DETERMINING THE STRUCTURAL BREAK IN SOME ECONOMIC VARIABLES OF PAKISTAN

By

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Structural Breaks Detection

Bai and Perron established a general methodology for estimating breakpoints and their associated confidence intervals in OLS regression employing dynamic programming. In that way, it is possible to find m breakpoints that minimize the residual sum of square (RSS) associated to a model with m+1 segments given some minimal segment size of h*n observations. The h bandwidth parameter is chosen by the user typically equal to 0.1 or 0.15. Since the number of breakpoints m is not known in advance, it is necessary to compute the optimal breakpoints for m = 0, 1, … breaks and choose the model that minimizes some information criterion such as BIC.

Structural Breaks Analysis

In the following, we determine the Exchange Rate time series structural changes dates, if any. Such analysis is named as “dating structural changes (breaks)”. Specifically, we are looking for:

* Level Structural Breaks

* Trend Structural Breaks

* Polynomial Fit Structural Breaks

* Auto-Regressive Model Structural Breaks

3.1 Research Design:

Appropriate quantitative techniques will be applied for the finding of this study. The method will be compare to find the adequate and appropriate technique to forecast the values of the water outflow data.

3.2 Data Collection and analysis

Secondary time series data of water outflow is used from 2015 to 2019 recorded on daily basis. Appropriate and adequate statistical method have been applied using R, a statistical software.

Determining the Structural Breaks in Exchange Rate of Pakistan

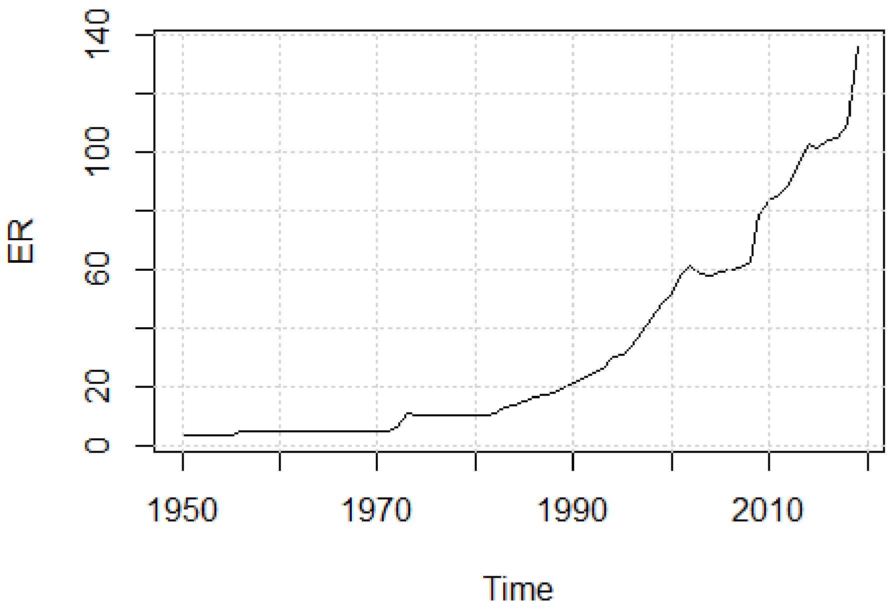
In time series analysis, structural changes represent shocks impacting the evolution with time of the data generating process. That is relevant because one of the key assumptions of the Box-Jenkins methodology is that the structure of the data generating process does not change over time. How can structural changes be identified?

