Time Series Assignment 9

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```
gold <- read.csv("/Users/arnavsomani/Desktop/NYU COURSE/sem 3/ba/r programming csv file
s/Gold.csv")
head(gold,5)
```

```
##          Date Value
## 1  January-90 410.1
## 2 February-90 416.8
## 3    March-90 393.1
## 4    April-90 374.2
## 5      May-90 369.1
```

```
ts.gold<-ts(gold)
```

```
head(ts.gold,5)
```

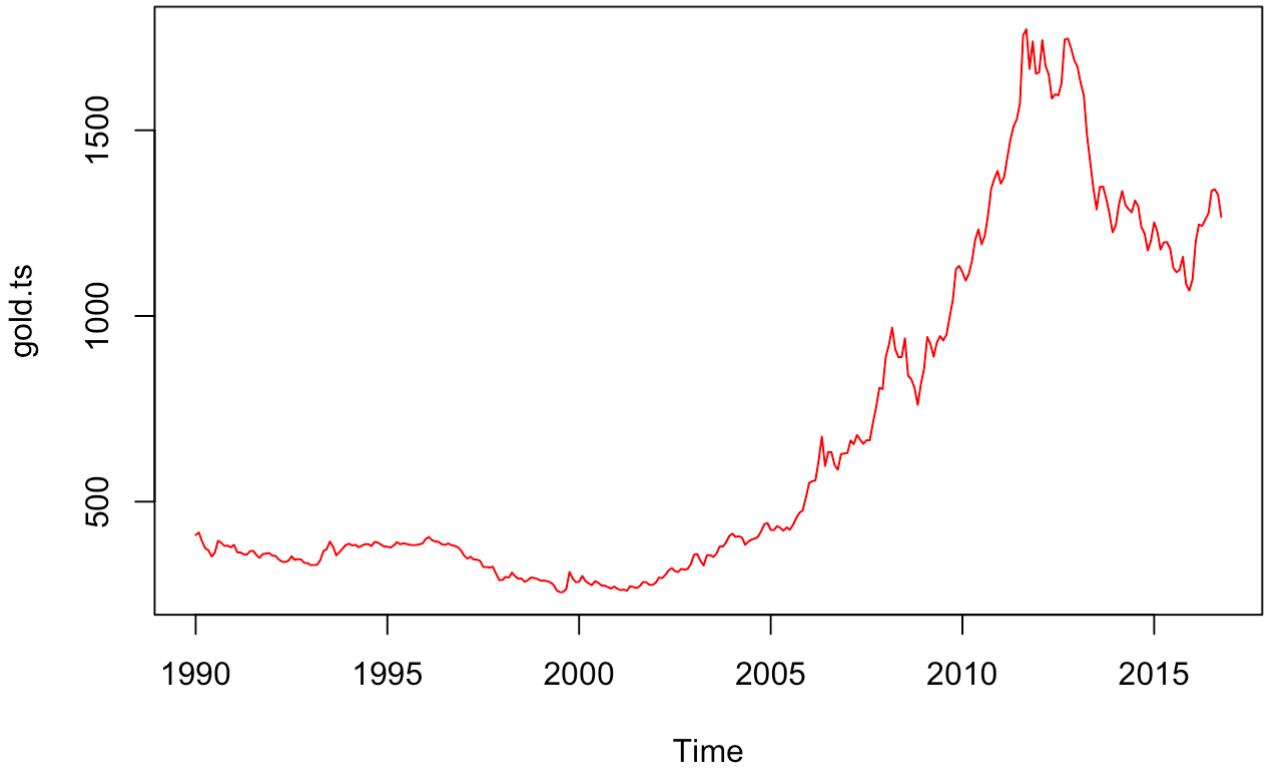
```
##      Date Value
## [1,]  125 410.1
## [2,]   98 416.8
## [3,]  206 393.1
## [4,]   18 374.2
## [5,]  233 369.1
```

