Texas Tech University

Department of Economics

Spring 2018

Eco 4306: Economic and Business Forecasting

Final Exam

Name:

ID:

Short questions (40 points)

Q1. 4 points
Q2. 4 points
Q3. 4 points
Q4. 4 points
Q5. 4 points
Q6. 4 points
Q7. 4 points
Q8. 4 points
Q9. 4 points
Q10. 4 points

Applied problems (64 points)

Q11. 8 points
Q12. 8 points
Q13. 8 points
Q14. 8 points
Q15. 8 points
Q16. 8 points
Q17. 8 points
Q18. 8 points

Good luck!

Question 1. (4 points)

What is Granger causality and how do we test it?

See slide 18 in lec20slides.pdf

Question 2. (4 points)

Explain what spurious regression problem is and give an example.

See slides 7-9 and 11 in lec23slides.pdf.

Question 3. (4 points)

Explain what is means if X_t and Y_t are cointegrated. Give an example.

See slide 12 in lec23slides.pdf.

Question 4. (4 points)

Explain the idea behind error correction model. Draw a diagram illustrating the error correction mechanism.

See slides 22-26 in lec23slides.pdf.

Question 5. (4 points)

Explain what volatility clustering means.

See slide 9 in lec25slides.pdf.

Question 6. (4 points)

Explain the difference between moving average (MA) and exponentially weighted moving average (EWMA) models of the conditional variance.

See slide 24, 28 and 31 in lec25slides.pdf.

Question 7. (4 points)

Write the equation for the autoregressive conditional heteroscedasticity ARCH(1) model. Explain the intuition behind this model.

See slide 6 in lec26slides.pdf.

Question 8. (4 points)

What are some weaknesses of ARCH models, and which alternative models have been developed to address them?

See slide 22 in lec26slides.pdf.

Question 9. (4 points)

Explain what 1% VaR is and draw a diagram to illustrate this.

See slides 6, 7 and 10 in lec28slides.pdf.

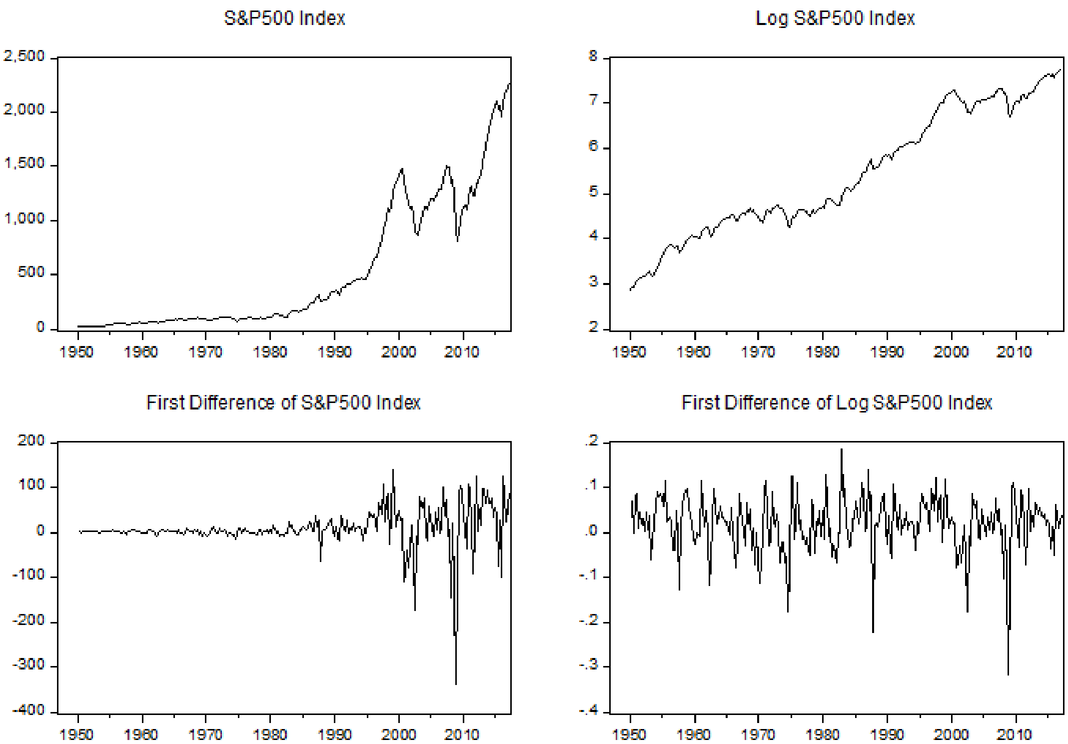
Question 10. (4 points)

