Kilger
MKT6971
Exercise #3

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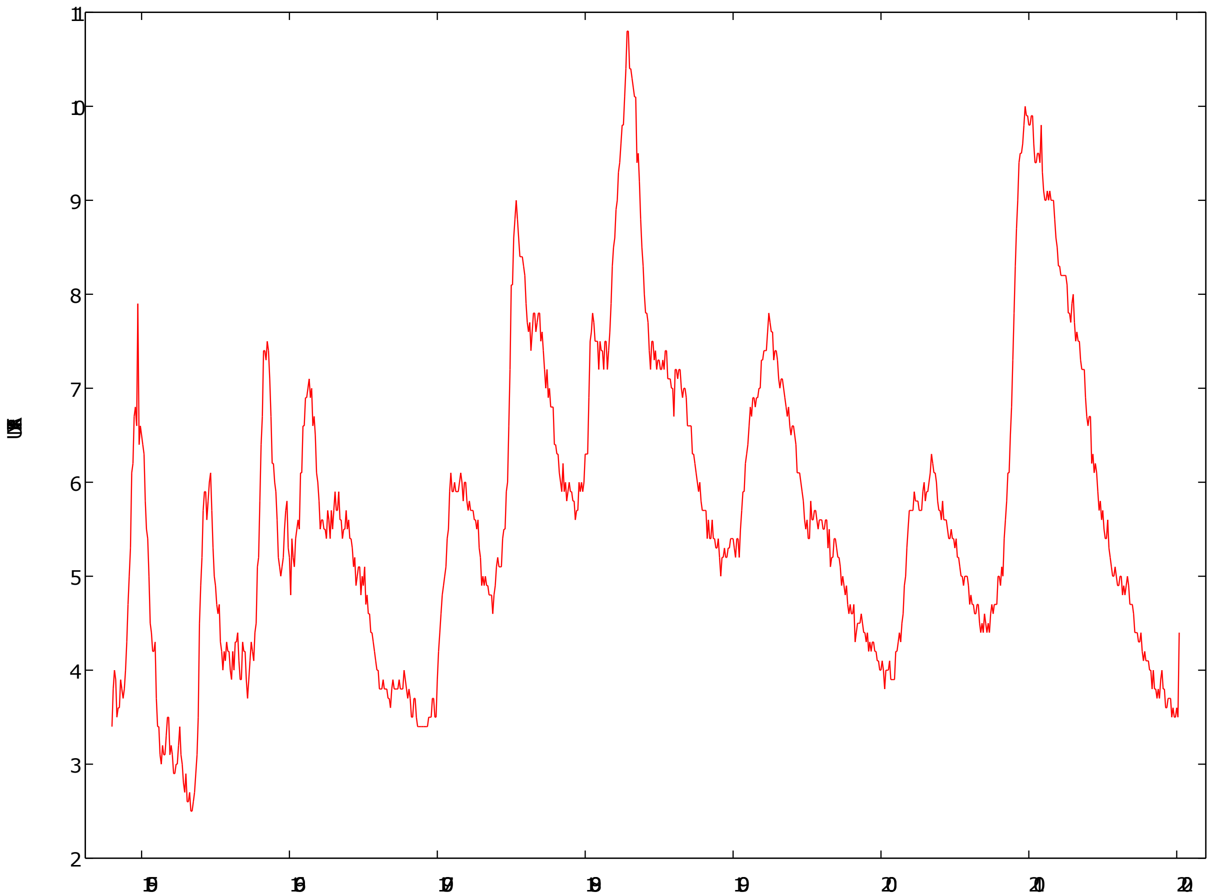
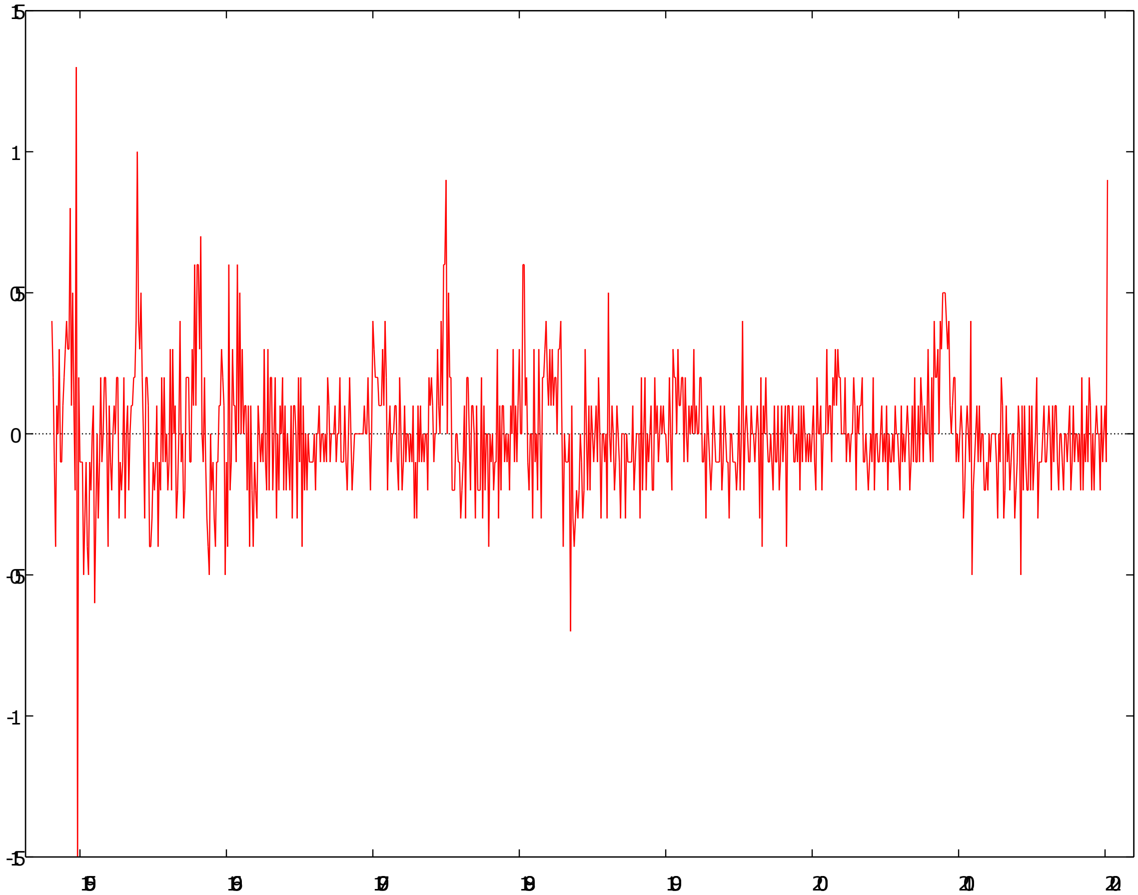
Here is the third and final exercise.  It lists the unemployment rate in the US from January 1948 to March 2020.  Here is the plot:



The unit root tests suggest a non-constant mean so here is the plot of the first differenced data:



Next step was to run some ARIMA models and compare them. This led to the following ARIMA runs:

Model 1

Model 1: ARMA, using observations 1948:02-2020:03 (T = 866)
Dependent variable: d_UNRATE
Standard errors based on Hessian

| | *Coefficient* | *Std. Error* | *z* | *p-value* | |
|---|---|---|---|---|---|
| const | 0.00287270 | 0.0147910 | 0.1942 | 0.8460 | |
| phi_1 | 0.870665 | 0.0296668 | 29.35 | <0.0001 | *** |
| theta_1 | −0.718031 | 0.0379465 | −18.92 | <0.0001 | *** |

| | | | |
|---|---|---|---|
| Mean dependent var | 0.001155 | S.D. dependent var | 0.209924 |
| Mean of innovations | −0.000378 | S.D. of innovations | 0.200521 |
| R-squared | 0.086522 | Adjusted R-squared | 0.085465 |
| Log-likelihood | 162.6270 | Akaike criterion | −317.2540 |
| Schwarz criterion | −298.1985 | Hannan-Quinn | −309.9612 |

| | | *Real* | *Imaginary* | *Modulus* | *Frequency* |
|---|---|---|---|---|---|
| AR | | | | | |
| | Root 1 | 1.1485 | 0.0000 | 1.1485 | 0.0000 |
| MA | | | | | |
| | Root 1 | 1.3927 | 0.0000 | 1.3927 | 0.0000 |

```
Test for autocorrelation up to order 12

Ljung-Box Q' = 75.3636,
with p-value = P(Chi-square(10) > 75.3636) = 4.042e-012
```

