Kilger

MKT6971

Exercise #3

Name:

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?
2. Which two are the most conservative in terms of penalizing the model for degrees of freedom?
3. What does the Ljung Box Q test test for ?
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?
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?