```
gold.ts<-ts(gold$Value,start=c(1990,1),frequency = 12)
gold.ts
```

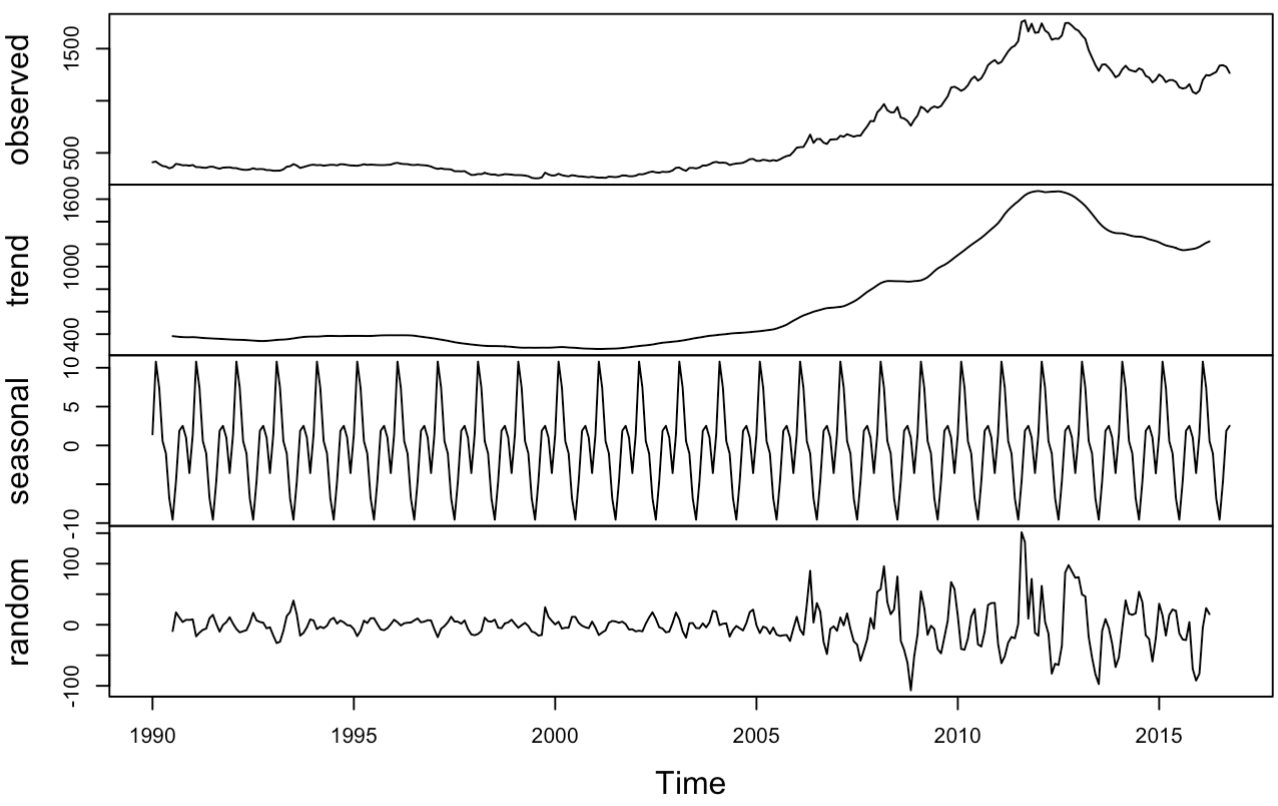
```
##         Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct
## 1990  410.1  416.8  393.1  374.2  369.1  352.3  362.5  394.7  389.3  380.7
## 1991  383.6  363.8  363.3  358.4  357.0  366.7  367.7  356.3  348.7  358.7
## 1992  354.5  353.9  344.3  338.6  337.2  340.8  352.7  343.1  345.4  344.4
## 1993  329.0  329.3  330.1  342.2  367.2  371.9  392.2  378.8  355.3  364.2
## 1994  386.9  381.9  384.1  377.3  381.4  385.6  385.5  380.4  391.6  389.8
## 1995  378.6  376.6  382.1  391.0  385.2  387.6  386.2  383.7  383.1  383.1
## 1996  399.5  404.8  396.2  392.9  391.9  385.3  383.5  387.3  383.2  381.1
## 1997  355.1  346.6  351.8  344.5  343.8  340.8  324.1  324.0  322.8  324.9
## 1998  289.1  297.5  295.9  308.3  299.1  292.3  292.9  284.1  289.0  295.9
## 1999  287.1  287.3  286.0  282.6  276.4  261.3  256.1  256.7  264.7  310.7
## 2000  284.3  299.9  286.4  279.7  275.2  285.7  281.6  274.5  273.7  270.0
## 2001  265.5  261.9  263.0  260.5  272.4  270.2  267.5  272.4  283.4  283.1
## 2002  281.5  295.5  294.1  302.7  314.5  321.2  313.3  310.3  319.1  316.6
## 2003  356.9  359.0  340.6  328.2  355.7  356.4  351.0  359.8  379.0  378.9
## 2004  413.8  404.9  406.7  403.3  383.8  392.4  398.1  400.5  405.3  420.5
## 2005  424.0  423.4  434.3  429.2  421.9  430.7  424.5  437.9  456.1  469.9
## 2006  549.9  555.0  557.1  610.7  675.4  596.2  633.7  632.6  598.2  585.8
## 2007  631.2  664.7  654.9  679.4  666.9  655.5  665.3  665.4  712.7  754.6
## 2008  889.6  922.3  968.4  909.7  888.7  889.5  939.8  839.0  829.9  806.6
## 2009  858.7  943.2  924.3  890.2  928.6  945.7  934.2  949.4  996.6 1043.2
## 2010 1118.0 1095.4 1113.3 1148.7 1205.4 1232.9 1193.0 1215.8 1271.0 1342.0
## 2011 1356.4 1372.7 1424.0 1473.8 1510.4 1528.7 1572.8 1755.8 1771.9 1665.2
## 2012 1656.1 1742.6 1673.8 1650.1 1585.5 1596.7 1593.9 1626.0 1744.5 1747.0
## 2013 1671.0 1627.6 1592.9 1485.1 1413.5 1342.4 1286.7 1347.1 1348.8 1316.2
## 2014 1244.8 1301.0 1336.1 1299.0 1287.5 1279.1 1311.0 1296.0 1238.8 1222.5
## 2015 1251.9 1227.2 1178.6 1197.9 1199.1 1181.5 1130.0 1117.5 1124.5 1159.3
## 2016 1097.4 1199.9 1246.3 1242.3 1259.4 1276.4 1337.3 1341.1 1326.0 1266.6
##         Nov    Dec
## 1990  381.7  377.0
## 1991  360.2  361.7
## 1992  335.0  334.8
## 1993  373.8  383.3
## 1994  384.4  379.3
## 1995  385.3  387.4
## 1996  377.9  369.0
## 1997  306.0  288.7
## 1998  294.1  291.7
## 1999  293.2  283.1
## 2000  266.0  271.5
## 2001  276.2  275.9
## 2002  319.1  331.9
## 2003  389.9  407.0
## 2004  439.4  442.1
## 2005  476.7  510.1
## 2006  627.8  629.8
## 2007  806.3  803.2
## 2008  760.9  816.1
## 2009 1127.0 1134.7
## 2010 1369.9 1390.6
## 2011 1739.0 1652.3
## 2012 1721.1 1688.5
## 2013 1275.8 1225.4
```