Basic Data Exploration

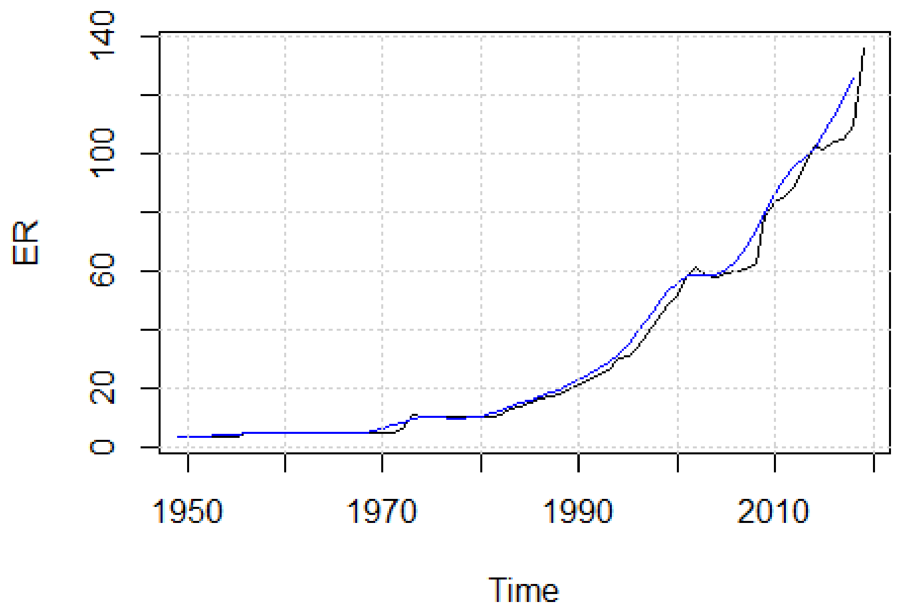
Summary of the Data Series

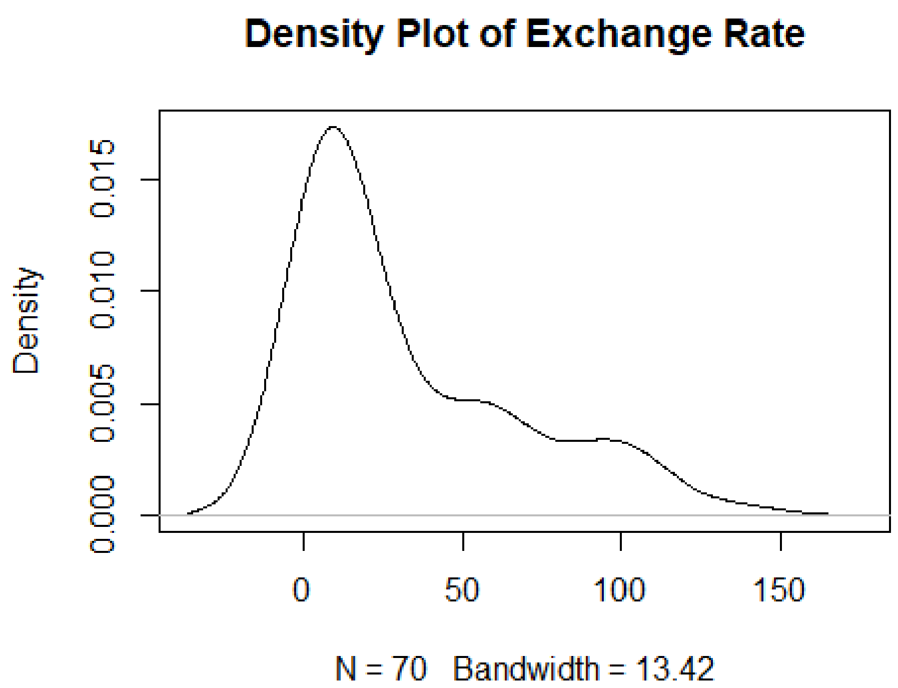
```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   3.309   4.770  14.330  32.229  58.222 136.090
```

Time Series Plot of Exchange Rate



Time Series Plot of Exchange Rate with Smooth Fit





Structural Changes Detection

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Structural Changes Analysis

In the following, we determine the Exchange Rate time series structural changes dates, if any. Such analysis is named as "dating structural changes (breaks)". Specifically, we are looking for:

