPENDIX 6

Correlogram of Residuals of ARMA Model



EViews - [Series: U Workfile: TSEFORECAST]

File Edit Objects View Procs Quick Options Window Help

View Procs Objects Print Name Freeze Sample Genr Sheet Stats Ident Line Bar

Date: 11/01/03 Time: 14:23
Sample: 1977:1 1997:4
Included observations: 82

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.138	-0.138	1.6115	0.204
		2	-0.127	-0.149	3.0025	0.223
		3	0.049	0.009	3.2101	0.360
		4	-0.043	-0.055	3.3698	0.498
		5	0.009	0.002	3.3763	0.642
		6	-0.042	-0.057	3.5398	0.739
		7	0.014	0.003	3.5566	0.829
		8	0.062	0.051	3.9197	0.864
		9	-0.022	0.001	3.9658	0.914
		10	-0.040	-0.034	4.1212	0.942
		11	0.032	0.017	4.2193	0.963
		12	0.006	0.007	4.2224	0.979
		13	0.093	0.109	5.0883	0.973
		14	-0.099	-0.070	6.0722	0.965
		15	-0.059	-0.061	6.4319	0.972
		16	-0.014	-0.071	6.4522	0.982
		17	-0.007	-0.018	6.4569	0.990
		18	-0.009	-0.027	6.4659	0.994
		19	-0.025	-0.036	6.5353	0.996
		20	0.098	0.073	7.6083	0.994
		21	-0.082	-0.080	8.3673	0.993
		22	-0.049	-0.042	8.6401	0.995
		23	0.076	0.049	9.3160	0.995
		24	-0.028	-0.020	9.4068	0.997
		25	0.186	0.208	13.588	0.968
		26	-0.069	-0.028	14.173	0.971
		27	-0.147	-0.099	16.861	0.934
		28	0.064	-0.003	17.385	0.941
		29	0.007	0.013	17.391	0.956
		30	-0.114	-0.112	19.100	0.938
		31	0.171	0.142	23.063	0.847
		32	0.149	0.183	26.129	0.758
		33	-0.035	0.012	26.303	0.789

APPENDIX 7

Comparison of In-Sample, Out-of-Sample, and Full Range

	In-Sample	Out-of-Sample	Full Range
Mean	0.666	1.185	0.766
Standard Deviation	0.331	0.377	0.397
Skewness	3.314	0.667	1.987
Kurtosis	18.869	2.33	8.22
Min	0.36	0.743	0.36
Max	2.69	1.991	2.69

Appendix 8

CUSUM test for structural breaks