Last name: ____________________________

Given name: ____________________________

Lucerne University of Applied Sciences

Time Series Analysis

Final Exam

Last name: ____________________________

Given name: ____________________________

mscbf_ rm01_ tsa, Fall term

Time Series Analysis
Fall term

Final Exam

Last name: ______________________

mscbf_ rm01_ tsa

Question 0

1. Hi

0 pts

Question 1 (27 points)

1. I have simulated 1000 observations $\{y_t\}$ from an ARMA(p, q) model. Figure 2 on Page 11 shows a plot of the correlogram. Based on it, what do you think p and q are, and why?

6 pts

2. The 11th sample autocorrelation (not shown in the graph) is $\hat{\tau}_{11} = -0.045$. Test if $\hat{\tau}_{11}$ is significantly different from zero.

6 pts

3. The output in Figure 3 on Page 11 shows the results of regressing Δy_t (`y`) on y_{t-1} (`x1`) and Δy_{t-1} (`x2`). Use it to test if the data are integrated.

6 pts

4. I have estimated a particular ARMA model. The estimation output is shown in Figure 4 on Page 12. Write down the estimated model in equation form.

3 pts

5. Use the estimated model from the previous question to forecast the value of the series at $t = 1001$. You may need some of the values below.

6 pts

t	y_t	u_t
999	-0.77	-4.18
1000	-0.75	-1.41

Question 2 (27 points) In this exercise, we analyze the daily returns on Tesla stock between 6/29/2010 and 12/14/2022. The returns are shown in Figure 1.

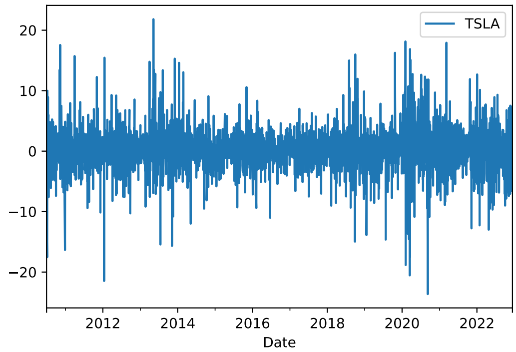

Figure 1: Returns on Tesla stock

The data clearly display volatility clustering, which we want to model using a GARCH model. The output is shown in Figure 5 on Page 12.

1. Write the model down as an equation (only the volatility equation).

3 pts

2. Does your model incorporate a leverage effect? Justify your answer.

6 pts

3. Explain what the standardized residuals from a GARCH model are, ideally with an equation. Also, explain what their properties should be if the volatility model is correct.

6 pts

4. Regressing the squared standardized residuals on an intercept and 5 of their own lags results in an R^2 of 0.00364. Use this to test if the GARCH model has successfully removed the volatility clustering.

6 pts

5. Use the model to predict the variance σ^2_{t+1} for 12/15/2022, using the following values on 12/14/2022: $\hat{u}_t = -2.72$ and $\sigma^2_t = 15.198$.

6 pts

Question 3 (18 points) We now turn our attention to Value at Risk forecasting.

1. Use the model from the previous question to predict the 1% Value at Risk for 12/15/2022. Note: If you weren't successful in predicting the variance in the previous question, you can use the value $\widehat{\sigma}^2_{t+1} = 15.00$. 6 pts

2. In a backtesting exercise, we have created 1% VaR forecasts for the entire sample. From this and the returns, we have created the hit series $\{I_t\}$. 12 pts

(a) (6 pts) Explain how the hit series is defined, and how many times you expect it to equal 1 if the VaR model is correct.

(b) (6 pts) Figure 6 on page 13 shows the result of regressing $(I_t - 0.01)$ on an intercept and I_{t-1}. Use it to test the independence of the VaR violations.

Question 4 (18 points) Answer the questions below.

18 pts

1.

(a) (3 pts) Spurious regressions can occur between cointegrated variables.

☐ True ☐ False

(b) (3 pts) In a stationary time series, shocks U_t have a transitory effect on the future of the series.

☐ True ☐ False

(c) (3 pts) An ARCH(q) model for the returns corresponds to an AR(q) for the squared returns.

☐ True ☐ False

(d) (3 pts) The order q of an MA(q) model can be determined from the correlogram.

☐ True ☐ False

(e) (3 pts) In the presence of the leverage effect, the news impact curve is steeper to the right of the origin than to the left.

☐ True ☐ False

(f) (3 pts) A VaR model is correctly specified if no VaR violations occur.

☐ True ☐ False

End of exam.