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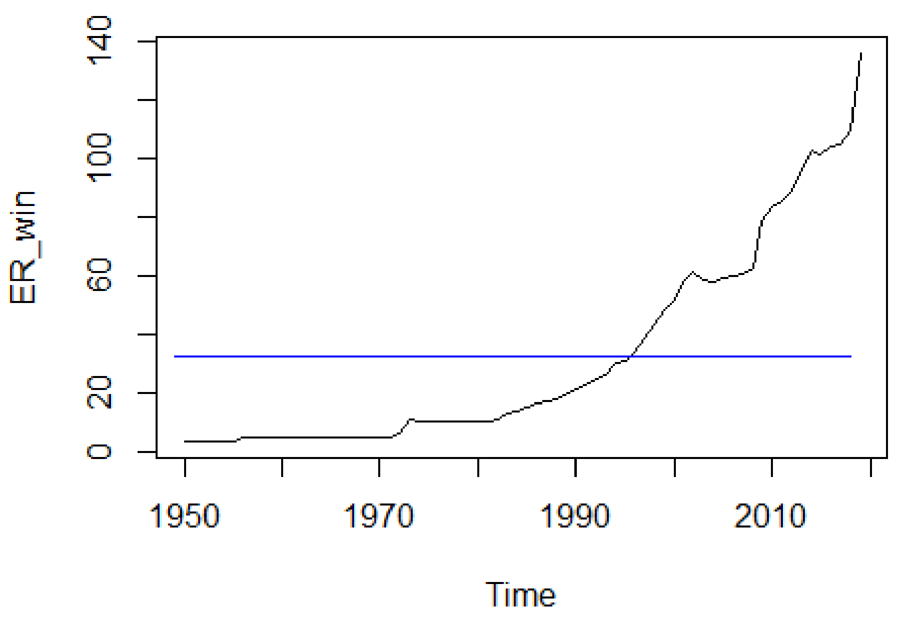
* Auto-Regressive Model Structural Changes

```
Summary of Level Fit

Residuals:
##    Min     1Q Median     3Q    Max
## -28.92 -27.46 -17.90  25.99 103.86
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)   32.229      4.167   7.734 6.12e-11 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 34.86 on 69 degrees of freedom
```