```
## 2014 1176.3 1202.3
## 2015 1085.7 1068.3
## 2016
```

```
plot.ts(gold.ts,col="red")
```




```
gold.ts.d<-decompose(gold.ts)
plot(gold.ts.d)
```




```
oil<-read.csv("/Users/arnavsomani/Desktop/NYU COURSE/sem 3/ba/r programming csv files/Oi
lmon.csv")
head(oil,5)
```

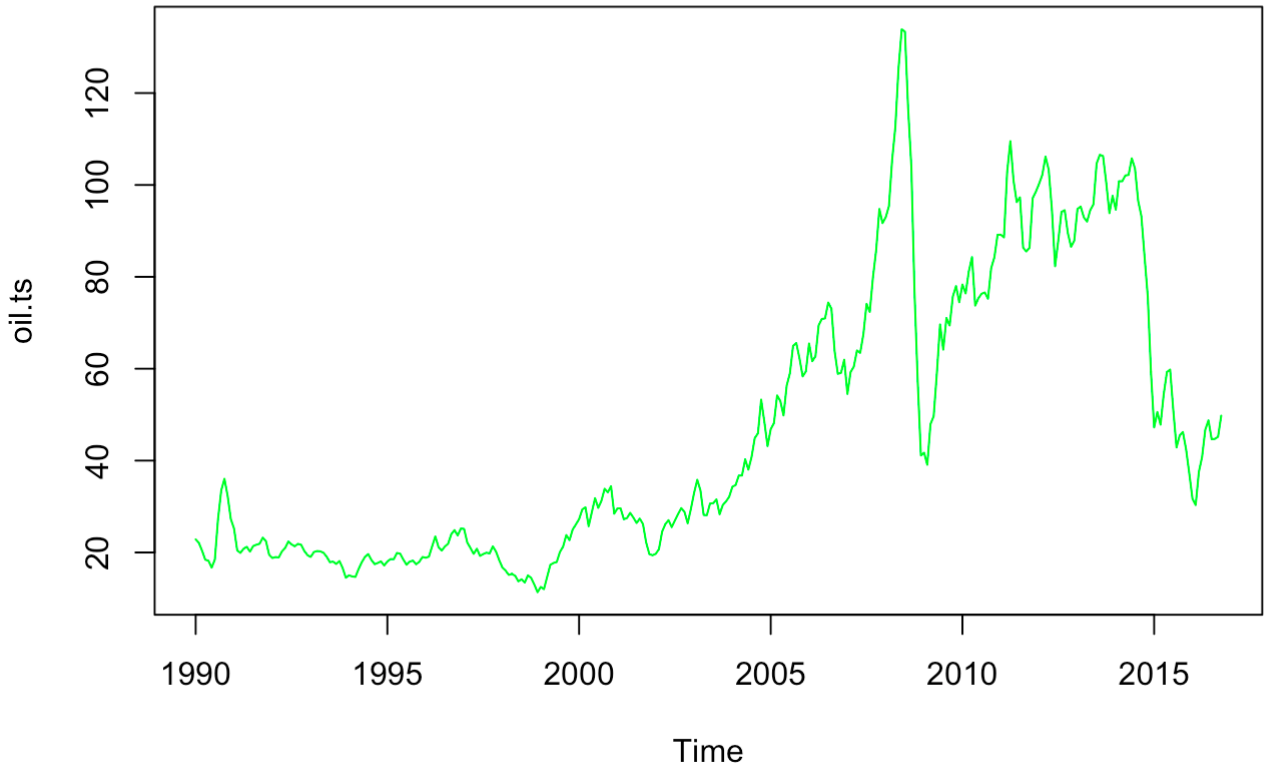
```
##          DATE VALUE
## 1  January-90 22.86
## 2 February-90 22.11
## 3    March-90 20.39
## 4    April-90 18.43
## 5      May-90 18.20
```

