UK Macro History

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UK Macro Economic Relationships

We look at a subset of the full series between 1885 and 1985 with the following variables

- U_t: percent unemployment rate. Col ;
- P_t : PGDP: GDP deáator, 2013=100.
- Qt: real UK GDP at market prices, geographically consistent estimate based on post 1922 borders. £ mn Chained Volume measure, 2013 prices. Col A1.B.
- RS_t: short interest rates, percent per annum, (Bank Rate).
- RL_t: long interest rates, percent per annum, (Consol/10 year debt) Col

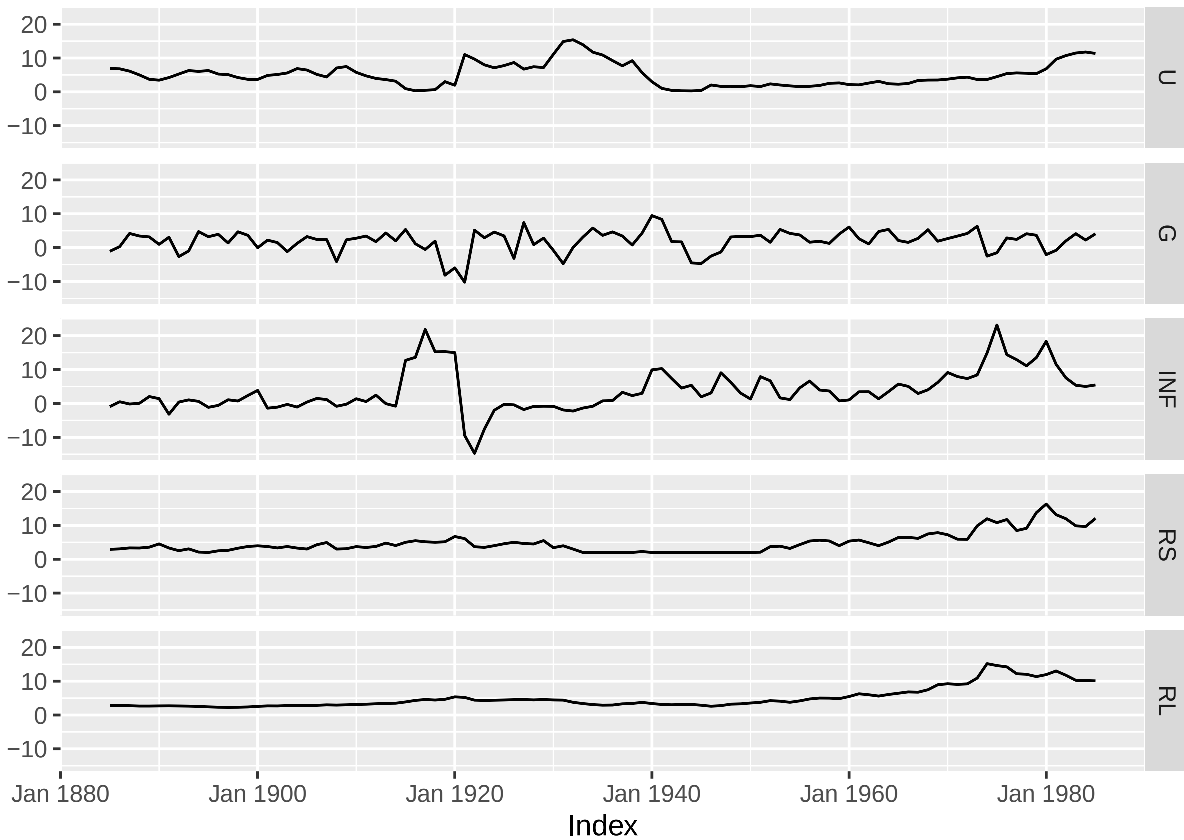
and their subsequent transformations

- log GDP: LQ_t
- log GDP deflator: LPt
- inflation: $INFt = 100($LP_t$ LP_{t-1})$;
- growth: $G_t = 100(LQ_t LQ_{t-1}$

Expected relationships

We would expect to see cycles of growth, decreasing unemployment, potentially encouraged by easier monetary policy and lower short term interest rates. In due course this may subsequently lead to inflationary pressures as slack in the labour supply decreases and wages increase. Measures of control may increases in short term interest rates and subsequent cooling of economic growth. We would also expect inflationary pressures to lead to higher long term interest rates. We may see inflationary shocks or high periods of inflation leading to poor economic growth.

```
autoplot.zoo(macro.subset)
```