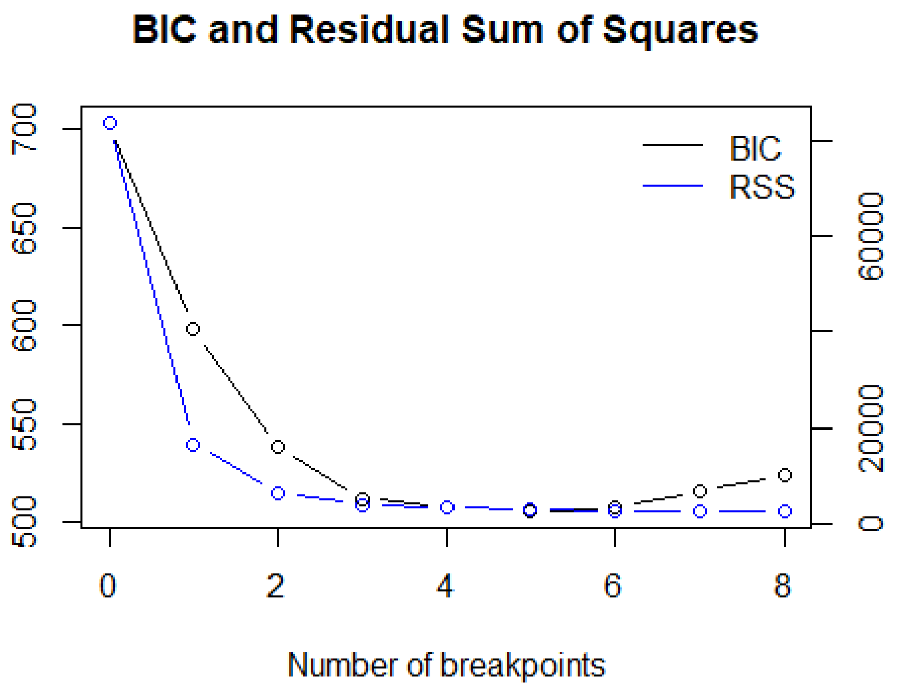


Summary regarding Breaks

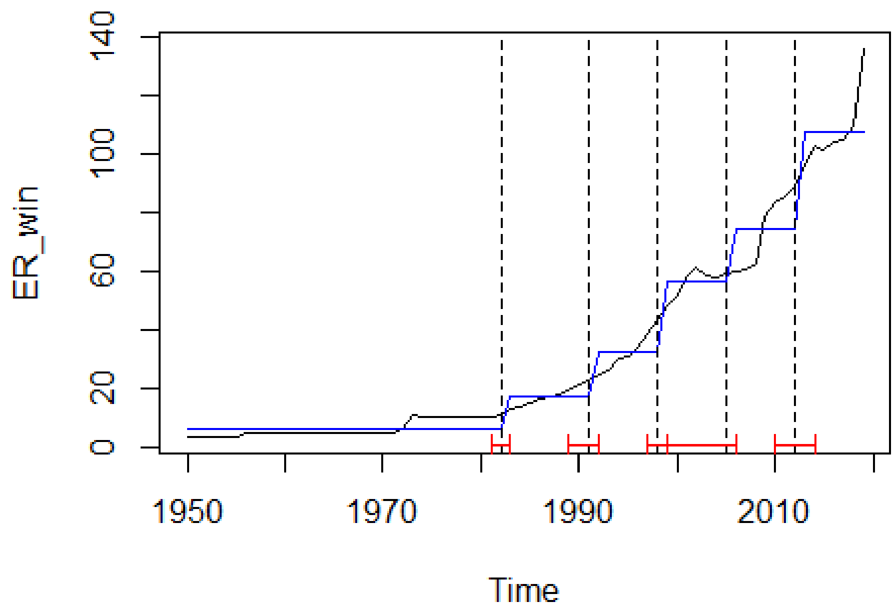
```
## ##
##   Optimal (m+1)-segment partition:
##
## Call:
## breakpoints.formula(formula = ER_win ~ 1, h = 0.1)
##
## Breakpoints at observation number:
##
## m = 1                   49
## m = 2                   46 59
## m = 3             36    48    60
## m = 4             33 42 49    60
## m = 5             33 42 49 56 63
## m = 6          23 35 42 49 56 63
## m = 7    7     23 35 42 49 56 63
## m = 8    7 16 23 35 42 49 56 63
##
## Corresponding to breakdates:
##
## m = 1                               1998
## m = 2                               1995 2008
## m = 3                     1985      1997      2009
## m = 4                     1982 1991 1998      2009
## m = 5                     1982 1991 1998 2005 2012
## m = 6                1972 1984 1991 1998 2005 2012
## m = 7    1956        1972 1984 1991 1998 2005 2012
```

```
## m = 8   1956 1965 1972 1984 1991 1998 2005 2012
##
## Fit:
##
## m   0       1       2       3       4       5       6       7
## RSS 83866.8 16584.4  6205.0  3798.1  3170.5  2714.4  2466.3  2457.8
## BIC   703.3   598.4   538.1   512.2   508.1   505.7   507.5   515.7
##
## m   8
## RSS  2457.7
## BIC   524.2
```

Above the results of finding m = 1 to 8 breakpoints with associated dates and {RSS, BIC} metri cs. The minimum value of BIC is reached for m = 5. Graphically, we have the following plot



The plot of the observed and fitted time series, along with confidence intervals for the breakpoints, is given by:




```
The break dates are

1982 1991 1998 2005 2012

Level breaks coefficients are

##              (Intercept)
## 1950 - 1982    6.131882
## 1983 - 1991   17.262322
## 1992 - 1998   32.425300
## 1999 - 2005   56.498371
## 2006 - 2012   74.296414
## 2013 - 2019  107.963957
```

