Udit Lal

1. In this part you need to estimate ARMA models for GDP and report your estimation results
   1. Generate the growth rate of real gdp using the same formula you used in HW1. The code will automatically generate this for you, but you will need to add a comment that indicates what line performs this function. (The answer to this part should be provided in your code)
      1. Lines 50 and 55 calculate real GDP growth rates. Growthrate answers in the appendix.
   2. Estimate and report the ACF and PACF for GDP growth for up to 12 lags. The code will perform this for y ou, but you will need to report the results in your submission. Report the results for the ACF and the PACF you got for the first 12 lags exactly as they appear in R. The results should be included in your main submission. You can either
      1. Make a table and enter the results yourself in a formatted table that is included in your main submission

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 1.0 | 0.357 | 0.233 | 0.027 | -0.05 | -0.121 | -0.041 | -0.052 | -0.022 | 0.057 | 0.089 | 0.029 | -0.096 |

* + 1. OR report the graphs for the ACF and the PACF in your main submission. A screenshot is NOT acceptable. Separate attachments with the graphs or the tables are NOT acceptable.
    2. Note: the default functions use years as the x-axis on the graphs, so when you read the graphs 12 lags= 3 years (3 years \* 4 quarters for years).
  1. Based on the results for the ACF and PACF, how many lags would you include if you had to estimate an ARMA(p,q) for output growth? Why? Are the results clear or ambiguous? The results should be included in your main submission.
     1. I would think that the optimal number of lags is 2. This is because the correlation is at a maximum when there is 2 lags. Also side note, if you let it lag for longer 19 has a randomly high correlation.
  2. Estimate an AR(1), AR(2), MA(1), MA(2), ARMA(1,1), ARMA(1,2), ARMA(2,1), and ARMA(2,2) model for gdp growth. The code gives you templates for estimating an AR1, AR2, MA1, and ARMA21 models. You will need to add your own code to estimate the MA(1), the ARMA11, ARMA12, and ARMA22 models. The results should be included in your main submission. It is up to you how you want to report the results of the regressions. You can report them as 8 equations, as 8 separate tables, or as 1 summary table. See an example of a summary table on the last page. The code also gives you the option to get the R output from several models in a single table that you can cut and paste.
     1. Table in appendix
  3. Change the template code to get the AIC and the BIC for all of the models. What model is selected by the AIC? What model is selected by the BIC? Did the model selection criteria match your “eyeball” selection criteria when you used informal visual analysis in part a?
     1. Both the AIC and the BIC prefer ARMA 21. This lines up with the prediction made earlier.