Model 2

Model 2: ARMA, using observations 1948:02-2020:03 (T = 866)
Dependent variable: d_UNRATE
Standard errors based on Hessian

| | *Coefficient* | *Std. Error* | *z* | *p-value* | |
|---|---|---|---|---|---|
| const | 0.00298555 | 0.0148977 | 0.2004 | 0.8412 | |
| phi_1 | 0.555245 | 0.0625183 | 8.881 | <0.0001 | *** |
| phi_2 | 0.238727 | 0.0373804 | 6.386 | <0.0001 | *** |
| theta_1 | −0.538385 | 0.0583563 | −9.226 | <0.0001 | *** |

| | | | |
|---|---|---|---|
| Mean dependent var | 0.001155 | S.D. dependent var | 0.209924 |
| Mean of innovations | −0.000420 | S.D. of innovations | 0.196462 |
| R-squared | 0.123133 | Adjusted R-squared | 0.121101 |
| Log-likelihood | 180.2785 | Akaike criterion | −350.5570 |
| Schwarz criterion | −326.7375 | Hannan-Quinn | −341.4410 |

| | | *Real* | *Imaginary* | *Modulus* | *Frequency* |
|---|---|---|---|---|---|
| AR | | | | | |
| | Root 1 | 1.1911 | 0.0000 | 1.1911 | 0.0000 |
| | Root 2 | -3.5169 | 0.0000 | 3.5169 | 0.5000 |
| MA | | | | | |
| | Root 1 | 1.8574 | 0.0000 | 1.8574 | 0.0000 |

```
Test for autocorrelation up to order 12

Ljung-Box Q' = 36.8101,
with p-value = P(Chi-square(9) > 36.8101) = 2.845e-005
```

Model 3

Model 3: ARMA, using observations 1948:02-2020:03 (T = 866)
Dependent variable: d_UNRATE
Standard errors based on Hessian

| | *Coefficient* | *Std. Error* | *z* | *p-value* | |
|---|---|---|---|---|---|
| const | 0.00257941 | 0.0115202 | 0.2239 | 0.8228 | |
| phi_1 | 1.65561 | 0.0374836 | 44.17 | <0.0001 | *** |
| phi_2 | −0.782771 | 0.0433592 | −18.05 | <0.0001 | *** |
| theta_1 | −1.64177 | 0.0383751 | −42.78 | <0.0001 | *** |
| theta_2 | 0.863215 | 0.0479172 | 18.01 | <0.0001 | *** |

| | | | |
|---|---|---|---|
| Mean dependent var | 0.001155 | S.D. dependent var | 0.209924 |
| Mean of innovations | −0.000443 | S.D. of innovations | 0.194870 |
| R-squared | 0.137289 | Adjusted R-squared | 0.134286 |
| Log-likelihood | 187.0535 | Akaike criterion | −362.1069 |
| Schwarz criterion | −333.5236 | Hannan-Quinn | −351.1678 |

| | | *Real* | *Imaginary* | *Modulus* | *Frequency* |
|---|---|---|---|---|---|
| AR | | | | | |
| | Root 1 | 1.0575 | -0.3989 | 1.1303 | -0.0574 |
| | Root 2 | 1.0575 | 0.3989 | 1.1303 | 0.0574 |
| MA | | | | | |
| | Root 1 | 0.9510 | -0.5041 | 1.0763 | -0.0776 |
| | Root 2 | 0.9510 | 0.5041 | 1.0763 | 0.0776 |

```
Test for autocorrelation up to order 12

Ljung-Box Q' = 39.2977,
with p-value = P(Chi-square(8) > 39.2977) = 4.328e-006
```