Trend Structural Changes

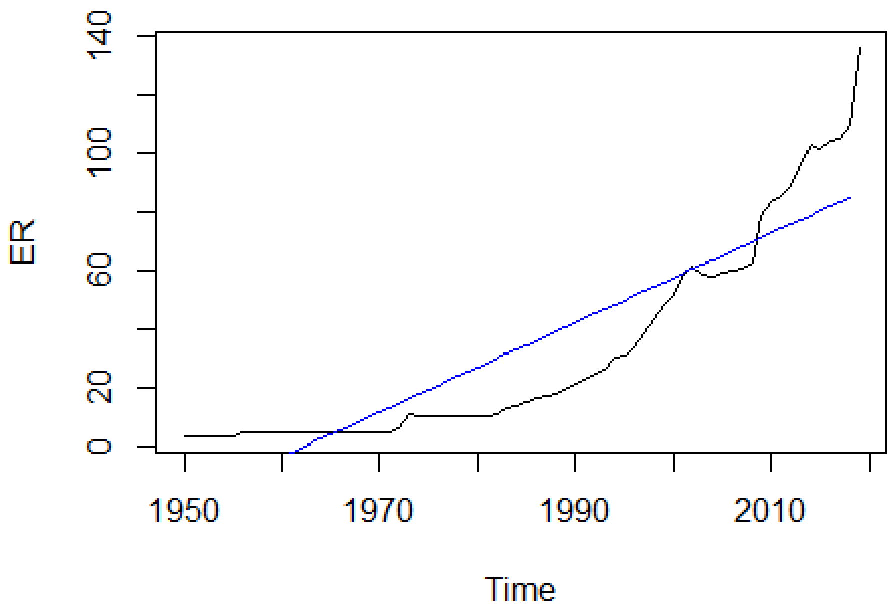
Trend structural changes can be determined as

```
Summary

## Residuals:
##     Min      1Q  Median      3Q     Max
## -19.984 -13.669  -4.128  12.687  51.078
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept) -22.08481    3.81755  -5.785 2.01e-07 ***
## tt            1.52995    0.09346  16.370  < 2e-16 ***
```

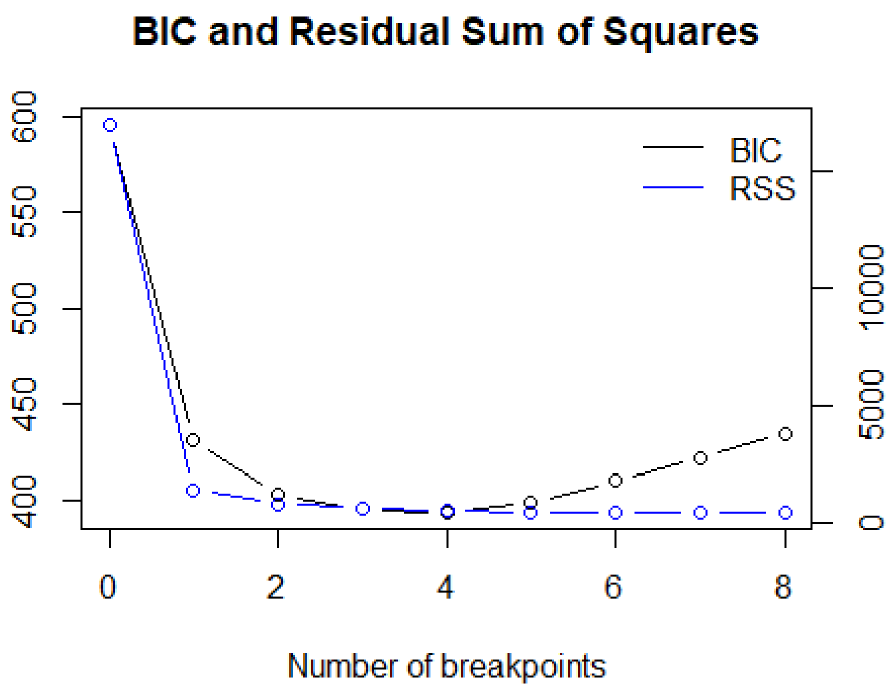
```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 15.8 on 68 degrees of freedom
## Multiple R-squared:  0.7976, Adjusted R-squared:  0.7946
## F-statistic:   268 on 1 and 68 DF,  p-value: < 2.2e-16
```