```
oil.ts<-ts(oil$VALUE,start=c(1990,1),frequency = 12)
oil.ts
```

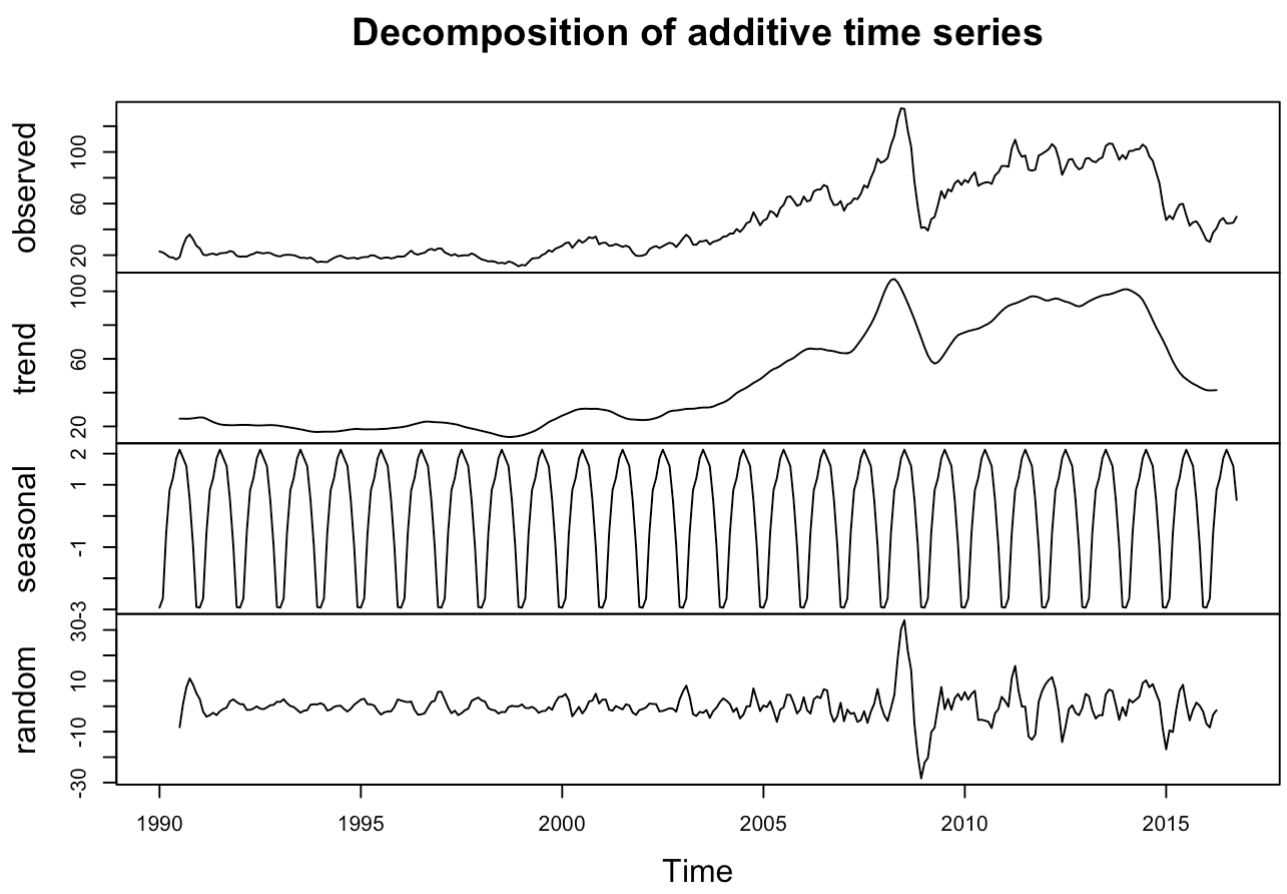
```
##         Jan    Feb    Mar    Apr    May    Jun    Jul    Aug    Sep    Oct
## 1990  22.86  22.11  20.39  18.43  18.20  16.70  18.45  27.31  33.51  36.04
## 1991  25.23  20.48  19.90  20.83  21.23  20.19  21.40  21.69  21.89  23.23
## 1992  18.79  19.01  18.92  20.23  20.98  22.38  21.78  21.34  21.88  21.69
## 1993  19.03  20.09  20.32  20.25  19.95  19.09  17.89  18.01  17.50  18.15
## 1994  15.03  14.78  14.68  16.42  17.89  19.06  19.65  18.38  17.45  17.72
## 1995  18.04  18.57  18.54  19.90  19.74  18.45  17.33  18.02  18.23  17.43
## 1996  18.85  19.09  21.33  23.50  21.17  20.42  21.30  21.90  23.97  24.88
## 1997  25.13  22.18  20.97  19.70  20.82  19.26  19.66  19.95  19.80  21.33
## 1998  16.72  16.06  15.12  15.35  14.91  13.72  14.17  13.47  15.03  14.46
## 1999  12.51  12.01  14.68  17.31  17.72  17.92  20.10  21.28  23.80  22.69
## 2000  27.26  29.37  29.84  25.72  28.79  31.82  29.70  31.26  33.88  33.11
## 2001  29.59  29.61  27.24  27.49  28.63  27.60  26.42  27.37  26.20  22.17
## 2002  19.71  20.72  24.53  26.18  27.04  25.52  26.97  28.39  29.66  28.84
## 2003  32.95  35.83  33.51  28.17  28.11  30.66  30.75  31.57  28.31  30.34
## 2004  34.31  34.68  36.74  36.75  40.28  38.03  40.78  44.90  45.94  53.28
## 2005  46.84  48.15  54.19  52.98  49.83  56.35  59.00  64.99  65.59  62.26
## 2006  65.49  61.63  62.69  69.44  70.84  70.95  74.41  73.04  63.80  58.89
## 2007  54.51  59.28  60.44  63.98  63.45  67.49  74.12  72.36  79.91  85.80
## 2008  92.97  95.39 105.45 112.58 125.40 133.88 133.37 116.67 104.11  76.61
## 2009  41.71  39.09  47.94  49.65  59.03  69.64  64.15  71.04  69.41  75.72
## 2010  78.33  76.39  81.20  84.29  73.74  75.34  76.32  76.60  75.24  81.89
## 2011  89.17  88.58 102.86 109.53 100.90  96.26  97.30  86.33  85.52  86.32
## 2012 100.27 102.20 106.16 103.32  94.65  82.30  87.90  94.13  94.51  89.49
## 2013  94.76  95.31  92.94  92.02  94.51  95.77 104.67 106.57 106.29 100.54
## 2014  94.62 100.82 100.80 102.07 102.18 105.79 103.59  96.54  93.21  84.40
## 2015  47.22  50.58  47.82  54.45  59.27  59.82  50.90  42.87  45.48  46.22
## 2016  31.68  30.32  37.55  40.76  46.71  48.76  44.65  44.72  45.18  49.78
##         Nov    Dec
## 1990  32.33  27.28
## 1991  22.46  19.50
## 1992  20.34  19.41
## 1993  16.61  14.51
## 1994  18.07  17.16
## 1995  17.99  19.03
## 1996  23.71  25.23
## 1997  20.19  18.33
## 1998  13.00  11.35
## 1999  25.00  26.10
## 2000  34.42  28.44
## 2001  19.64  19.39
## 2002  26.35  29.46
## 2003  31.11  32.13
## 2004  48.47  43.15
## 2005  58.32  59.41
## 2006  59.08  61.96
## 2007  94.77  91.69
## 2008  57.31  41.12
## 2009  77.99  74.47
## 2010  84.25  89.15
## 2011  97.16  98.56
## 2012  86.53  87.86
## 2013  93.86  97.63
```