Consider a GARCH(1,1) model for daily S&P 500 returns from 1/2/1998 to 7/25/2008 sample. With normal innovations, the number of violations $r_t < r_t^{VaR(0.01)}$ is 42 which represents 1.58% of observations. With innovations from Student-t distribution the number of violations $r_t < r_t^{VaR(0.01)}$ is 30 or 1.13% of the sample. Which of these two models would be more suitable for risk management purposes and why?

In a large sample, the actual return should be below the 1% VaR threshold in 1% of the sample. With normally distributed innovations, the actual number of days with return below the 1%VaR is 1.58% of the sample so quite a bit more. This is because normal distribution underpredicts how likely extremely low or extremely high realizations can occur. Student-t distribution has fat tails, so these kind of outcomes are more likely to happen, and the actual return is below 1% VaR threshold only 1.13% of times.

Question 11 (8 points)

Figure below shows the time series for the S&P500 Index, the log transformed S&P500 Index, and also their first differences. Explain which of the four series are nonstationary, first order weakly stationary, second order weakly stationary.



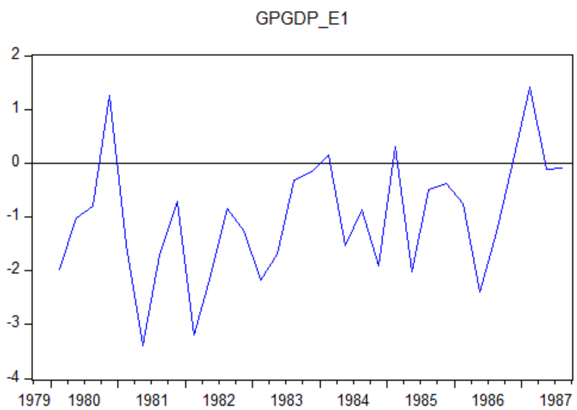
- SP500: it is nonstationary, because it is growing and thus mean is not constant over time
- log og SP500: it is nonstationary, because it is growing and thus mean is not constant over time
- first difference of SP500: it is first order weakly stationary stationary, it fluctuates around a constant mean, but its variance is not constant over time, with larger fluctuations toward the end of the sample
- first difference of log of SP500: it may be first order weakly stationary or second order weakly nonstationary - mean does not appear to be growing over time, whether variance is constant over time or not would need to be further tested

Question 12 (8 points)

Consider the one quarter ahead Fed's forecast for inflation during the 1979Q4-1987Q3 period.

Suppose that we want to test whether the Fed's forecast are optimal under the symmetric quadratic loss function, which would imply that $E(y_{t+1}) = f_{t,1}$ and thus the forecast error $e_{t,1} = y_{t+1} - f_{t,1}$ would have to satify $E(e_{t,1}) = 0$, and in the regression $e_{t,1} = \beta_0 + e_t$ coefficient β_0 should be zero. Figure below shows that time series plot for the forecast errors, and the results of that regression.

Interpret these results; what can we say about Fed's loss function during 1979Q4-1987Q3 based on them?