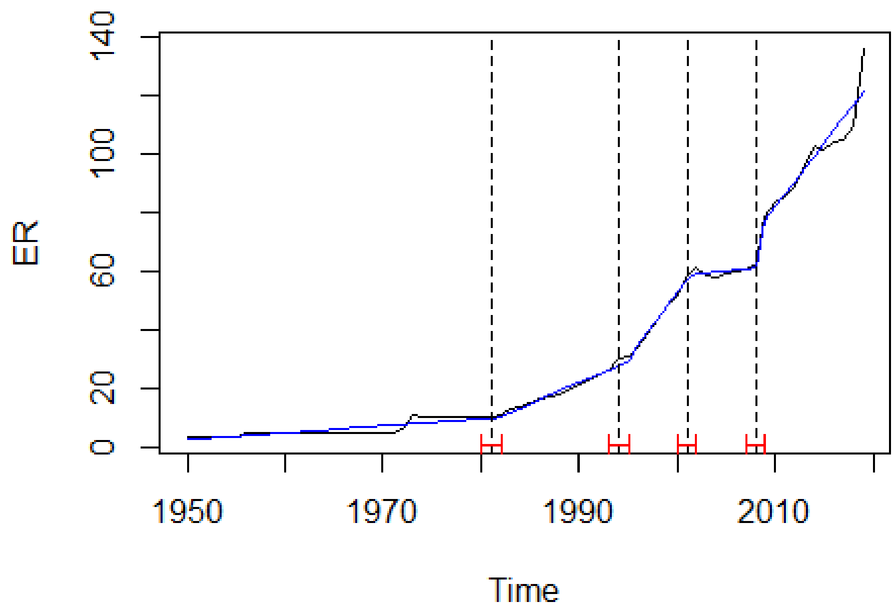
Both intercept and slope coefficients are reported as significative. Let us plot the time series again st the fit.




```
## Breakpoints at observation number:
##
## m = 1                 41
## m = 2                 39    55
## m = 3                 35    49 59
## m = 4              32    45 52 59
## m = 5           23 32    45 52 59
## m = 6           23 31 38 45 52 59
## m = 7    7      23 31 38 45 52 59
## m = 8    7 16 23 31 38 45 52 59
##
## Corresponding to breakdates:
##
## m = 1                              1990
## m = 2                              1988      2004
## m = 3                              1984      1998 2008
## m = 4                         1981      1994 2001 2008
```

```
## m = 5            1972 1981      1994 2001 2008
## m = 6            1972 1980 1987 1994 2001 2008
## m = 7   1956     1972 1980 1987 1994 2001 2008
## m = 8   1956 1965 1972 1980 1987 1994 2001 2008
##
## Fit:
##
## m   0       1       2       3       4       5       6       7
## RSS 16973.7  1351.1   753.4   561.7   456.7   408.8   400.4   398.4
## BIC   595.8   431.4   403.2   395.4   393.7   398.7   410.0   422.3
##
## m   8
## RSS   398.1
## BIC   435.0
```






```
Trend Break dates are

## [1] 1981 1994 2001 2008

Trend Break Coefficients are



##              (Intercept)        tt
## 1950 - 1981     2.017539 0.2409590
## 1982 - 1994   -37.524566 1.4491368
## 1995 - 2001  -182.566250 4.6140071
## 2002 - 2008    40.157757 0.3540571
## 2009 - 2019  -186.822459 4.4025627

Where tt is stands for time trend
```