```
## 2014  75.79  59.29
## 2015  42.44  37.19
## 2016
```

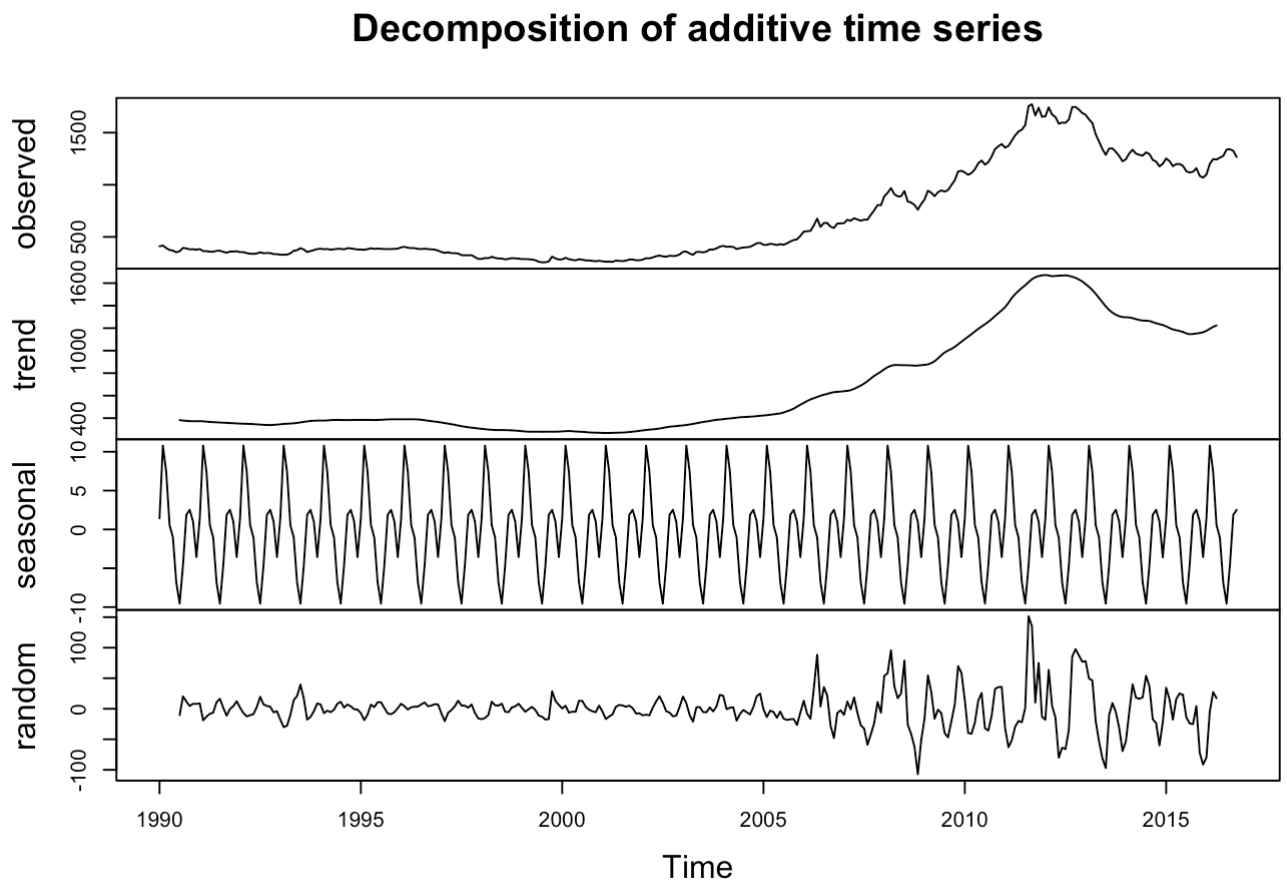
```
plot.ts(oil.ts,col="green")
```



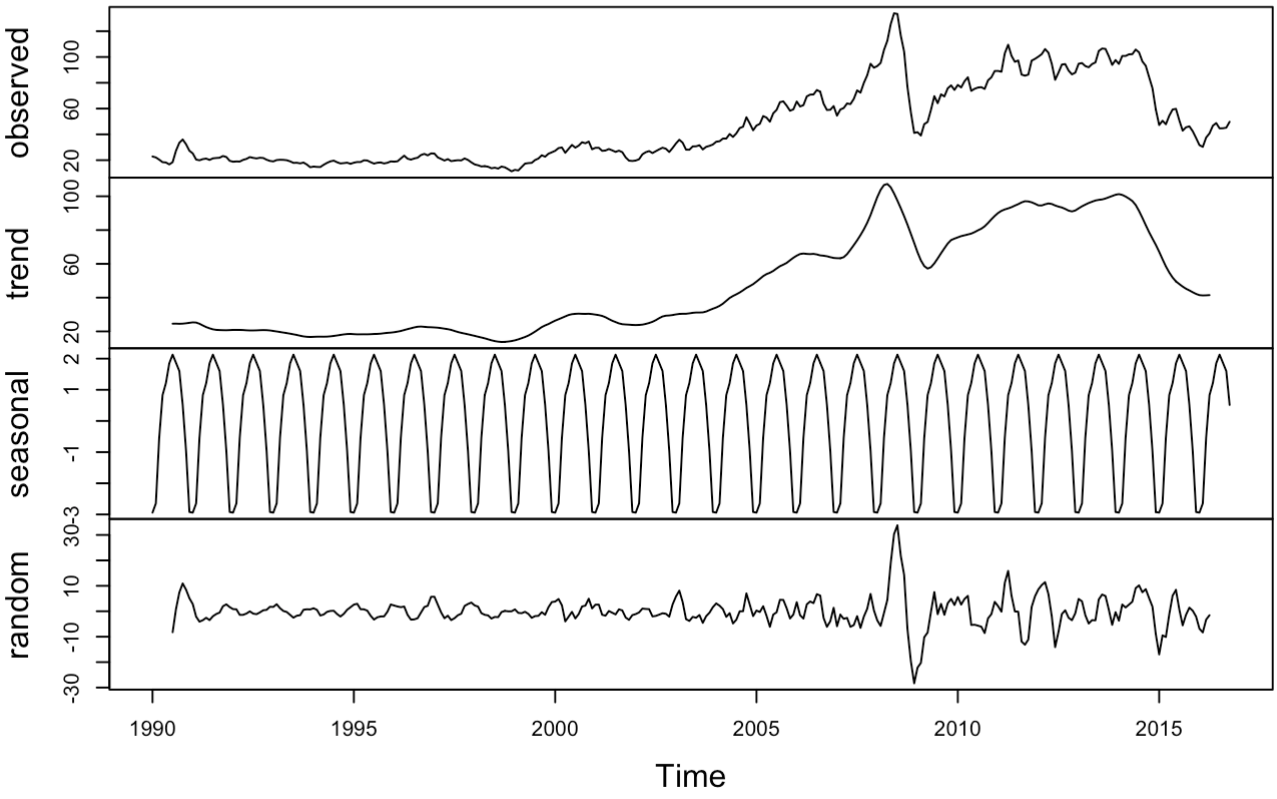