Appendix

**Answer to 1.a**

Qtr1 Qtr2 Qtr3 Qtr4

1948 1.637182420 0.571262447 0.111679256

1949 -1.387533247 -0.341679642 1.027122473 -0.842816777

1950 3.854857018 3.004252420 3.791591512 1.896662073

1951 1.349023605 1.717894892 2.040031816 0.219998432

1952 1.062879993 0.215154808 0.719278198 3.231420411

1953 1.841788563 0.770012245 -0.564282627 -1.525553856

1954 -0.479158756 0.108931856 1.123034480 1.937786146

1955 2.816218333 1.614082501 1.341440186 0.598530051

1956 -0.389161989 0.822937845 -0.089873056 1.632530432

1957 0.638350187 -0.219341989 0.975113141 -1.039977393

1958 -2.630134184 0.655219656 2.287490335 2.312362975

1959 1.903074417 2.231339792 0.071175461 0.284633317

1960 2.222417952 -0.540846716 0.488081633 -1.291741127

1961 0.672760941 1.683232422 1.901446766 1.942127332

1962 1.767879702 0.899613092 1.221022851 0.328321129

1963 1.085690472 1.115874811 2.174608925 0.653456192

1964 2.086361890 1.082820908 1.550222656 0.308416831

1965 2.390952899 1.255358379 2.198913777 2.277900962

1966 2.405076686 0.341034534 0.843338960 0.817025525

1967 0.881688309 0.061252194 0.941684840 0.751191779

1968 2.018973888 1.657004811 0.771984700 0.392531333

1969 1.552986016 0.303546165 0.658340329 -0.488878254

1970 -0.148595310 0.141819101 0.917354775 -1.077426993

1971 2.679762917 0.539653171 0.819616583 0.235501776

1972 1.822249224 2.244383847 0.939959468 1.660596725

1973 2.444685485 1.082768337 -0.527290341 0.944748591

1974 -0.863482384 0.237395088 -0.949628521 -0.388896492

1975 -1.224770301 0.712002948 1.697173724 1.337522657

1976 2.223849083 0.731017107 0.547220489 0.722231871

1977 1.174566974 1.925452775 1.788265641 0.002187149

1978 0.318669376 3.791457986 1.000501199 1.335192875

1979 0.179622245 0.106871915 0.740127777 0.249761375

1980 0.314021716 -2.082000705 -0.118919323 1.847748622

1981 1.940488241 -0.743837627 1.190410789 -1.095525155

1982 -1.565734448 0.455159142 -0.383027870 0.039934488

1983 1.309246158 2.250099700 1.979349786 2.064755777

1984 1.935909405 1.713034284 0.959446665 0.817512057

1985 0.964421279 0.876601927 1.515581154 0.740543226

1986 0.929173669 0.449372756 0.952481834 0.535638628

1987 0.742408757 1.073119335 0.863869915 1.702477834

1988 0.515296367 1.305310920 0.584218886 1.323696181

1989 1.011469844 0.760370959 0.738149675 0.196852894

1990 1.086862527 0.362251297 0.066500807 -0.914548690

1991 -0.468941632 0.776694733 0.504024267 0.347892821

1992 1.189943662 1.078516394 0.983420460 1.037761270

1993 0.167260350 0.580730119 0.476179198 1.350946809

1994 0.965539903 1.345947222 0.582813578 1.139012993

1995 0.354128367 0.297896724 0.847079663 0.676726063

1996 0.746156138 1.654091591 0.892992306 1.033027835

1997 0.643489523 1.648341356 1.243089560 0.855149663

1998 0.994518148 0.921547812 1.244787674 1.602963841

1999 0.942020899 0.766215698 1.301162875 1.685303673

2000 0.361107374 1.814600755 0.133466179 0.620957651

2001 -0.285585061 0.582853892 -0.415901767 0.272001114

2002 0.870712489 0.603905352 0.443586034 0.154702910

2003 0.553233578 0.856580668 1.683951052 1.141625635

2004 0.532327930 0.759187231 0.940887783 0.996690608

2005 1.100881537 0.460499384 0.887384916 0.629477750

2006 1.321516503 0.233427086 0.154513359 0.848257333

2007 0.235216257 0.571237726 0.541800932 0.606002006

2008 -0.576357600 0.515058393 -0.542826230 -2.187564921

2009 -1.129044839 -0.144093514 0.363449821 1.092395677

2010 0.384041356 0.917803572 0.734507154 0.500647205

2011 -0.240730776 0.712429510 -0.027782521 1.152616765

2012 0.779943285 0.429278790 0.134857236 0.113808459

2013 0.881775993 0.123320404 0.780362404 0.795079785

2014 -0.283105552 1.344600921 1.213538991 0.561215971

2015 0.781756360 0.738625048 0.330111171 0.032520210

2016 0.502128904 0.469243953 0.540826061 0.501456296

2017 0.565184440 0.532973998 0.787687100 0.871056893

2018 0.629968016 0.863377870 0.721042061 0.270965284

**1.d**

|  | **AR1** | **AR2** | **MA2** | **ARMA21** | **ARMA11** | **ARMA12** |
| --- | --- | --- | --- | --- | --- | --- |
| ar1 | 0.358 \*\*\* | 0.315 \*\*\* |  | -0.206 | 0.524 \*\*\* | 0.278 |
|  | (0.055) | (0.059) |  | (0.309) | (0.105) | (0.172) |
| intercept | 0.777 \*\*\* | 0.777 \*\*\* | 0.777 \*\*\* | 0.777 \*\*\* | 0.777 \*\*\* | 0.778 \*\*\* |
|  | (0.081) | (0.091) | (0.078) | (0.087) | (0.088) | (0.086) |
| ar2 |  | 0.120 \* |  | 0.310 \*\* |  |  |
|  |  | (0.059) |  | (0.101) |  |  |
| ma1 |  |  | 0.302 \*\*\* | 0.531 | -0.187 | 0.040 |
|  |  |  | (0.058) | (0.321) | (0.115) | (0.169) |
| ma2 |  |  | 0.227 \*\*\* |  |  | 0.181 \* |
|  |  |  | (0.055) |  |  | (0.074) |
| AIC | 731.575 | 729.456 | 728.439 | 729.488 | 731.168 | 728.523 |
| BIC | 742.511 | 744.038 | 743.021 | 747.715 | 745.750 | 746.750 |
| Log Likelihood | -362.787 | -360.728 | -360.220 | -359.744 | -361.584 | -359.262 |
| Num. obs. | 283 | 283 | 283 | 283 | 283 | 283 |