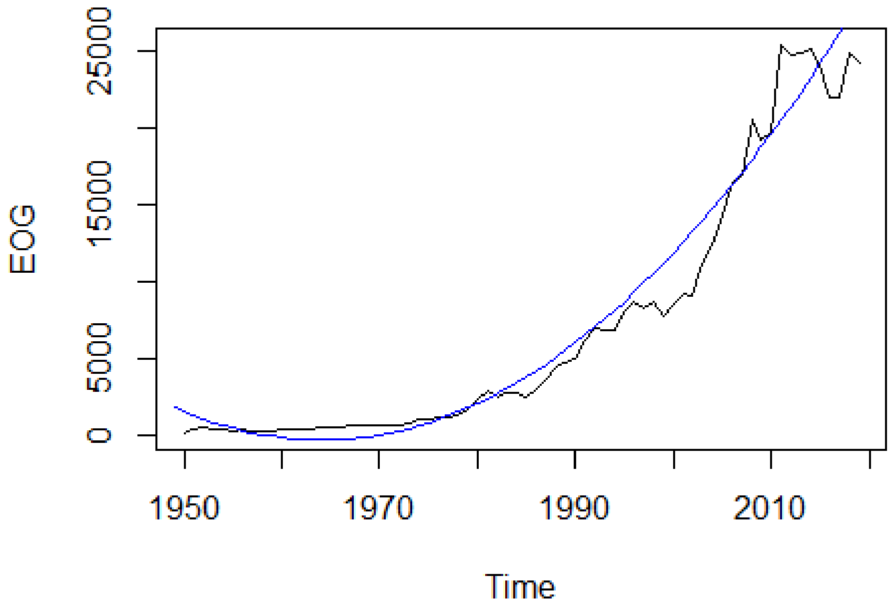
Polynomial Fit Structural Changes

Second degree polynomial structural changes can be determined as

```
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 12.554169   1.778427   7.059 1.19e-09 ***
## tt          -1.356626   0.115593 -11.736  < 2e-16 ***
## I(tt^2)      0.040656   0.001578  25.768  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 4.819 on 67 degrees of freedom
```

```
## Multiple R-squared:  0.9814, Adjusted R-squared:  0.9809
## F-statistic:  1772 on 2 and 67 DF,  p-value: < 2.2e-16
```

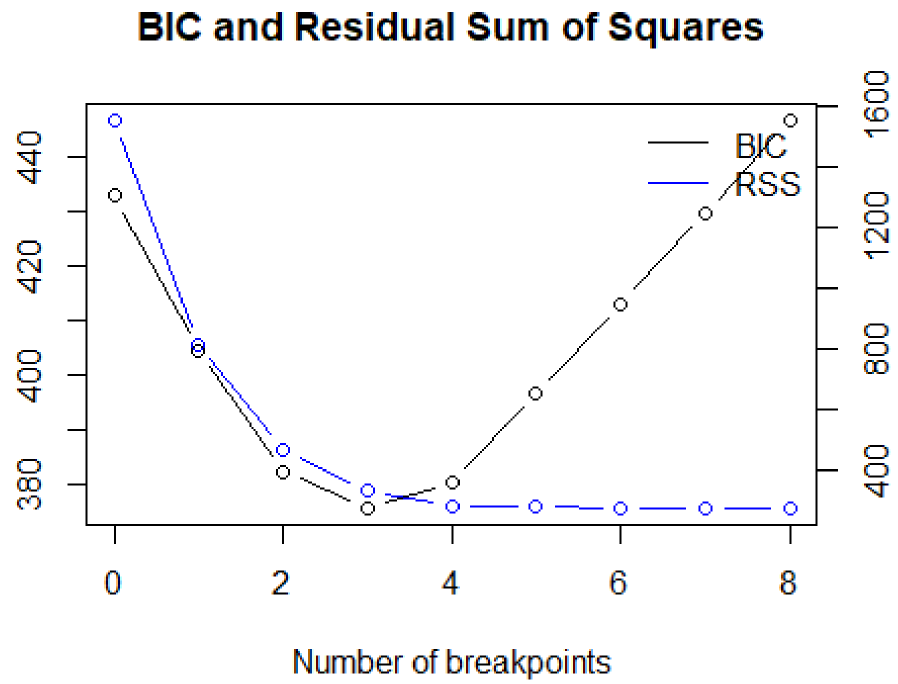
All coefficients are reported as significative. Let us plot the time series against the fit.