```
oil.ts.d<-decompose(oil.ts)
plot(oil.ts.d)
```




```
gold.ts.d<-decompose(gold.ts)
plot(gold.ts.d)
```

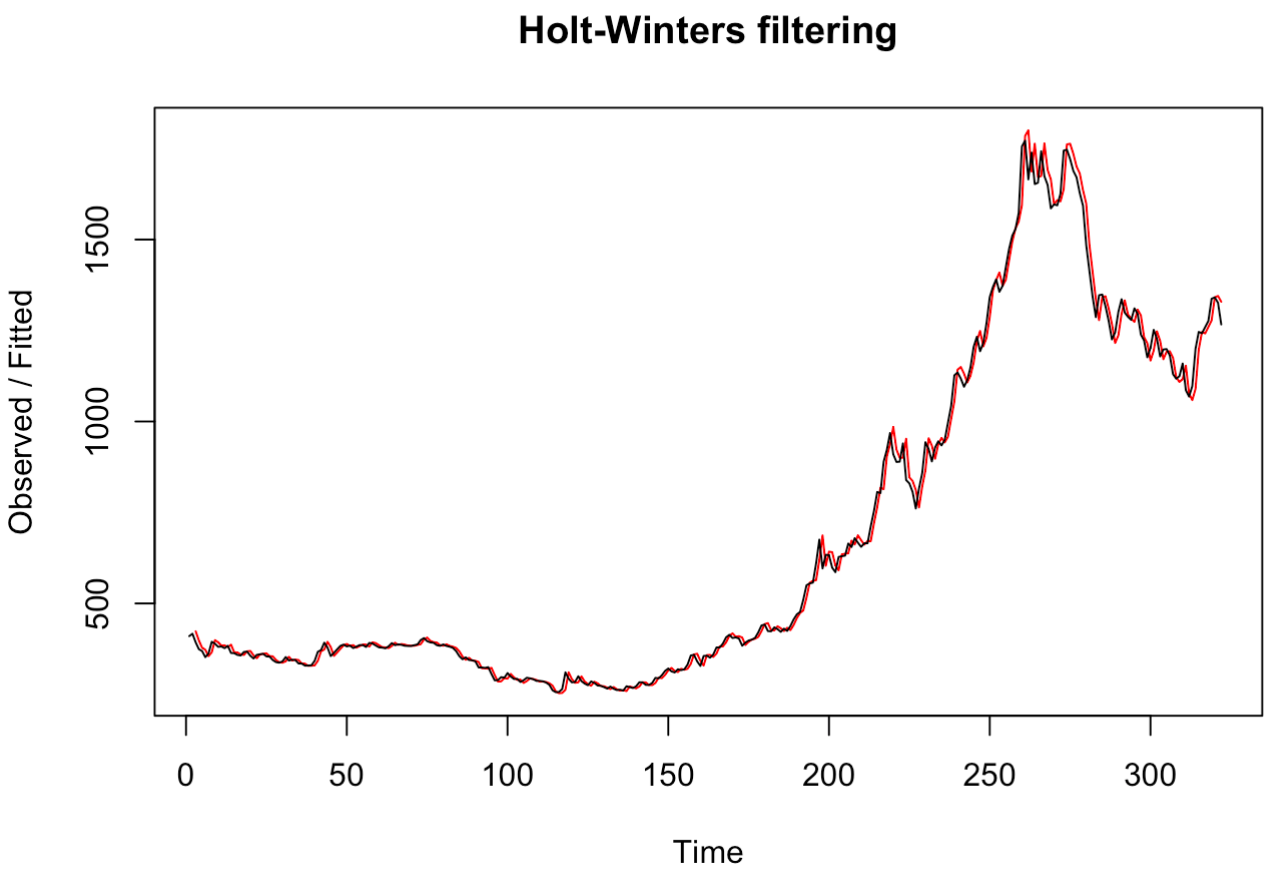