Summary Statistics & Commentary

```r
summary(macro.subset)
```

```
##      Index            U                 G                  INF
##  Min.   :1885   Min.   : 0.2835   Min.   :-10.2153   Min.   :-14.7434
##  1st Qu.:1910   1st Qu.: 2.3972   1st Qu.:  0.9712   1st Qu.: -0.1722
##  Median :1935   Median : 4.3887   Median :  2.6406   Median :  2.3143
##  Mean   :1935   Mean   : 5.0910   Mean   :  1.9688   Mean   :  3.7673
##  3rd Qu.:1960   3rd Qu.: 6.8727   3rd Qu.:  3.9406   3rd Qu.:  6.6286
##  Max.   :1985   Max.   :15.3873   Max.   :  9.4607   Max.   : 23.1675
##        RS               RL
##  Min.   : 2.000   Min.   : 2.264
##  1st Qu.: 3.000   1st Qu.: 2.904
##  Median : 3.959   Median : 3.756
##  Mean   : 4.824   Mean   : 5.061
##  3rd Qu.: 5.496   3rd Qu.: 5.458
##  Max.   :16.301   Max.   :15.173
```

Unemployment averages at 5% over the period with an average growth rate of 1.96%. The mean of inflation is 3.76% with the short and long term interest rates averaging at 4.8% and 5% respectively. We see peaks of inflation at 23% during the 1970s oil crisis (similar sustained periods of high inflation during WWI), unemployment at 15% following the great depression. Short term and long term interest rates show significant increases during the 1970s and onwards.

```r
cor(macro.subset)
```

```
##                U           G         INF          RS          RL
```

```
## U    1.0000000 -0.0883304 -0.4006868  0.1359800  0.1201737
## G   -0.0883304  1.0000000 -0.1001583 -0.0861742 -0.0204763
## INF -0.4006868 -0.1001583  1.0000000  0.5439262  0.5781197
## RS   0.1359800 -0.0861742  0.5439262  1.0000000  0.9114121
## RL   0.1201737 -0.0204763  0.5781197  0.9114121  1.0000000
```

Unrestricted Model

We consider the unrestricted model $U_t = \alpha_0 + \alpha_1 U_{t-1} + \alpha_2 U_{t-2} + \beta_0 LQ_t + \beta_1 LQ_{t-1} + \beta_2 LQ_{t-2} + \gamma t + \epsilon_{1t}$ and observe the following

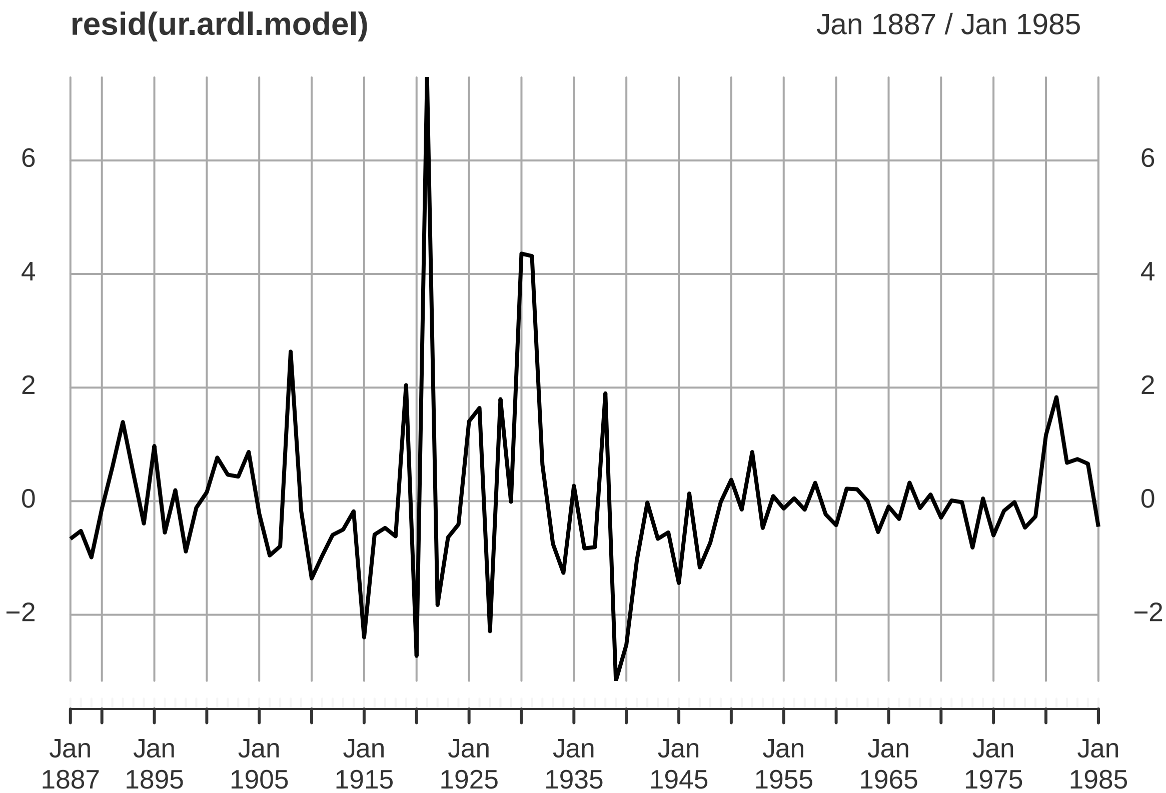
```
ur.ardl.model <- dyn$lm(U ~ stats::lag(U, k=1) +
                      stats::lag(U, k=2) +
                      stats::lag(LQ, k=1) +
                      stats::lag(LQ, k=2) + trend, data = macro.series)

summary(ur.ardl.model)
```

```
##
## Call:
## lm(formula = dyn(U ~ stats::lag(U, k = 1) + stats::lag(U, k = 2) +
##     stats::lag(LQ, k = 1) + stats::lag(LQ, k = 2) + trend), data = macro.series)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3.1630 -0.6100 -0.1478  0.3516  7.4618
##
## Coefficients:
##                        Estimate Std. Error t value Pr(>|t|)
## (Intercept)           -16.08803   15.58140  -1.033  0.30451
## stats::lag(U, k = 1)    0.82039    0.13432   6.108 2.32e-08 ***
## stats::lag(U, k = 2)    0.11268    0.14153   0.796  0.42797
## stats::lag(LQ, k = 1) -17.08970    6.30805  -2.709  0.00803 **
## stats::lag(LQ, k = 2)  18.50308    6.41456   2.885  0.00487 **
## trend                  -0.02005    0.02573  -0.780  0.43766
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.424 on 93 degrees of freedom
##   (2 observations deleted due to missingness)
## Multiple R-squared:  0.8388, Adjusted R-squared:  0.8301
## F-statistic: 96.76 on 5 and 93 DF,  p-value: < 2.2e-16
```