Dependent Variable: GPGDP_E1
Method: Least Squares
Date: 02/19/19 Time: 18:00
Sample (adjusted): 1980Q1 1987Q3
Included observations: 31 after adjustments

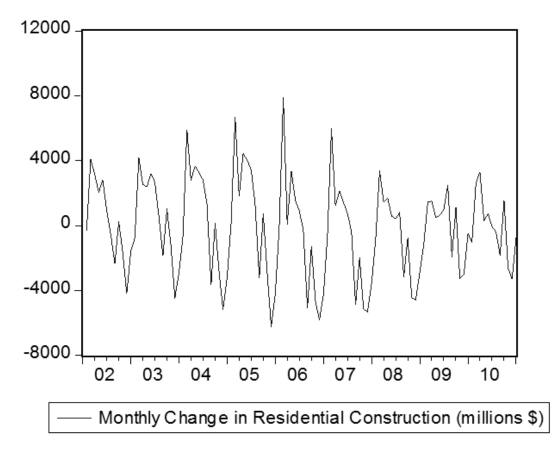
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.017073	0.202722	-5.017080	0.0000

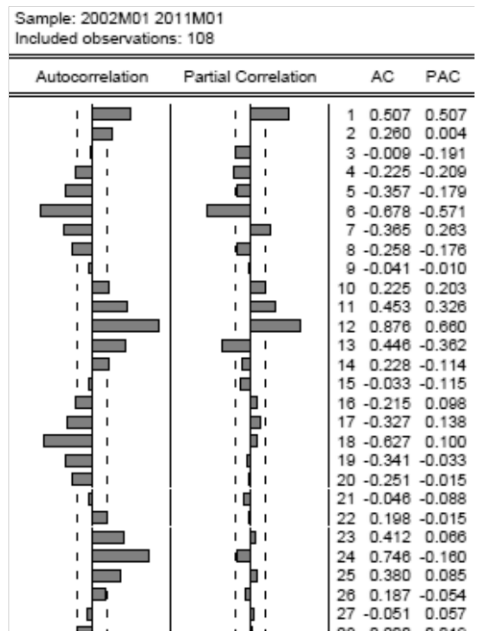
R-squared	0.000000	Mean dependent var	-1.017073
Adjusted R-squared	0.000000	S.D. dependent var	1.128708
S.E. of regression	1.128708	Akaike info criterion	3.111751
Sum squared resid	38.21948	Schwarz criterion	3.158009
Log likelihood	-47.23215	Hannan-Quinn criter.	3.126830
Durbin-Watson stat	1.562466		

Based on on the time series plot the forecast error appears to be negative most of the time, thus the inflation forecast $f_{t,1}$ tends overestimate the true inflation y_{t+1}. This is confirmed by the negative and statistically significant estimate of β_0 in the regression. It suggests that the Fed's loss function is not symmetric quadratic but rather asymmetric, with larger losses associated with underestimating inflation. This makes sense intuitively, since the main goal of Fed in the 1980s was to bring down inflation from double digit levels.

Question 13 (8 points)

Consider the data for monthly changes in U.S. residential construction for the period January 2002-January 2011 shown below. Discuss what kind of model would you would estimate for this time series, write its equation, and explain why you would choose this model.





See slide 16 to 20 in lec11slides.pdf.

Question 14 (8 points)

Consider two candidate models for change in monthly private residential construction spending, AR(1) and AR(2)+SAR(1), the results for which are below. Evaluate the adequacy of these models based on the correlograms of residuals, AIC and BIC, and statistical significance of coefficients.