```
oil.ts.d<-decompose(oil.ts)
plot(oil.ts.d)
```

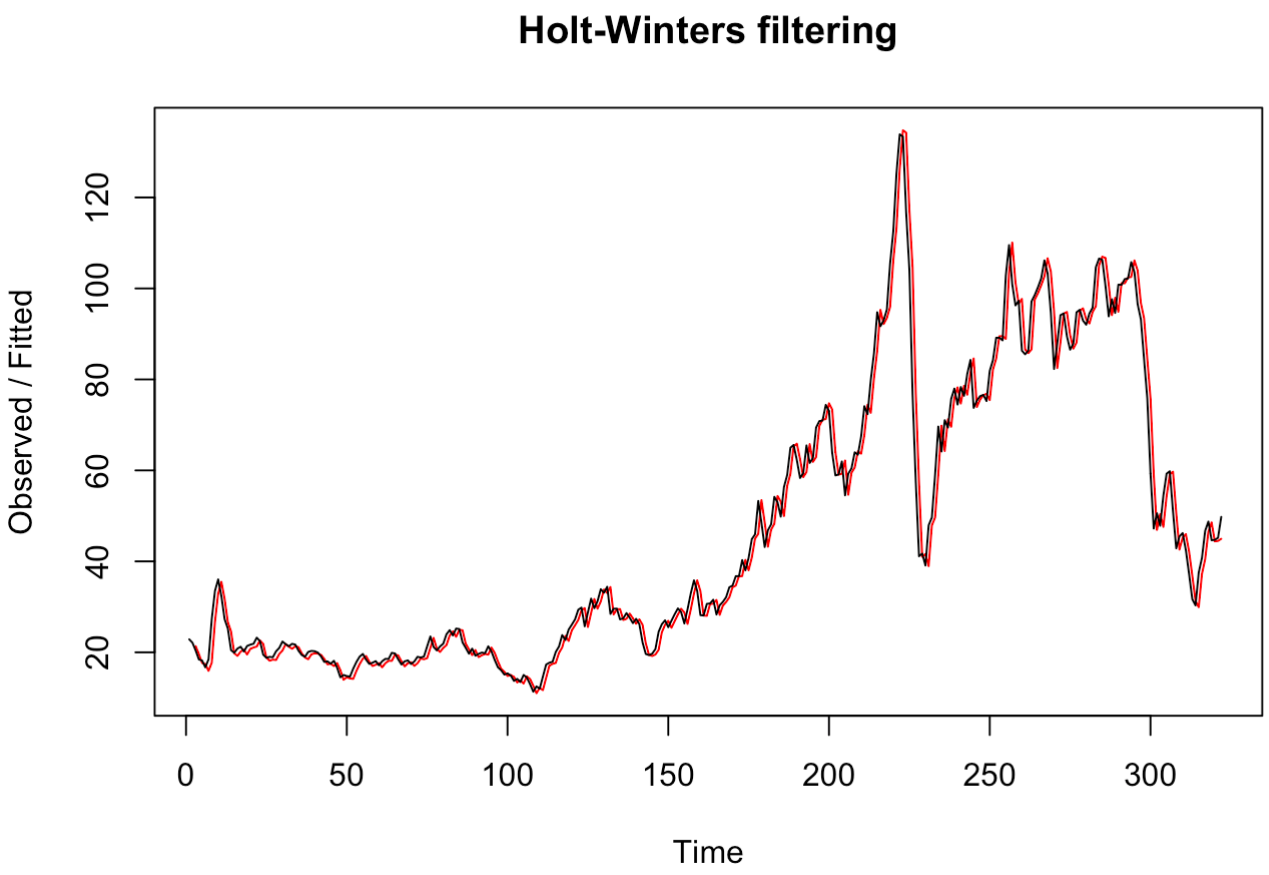



```
gold.holt<-HoltWinters(gold$Value,gamma=F)
oil.holt<-HoltWinters(oil$VALUE,gamma=F)
```