We note the coefficient of 1 period lagged unemployment, $\alpha_1 = 0.82$, as individually significant, suggesting a 1% increase in lagged unemployment will lead to a 0.82% increase in the following period. We also note that the lagged log GDP LQ as significant at the 5% level. In addition, we see that the coefficients LQ_{t-1} and LQ_{t-2} are of equal magnitute but of opposite sign. The trend, t nor 2 period lagged unemplpoyment, U_{t-2} are deemed to be significant.

```
plot(resid(ur.ardl.model))
```



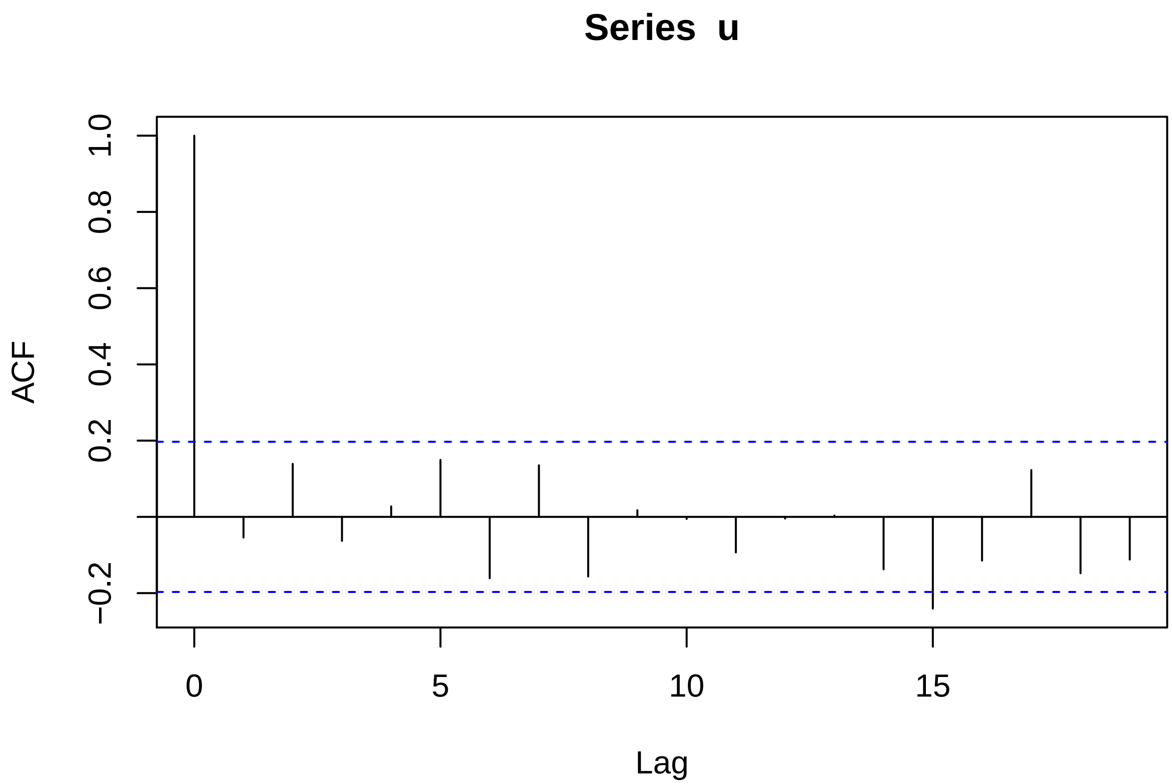
We can observe potential heteroskedasticity in the residuals with greater variance in the early to mid 20th century and some notable outliers.