Dependent Variable: DCONST
Method: ARMA Maximum Likelihood (BFGS)
Date: 04/13/19 Time: 10:04
Sample: 1993M02 2013M12
Included observations: 251
Convergence achieved after 3 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	34.02301	284.5681	0.119560	0.9049
AR(1)	0.503787	0.082472	6.108569	0.0000
SIGMASQ	4263658.	311155.6	13.70266	0.0000

R-squared	0.254386	Mean dependent var	49.44223
Adjusted R-squared	0.248373	S.D. dependent var	2396.078
S.E. of regression	2077.314	Akaike info criterion	18.12859
Sum squared resid	1.07E+09	Schwarz criterion	18.17072
Log likelihood	-2272.138	Hannan-Quinn criter.	18.14554
F-statistic	42.30579	Durbin-Watson stat	2.030264
Prob(F-statistic)	0.000000		

Date: 04/13/19 Time: 10:04
Sample: 1993M01 2013M12
Included observations: 251
Q-statistic probabilities adjusted for 1 ARMA term

Lag	AC	PAC	Q-Stat	Prob
1	-0.016	-0.016	0.0654	
2	0.196	0.196	9.8361	0.002
3	-0.156	-0.156	16.045	0.000
4	-0.152	-0.202	21.954	0.000
5	-0.073	-0.014	23.343	0.000
6	-0.437	-0.430	72.819	0.000
7	-0.077	-0.174	74.368	0.000
8	-0.167	-0.097	81.652	0.000
9	-0.141	-0.424	86.868	0.000
10	0.174	-0.055	94.847	0.000
11	-0.004	-0.168	94.852	0.000
12	0.928	0.873	323.74	0.000
13	-0.022	0.004	323.87	0.000
14	0.191	-0.179	333.60	0.000
15	-0.170	-0.052	341.37	0.000
16	-0.138	0.000	346.48	0.000
17	-0.073	-0.027	347.93	0.000
18	-0.426	0.036	397.29	0.000
19	-0.074	0.040	398.77	0.000
20	-0.181	-0.046	407.75	0.000
21	-0.107	0.110	410.89	0.000
22	0.145	-0.070	416.75	0.000
23	0.014	-0.017	416.81	0.000
24	0.859	-0.003	623.42	0.000
25	-0.023	0.005	623.56	0.000
26	0.187	-0.009	633.38	0.000
27	-0.183	-0.013	642.88	0.000
28	-0.128	-0.051	647.55	0.000
29	-0.074	-0.018	649.09	0.000
30	-0.408	0.052	696.98	0.000
31	-0.070	-0.020	698.38	0.000
32	-0.203	-0.115	710.36	0.000
33	-0.069	0.028	711.77	0.000
34	0.118	-0.001	715.82	0.000
35	0.035	-0.014	716.18	0.000
36	0.783	-0.102	897.23	0.000

Dependent Variable: DCONST
Method: ARMA Maximum Likelihood (BFGS)
Date: 04/13/19 Time: 10:04
Sample: 1993M02 2013M12
Included observations: 251
Convergence achieved after 7 iterations
Coefficient covariance computed using outer product of gradients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	214.4219	1374.109	0.156044	0.8761
AR(1)	0.497140	0.054595	9.105947	0.0000
AR(2)	0.116143	0.052147	2.227211	0.0268
SAR(12)	0.944592	0.013249	71.29646	0.0000
SIGMASQ	373960.6	26485.07	14.11968	0.0000

R-squared	0.934603	Mean dependent var	49.44223
Adjusted R-squared	0.933540	S.D. dependent var	2396.078
S.E. of regression	617.7066	Akaike info criterion	15.81783
Sum squared resid	93864109	Schwarz criterion	15.88805
Log likelihood	-1980.137	Hannan-Quinn criter.	15.84609
F-statistic	878.9103	Durbin-Watson stat	1.975678
Prob(F-statistic)	0.000000		

Date: 04/13/19 Time: 10:04
Sample: 1993M01 2013M12
Included observations: 251
Q-statistic probabilities adjusted for 3 ARMA terms