Model 4

Model 15: ARMA, using observations 1948:02-2020:03 (T = 866)
Dependent variable: d_UNRATE
Standard errors based on Hessian

| | *Coefficient* | *Std. Error* | *z* | *p-value* | |
|---|---|---|---|---|---|
| const | 0.00250730 | 0.0113898 | 0.2201 | 0.8258 | |
| phi_1 | 0.578072 | 0.0624914 | 9.250 | <0.0001 | *** |
| phi_2 | 0.117027 | 0.0739480 | 1.583 | 0.1135 | |
| phi_3 | 0.611279 | 0.108845 | 5.616 | <0.0001 | *** |
| phi_4 | −0.695650 | 0.0557809 | −12.47 | <0.0001 | *** |
| theta_1 | −0.585967 | 0.0671052 | −8.732 | <0.0001 | *** |
| theta_2 | 0.0631790 | 0.0740003 | 0.8538 | 0.3932 | |
| theta_3 | −0.595233 | 0.107839 | −5.520 | <0.0001 | *** |
| theta_4 | 0.766918 | 0.0693611 | 11.06 | <0.0001 | *** |
| theta_5 | 0.0305044 | 0.0709625 | 0.4299 | 0.6673 | |

| | | | |
|---|---|---|---|
| Mean dependent var | 0.001155 | S.D. dependent var | 0.209924 |
| Mean of innovations | −0.000422 | S.D. of innovations | 0.192210 |
| R-squared | 0.160680 | Adjusted R-squared | 0.152845 |
| Log-likelihood | 198.7941 | Akaike criterion | −375.5881 |
| Schwarz criterion | −323.1854 | Hannan-Quinn | −355.5330 |

| | | *Real* | *Imaginary* | *Modulus* | *Frequency* |
|---|---|---|---|---|---|
| AR | | | | | |
| | Root 1 | 1.0508 | 0.4052 | 1.1262 | 0.0586 |
| | Root 2 | 1.0508 | -0.4052 | 1.1262 | -0.0586 |
| | Root 3 | -0.6114 | -0.8715 | 1.0646 | -0.3474 |
| | Root 4 | -0.6114 | 0.8715 | 1.0646 | 0.3474 |
| MA | | | | | |
| | Root 1 | 0.9450 | 0.5028 | 1.0704 | 0.0778 |
| | Root 2 | 0.9450 | -0.5028 | 1.0704 | -0.0778 |
| | Root 3 | -0.5661 | -0.8856 | 1.0511 | -0.3405 |
| | Root 4 | -0.5661 | 0.8856 | 1.0511 | 0.3405 |
| | Root 5 | -25.8989 | 0.0000 | 25.8989 | 0.5000 |

LM test for autocorrelation up to order 12 -
Null hypothesis: no autocorrelation
Test statistic: Chi-square(3) = 17.9674

```
Test for autocorrelation up to order 12

Ljung-Box Q' = 17.9674,
with p-value = P(Chi-square(3) > 17.9674) = 0.0004467
```

1. What kind of metrics are the Akaike (AIC), Schwartz (BIC) and Hannan-Quinn statistics?

   AIC: is a math method that evaluates how the selected model fits with the data it is from.
   BIC: Is a statistical model that uses comparative evaluation from times series as measurements.
   Hannan-Quinn: Measures the fit of a model. but importantly - they are all relative measures of g

2. Which two are the most conservative in terms of penalizing the model for degrees of freedom?

   Model 2 &3

3. What does the Ljung Box Q test test for ?

   Autocorrelation in the residuals... -3

4. **Create a table with the ARIMA model designation, adjusted R square, AIC, BIC and Ljung Box values for the four models. What looks like the best model of the four? How do you tell? Be sure to paste your table into this exercise!**
   Model 3

where is your table? It distinctly says to paste your table into this exercise. And why model 3? you b

5. Examining the Ljung Box test statistic, do you think that there is more variance in the residuals that you might be able to find with some additional ARIMA models?
   No

   yes for all of the models because the p value for Ljung box < .05 in all of them -6