Diagnostic tests

```
u <- resid(ur.ardl.model)
durbinWatsonTest(as.vector(u))
```

```
## [1] 2.104976
```

```
acf(u)
```



We note that DW is close to 2 (2.1) so no serial correlation. We can also observe this visually in the included ACF chart. The inclusion of two lagged terms appears to take care of any serial correlation concerns.

We test for heteroskedasticity using $\hat{u}_t^2 = \alpha + b' z_t + v_t$ using the hypothesis that $b' = 0$. In this case we use $z_t = x_t$

```
u2 <- u * u
summary(dyn$lm(u2 ~ stats::lag(U, k=1) +
                 stats::lag(U, k=2) +
                 stats::lag(LQ, k=1) +
                 stats::lag(LQ, k=2) + trend, data = macro.series))$fstatistic
```

```
##     value     numdf     dendf
##  3.853466  5.000000 93.000000
```

When we retrieve the F-statistic we see that this is 3.853 which at significance levels 1% to 10% means we can reject the null hypothesis that $b' = 0$ and of homoskedasticity and constant variance. Given what we observe visually in the residuals with differing regimes throughough the sample, a further variance ratio test (Goldfeld-Quandt) might be warranted

Note, However, if we perform a reset test $\hat{u}_i = \alpha + b' \hat{y}_i^2 + \epsilon_i$ we observe different results and we fail to reject the null hypothesis of homoskedasticity

```
yhat <- ur.ardl.model$fitted.values

summary(lm(as.vector(u) ~ (yhat * yhat)))
```

```
##
## Call:
## lm(formula = as.vector(u) ~ (yhat * yhat))
##
## Residuals:
```

```
##     Min      1Q  Median      3Q     Max
## -3.1630 -0.6100 -0.1478  0.3516  7.4618
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -8.519e-17  2.651e-01       0        1
## yhat         2.127e-17  4.452e-02       0        1
##
## Residual standard error: 1.394 on 97 degrees of freedom
## Multiple R-squared:  6.139e-33,  Adjusted R-squared:  -0.01031
## F-statistic: 5.955e-31 on 1 and 97 DF,  p-value: 1
```

Similarly another BPG test returns a p-value < 0.05 so we reject the null hypothesis of homoskedasticity. We can say our estimator is unbiased but not minimum variance and efficient.

```r
bptest(ur.ardl.model)
```

```
##
##  studentized Breusch-Pagan test
##
## data:  ur.ardl.model
## BP = 16.99, df = 5, p-value = 0.004518
```

Testing for normality using the Jarque Bera test we see a χ^2 value of 380 and a p-value $<$ 2.2e-16, so we reject the null hypothesis of normality.

```r
jarque.bera.test(u)
```

```
##
##  Jarque Bera Test
##
## data:  u
## X-squared = 380.73, df = 2, p-value < 2.2e-16
```

This implies our estimator is no longer the Maximum Likelihood estimator but is the minimum variance estimator in the class of linear unbiased estimators.

Performing a RESET test for functional form and non-linearity we see a p-value of > 0.05. We fail to reject the null hypothesis correct functional form and linearity. The RESET test takes the form of $y_t = \hat{\beta}_t x_t + \hat{u}_t$ then taking the residuals and $\hat{u}_t = b' x_t + c\hat{y}_t^2 + v_t$

Restricted Model

We consider the model Δ