Lag	AC	PAC	Q-Stat	Prob
1	0.011	0.011	0.0322	
2	0.054	0.054	0.7743	
3	-0.054	-0.056	1.5282	
4	-0.032	-0.034	1.7972	0.180
5	0.042	0.049	2.2539	0.324
6	-0.091	-0.092	4.3953	0.222
7	-0.081	-0.089	6.1091	0.191
8	0.112	0.132	9.3965	0.094
9	-0.073	-0.078	10.799	0.095
10	-0.031	-0.065	11.048	0.137
11	-0.041	-0.009	11.501	0.175
12	-0.005	-0.001	11.507	0.243
13	-0.013	-0.053	11.553	0.316
14	-0.007	0.014	11.565	0.397
15	0.006	0.021	11.575	0.480
16	0.019	-0.024	11.670	0.555
17	0.040	0.045	12.109	0.598
18	-0.095	-0.096	14.580	0.482
19	0.042	0.037	15.068	0.520
20	0.070	0.082	16.416	0.495
21	-0.041	-0.061	16.875	0.532
22	0.010	-0.006	16.904	0.596
23	-0.005	0.036	16.912	0.659
24	0.158	0.146	23.933	0.296
25	0.008	-0.038	23.952	0.350
26	-0.075	-0.038	25.527	0.324
27	-0.033	-0.021	25.837	0.362
28	0.024	0.018	25.999	0.408
29	-0.044	-0.047	26.564	0.432
30	-0.043	-0.024	27.097	0.459
31	-0.037	-0.000	27.498	0.491
32	0.064	0.024	28.673	0.482
33	0.022	0.028	28.816	0.527
34	0.044	0.058	29.388	0.549
35	-0.016	-0.004	29.459	0.596
36	-0.071	-0.119	30.955	0.569

While coefficients are statistically significant in both AR(1) and AR(2)+S-AR(1) model, both the AIC and the BIC favor AR(2)+S-AR(1) model, and the correlograms of residuals shows that there is a serious problem with seasonality that is not accounted for in the AR(1). Overall, AR(2)+SAR(1) is a much better model for change in monthly private residential construction spending.

Question 15 (8 points)

Consider two models for U.S. real GDP, used to construct forecast for the period 2010Q1-2016Q4:

- model A: deterministic trend model for which the sequence of 1-step ahead forecasts has RMSE=103.45 and the multistep forecast has RMSE=1649.06
- model B: stochastic trend model for which the sequence of 1-step ahead forecasts has RMSE=77.32 and the multistep forecast has RMSE=905.18.

The 1-step ahead forecasts are then used to perform the test of equal predictive ability be estimating

$$\Delta L_{t+j,1} = \beta_0 + u_{t+j} \quad \text{with } j = 0, 1, 2, \ldots, T-t-1$$

where $\Delta L_{t+j,1} = (e^A_{t+j,1})^2 - (e^B_{t+j,1})^2$, and $e^k_{t+j,1}$ is the one step ahead forecast error for forecast from model k in period $t+j$. Explain the idea behind this test and interpret its results below. Discuss how we would use it together with above RMSE values in model selection process.

Dependent Variable: DL_TREND
Method: Least Squares
Date: 04/09/17 Time: 18:34
Sample (adjusted): 2010Q1 2016Q4
Included observations: 28 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5454.311	1293.939	4.215275	0.0002

R-squared	0.000000	Mean dependent var	5454.311
Adjusted R-squared	0.000000	S.D. dependent var	6846.884
S.E. of regression	6846.884	Akaike info criterion	20.53604
Sum squared resid	1.27E+09	Schwarz criterion	20.58361
Log likelihood	-286.5045	Hannan-Quinn criter.	20.55058
Durbin-Watson stat	2.683486		

The main idea behind the test of equal predictive ability is to test whether the difference in MSE or RMSE between two two competing forecasts is statistically significant or not. The null hypothesis of equal predictive ability of forecasts from two models A and B is that the difference in the MSE and RMSE is not statistically significant, and thus the estimated coefficient β_0 in the test regression is not statistically significant. If β_0 is statistically significant we reject the hypothesis of equal predictive ability of forecasts A and B. This is exactly the case here when comparing model A: a deterministic trend model for real GDP growth vs model B: stochastic trend model since the p-value for β_0 is only 0.0002. Model B is thus a much better model for real GDP growth rate forecasting.