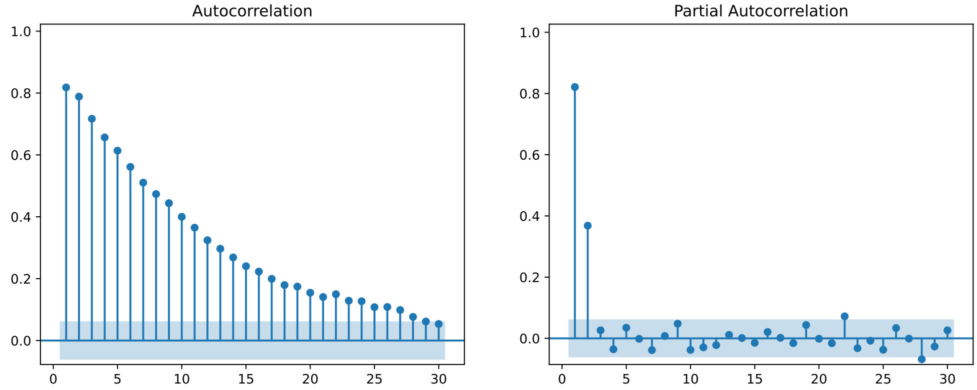

Figure 2: Correlogram of simulated data.

```
                            OLS Regression Results
==============================================================================
Dep. Variable:                      y   R-squared:                       0.208
Model:                            OLS   Adj. R-squared:                  0.207
Method:                 Least Squares   F-statistic:                     130.9
Date:                Mon, 16 Oct 2023   Prob (F-statistic):           3.47e-51
Time:                        15:04:00   Log-Likelihood:                -2086.9
No. Observations:                 998   AIC:                             4180.
Df Residuals:                     995   BIC:                             4195.
Df Model:                           2
Covariance Type:            nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
x1            -0.1161      0.018     -6.520      0.000      -0.151      -0.081
x2            -0.3594      0.030    -12.164      0.000      -0.417      -0.301
const          0.0309      0.062      0.497      0.619      -0.091       0.153
==============================================================================
Omnibus:                        0.529   Durbin-Watson:                   2.023
Prob(Omnibus):                  0.768   Jarque-Bera (JB):                0.404
Skew:                           0.003   Prob(JB):                        0.817
Kurtosis:                       3.098   Cond. No.                         3.76
==============================================================================
```

Figure 3: Output for ADF test.

```
                               SARIMAX Results
==============================================================================
Dep. Variable:                      y   No. Observations:                 1000
Model:                 ARIMA(2, 0, 0)   Log Likelihood               -2091.958
Date:                Mon, 16 Oct 2023   AIC                           4191.917
Time:                        15:10:43   BIC                           4211.548
Sample:                             0   HQIC                          4199.378
                               - 1000
Covariance Type:                  opg
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
const          0.2158      0.528      0.409      0.683      -0.818       1.250
ar.L1          0.5236      0.032     16.396      0.000       0.461       0.586
ar.L2          0.3595      0.032     11.326      0.000       0.297       0.422
sigma2         3.8369      0.169     22.770      0.000       3.507       4.167
===================================================================================
Ljung-Box (L1) (Q):                   0.13   Jarque-Bera (JB):                 0.36
Prob(Q):                              0.71   Prob(JB):                         0.83
Heteroskedasticity (H):               0.86   Skew:                             0.00
Prob(H) (two-sided):                  0.18   Kurtosis:                         3.09
===================================================================================
```

Figure 4: Estimated ARMA model.

```
                     Constant Mean - GARCH Model Results
==============================================================================
Dep. Variable:                   TSLA   R-squared:                       0.000
Mean Model:             Constant Mean   Adj. R-squared:                  0.000
Vol Model:                      GARCH   Log-Likelihood:               -8267.70
Distribution:                  Normal   AIC:                           16543.4
Method:            Maximum Likelihood   BIC:                           16567.6
                                        No. Observations:                 3138
Date:                Mon, Oct 16 2023   Df Residuals:                     3137
Time:                        15:33:03   Df Model:                            1
                                 Mean Model
===========================================================================
                 coef    std err          t      P>|t|     95.0% Conf. Int.
---------------------------------------------------------------------------
mu             0.1118  5.774e-02      1.936  5.281e-02 [-1.359e-03,  0.225]
                              Volatility Model
============================================================================
                 coef    std err          t      P>|t|      95.0% Conf. Int.
----------------------------------------------------------------------------
omega          0.1400      0.117      1.196      0.232  [-8.938e-02,  0.369]
alpha[1]       0.0323  1.341e-02      2.409  1.599e-02 [6.024e-03,5.859e-02]
beta[1]        0.9564  2.205e-02     43.369      0.000     [  0.913,  1.000]
============================================================================
```

Figure 5: Estimated GARCH model.

```
                            OLS Regression Results
==============================================================================
Dep. Variable:     np.subtract(I, 0.01)   R-squared:                       0.000
Model:                              OLS   Adj. R-squared:                  0.000
Method:                   Least Squares   F-statistic:                     1.409
Date:                  Mon, 16 Oct 2023   Prob (F-statistic):              0.235
Time:                          18:54:56   Log-Likelihood:                 1976.8
No. Observations:                  3137   AIC:                           -3950.
Df Residuals:                      3135   BIC:                           -3938.
Df Model:                             1
Covariance Type:              nonrobust
==============================================================================
                 coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
b0             0.0065      0.002      2.817      0.005       0.002       0.011
I.shift(1)     0.0212      0.018      1.187      0.235      -0.014       0.056
==============================================================================
Omnibus:                     4069.691   Durbin-Watson:                   2.001
Prob(Omnibus):                  0.000   Jarque-Bera (JB):           412759.104
Skew:                           7.492   Prob(JB):                         0.00
Kurtosis:                      57.160   Cond. No.                         7.76
==============================================================================
```

Figure 6: Test regression for the Value at Risk backtest.