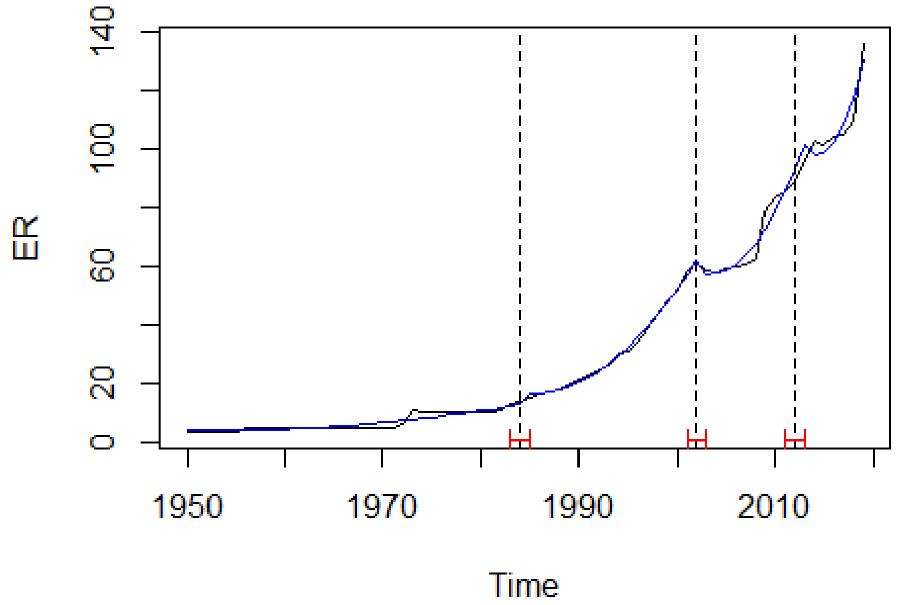
We go on with the search for structural changes.

```
## Breakpoints at observation number:
## 
## m = 1                   48            
## m = 2                   45 59         
## m = 3             35       53 63      
## m = 4          23          47 56 63   
## m = 5          23 33       48 56 63   
## m = 6          23 33 40 48 56 63      
## m = 7    7     23 33 40 48 56 63      
## m = 8    7 16 23 33 40 48 56 63       
## 
## Corresponding to breakdates:
## 
## m = 1                              1997
## m = 2                              1994 2008
## m = 3                    1984           2002 2012
## m = 4               1972           1996 2005 2012
## m = 5               1972 1982      1997 2005 2012
## m = 6               1972 1982 1989 1997 2005 2012
```

```
## m = 7    1956       1972 1982 1989 1997 2005 2012
## m = 8    1956 1965 1972 1982 1989 1997 2005 2012
##
## Fit:
##
## m    0       1       2       3       4       5       6       7       8
## RSS 1555.8   815.6   466.7   332.3   279.3   275.9   273.8   271.9   271.6
## BIC  432.7   404.5   382.4   375.7   380.5   396.6   413.1   429.6   446.5
```



The BIC minimum value is reached for m = 3




```
Polynomial fit Break dates

## 1984 2002 2012

Polynomial fit Coefficients

##               (Intercept)            tt    I(tt^2)
## 1950 - 1984    3.735494   -0.06319485 0.00922888
## 1985 - 2002  217.052405  -11.21131047 0.15637110
## 2003 - 2012 1411.066513  -49.94630515 0.46067424
## 2013 - 2019 6680.616193 -201.22010357 1.53774643
```