Question 16. (8 points)

Interpret the results of the Granger causality test for a VAR with two variables: $y_{1,t} = 400\Delta \log GDP_t$ is the growth rate of the U.S. real GDP and $y_{2,t} = 400(\Delta \log SP500_t - \Delta \log p_t^{GDP})$ is the inflation adjusted return of S&P 500.

Explain what these Granger causality imply about the usefulness of each of the variables when it comes to predicting the other one. Is there any economic intuition behind these results?

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 04/26/18 Time: 16:57
Sample: 2000Q1 2016Q4
Included observations: 68

Dependent variable: DLRGDP

Excluded	Chi-sq	df	Prob.
DLRSP500	6.679366	2	0.0354
All	6.679366	2	0.0354

Dependent variable: DLRSP500

Excluded	Chi-sq	df	Prob.
DLRGDP	1.201515	2	0.5484
All	1.201515	2	0.5484

The Granger causality tests show that

- we reject the hypothesis that real return of the S&P 500 is not Granger causing real GDP growth rate, since the p-value for the test with $H_0 : \beta_{11} = \beta_{12} = 0$ is 0.0354
- we can not reject the hypothesis that real GDP growth rate is not Granger causing real return of the S&P 500, since the p-value for the test with $H_0 : \alpha_{21} = \alpha_{22} = 0$ is 0.5484

The real returns of the S&P 500 index in the current quarter and the previous quarter are thus useful for predicting next quarter's real GDP growth rate, but real GDP growth in the current quarter and the previous quarter are not useful for predicting next quarter's real return pf the S&P 500 index.

The intuition behind this result is that the financial markets are incorporating news fast, and thus move up or down before the GDP does - they are procyclical but lead the GDP.

Question 17. (8 points)

Consider a bivariate VEC

$$\Delta \log p_t^{GAS} = \gamma_1 z_{t-1} + \kappa_{11} \Delta \log p_{t-1}^{GAS} + \kappa_{12} \Delta \log p_{t-2}^{GAS} + \phi_{11} \Delta \log p_{t-1}^{OIL} + \phi_{12} \Delta \log p_{t-2}^{OIL} + \varepsilon_{1,t}$$
$$\Delta \log p_t^{OIL} = \gamma_2 z_{t-1} + \kappa_{21} \Delta \log p_{t-1}^{GAS} + \kappa_{22} \Delta \log p_{t-2}^{GAS} + \phi_{21} \Delta \log p_{t-1}^{OIL} + \phi_{22} \Delta \log p_{t-2}^{OIL} + \varepsilon_{2,t}$$

where $z_{t-1} = \log p_{t-1}^{GAS} - \beta_1 \log p_{t-1}^{OIL} - \beta_0$ is the error terms period $t-1$.

Is the coefficient β_1 statistically significant? Interpret what the estimated value for β_1 means.

Are γ_1 and γ_2 statistically significant? Are the signs of γ_1 and γ_2 in the estimated VEC model consistent with error correction mechanism that moves the system back to the long run equilibrium, whenever there is a disruption and $z_{t-1} \neq 0$?

Vector Error Correction Estimates
Date: 05/05/19 Time: 14:53
Sample (adjusted): 1995M04 2010M12
Included observations: 189 after adjustments
Standard errors in ( ) & t-statistics in [ ]

Cointegrating Eq:	CointEq1	
LOG(PGAS(-1))	1.000000	
LOG(POIL(-1))	-0.596465 (0.01477) [-40.3934]	
C	1.582645 (0.05270) [30.0338]	
Error Correction:	**D(LOG(PGAS))**	**D(LOG(POIL))**
CointEq1	-0.329559 (0.07388) [-4.46050]	-0.111602 (0.12907) [-0.86464]
D(LOG(PGAS(-1)))	0.354414 (0.09821) [3.60885]	-0.114818 (0.17157) [-0.66924]
D(LOG(PGAS(-2)))	-0.125795 (0.09095) [-1.38320]	-0.027945 (0.15888) [-0.17589]
D(LOG(POIL(-1)))	0.104894 (0.06474) [1.62034]	0.201887 (0.11309) [1.78517]
D(LOG(POIL(-2)))	0.008025 (0.06324) [0.12688]	0.079805 (0.11048) [0.72232]

The estimated coefficient $\beta_1 = 0.596$ implies that in the long run a one percent increase in price of oil increases price of gas by 0.596 percent.

The adjustment parameters are $\gamma_1 = -0.329$ and $\gamma_2 = -0.111$. For error correction mechanism to move the system back to the long run equilibrium, whenever there is a disruption and $z_{t-1} \neq 0$ the adjustment parameters need to satisfy $\gamma_1 \leq 0$, $\gamma_2 \geq 0$ and they can not be both equal zero at the same time. In the estimated VEC γ_1 is consistent with the error correction mechanism since it's negative, while γ_2 is not consistent with the error correction mechanism because it's negative. But only γ_1 is statistically significant, γ_2 is not. It thus makes sense to restrict the model and impose $\gamma_2 = 0$ which will make model consistent with the error correction mechanism that moves the system back to the long run equilibrium, whenever there is a disruption and $z_{t-1} \neq 0$.

Question 18. (8 points)

Consider the GARCH(1,1) model for the S&P 500 daily returns.

Dependent Variable: R
Method: ML - ARCH (BHHH) - Normal distribution
Sample: 5815 8471
Included observations: 2657
Convergence achieved after 10 iterations
Bollerslev-Wooldrige robust standard errors & covariance
Variance backcast: ON
GARCH = C(2) + C(3)*RESID(-1)^2 + C(4)*GARCH(-1)

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.036267	0.017439	2.079665	0.0376
Variance Equation				
C	0.010421	0.005245	1.987099	0.0469
RESID(-1)^2	0.065649	0.011338	5.790038	0.0000
GARCH(-1)	0.927400	0.011045	83.96233	0.0000

R-squared	-0.000534	Mean dependent var	0.009761
Adjusted R-squared	-0.001666	S.D. dependent var	1.146761
S.E. of regression	1.147716	Akaike info criterion	2.888638
Sum squared resid	3494.671	Schwarz criterion	2.897498
Log likelihood	-3833.556	Durbin-Watson stat	2.079139

Write the equations for the estimated GARCH(1,1) model, with estimated parameter values plugged into these equations.

On April 2, 2008, the 1-day-ahead conditional mean is $\mu_{t|t-1} = 0.036$, the 1-day-ahead conditional standard deviation $\sigma_{t|t-1} = 1.785$. Calculate the 1% VaR and 5% VaR, given that $\Phi^{-1}(0.05) = -1.645$ and $\Phi^{-1}(0.01) = -2.326$. Interpret these numbers, given a portfolio worth 1 million dollars.

The estimated GARCH(1,1) model is

$$r_t = 0.036 + \varepsilon_t$$
$$\varepsilon_t = \sigma_{t|t-1} z_t \qquad z_t \sim N(0,1)$$
$$\sigma^2_{t|t-1} = 0.010 + 0.065\varepsilon^2_{t-1} + 0.927\sigma^2_{t-1|t-2}$$

With normally distributed innovastions, the 1% VaR and 5% VaR are calculated as

$$r_t^{VaR(0.01)} = \mu_{t|t-1} - 2.326\sigma_{t|t-1}$$

and

$$r_t^{VaR(0.05)} = \mu_{t|t-1} - 1.645\sigma_{t|t-1}$$

Thus, the 1% VaR is $0.036 - 2.326 \times 1.785 = -4.117\%$ and the 5% VaR is $0.036 - 1.645 \times 1.785 = -2.900\%$. This means that if on April 1, we have a portfolio worth 1 million dollars, there is 1% chance that we could lose at least \$41,170 on April 2 and 1% chance that we could lose at least \$29,000.