```
plot(gold.holt)
```




```
plot(oil.holt)
```




```
library(forecast)
```

```
## Loading required package: zoo
```

```
##
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

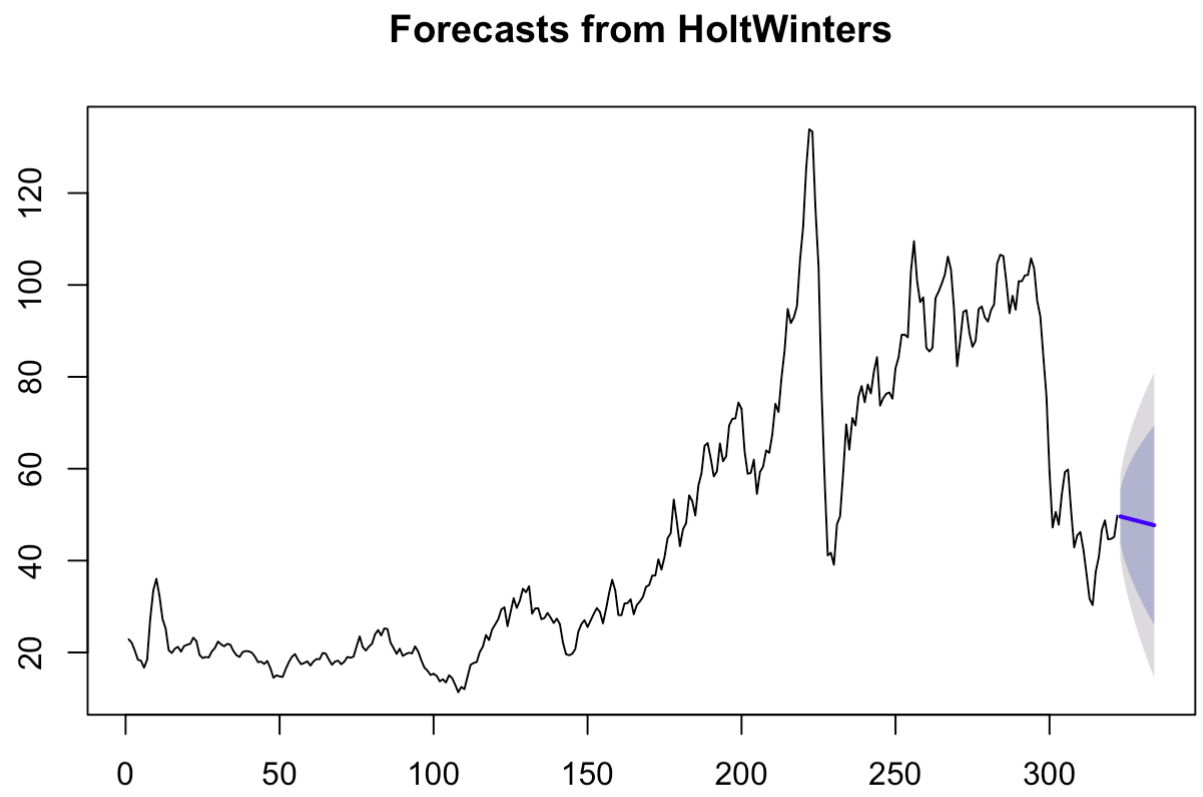
```
## Loading required package: timeDate
```

```
## This is forecast 7.3
```

```
##
## Attaching package: 'forecast'
```

```
## The following object is masked _by_ '.GlobalEnv':
##
##     gold
```

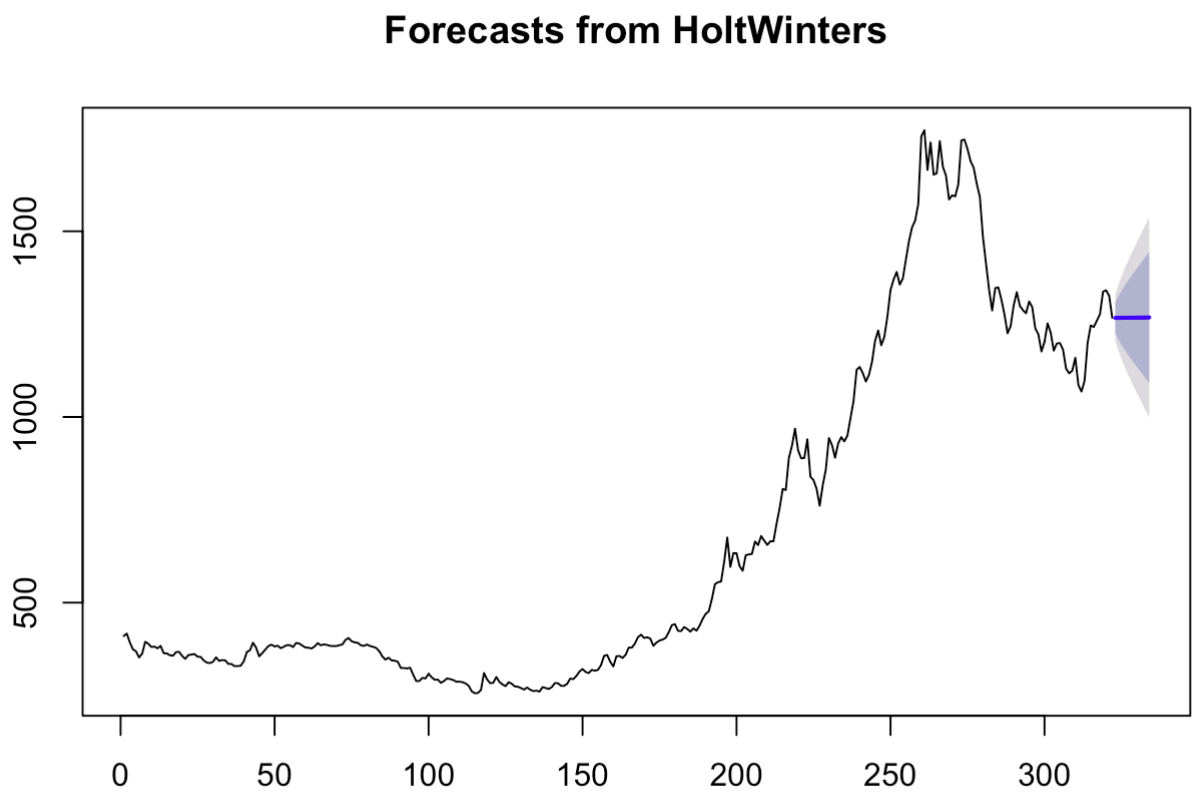
```
oil.for<-forecast.HoltWinters(oil.holt,h=12)
plot(oil.for)
```




```
gold.for<-forecast.HoltWinters(gold.holt,h=12)
gold.for
```

```
##     Point Forecast    Lo 80    Hi 80     Lo 95    Hi 95
## 323       1266.715 1226.652 1306.779 1205.4439 1327.987
## 324       1266.831 1208.821 1324.841 1178.1119 1355.549
## 325       1266.946 1194.231 1339.661 1155.7383 1378.153
## 326       1267.061 1181.160 1352.962 1135.6864 1398.436
## 327       1267.176 1168.957 1365.396 1116.9624 1417.390
## 328       1267.292 1157.297 1377.286 1099.0696 1435.514
## 329       1267.407 1145.993 1388.821 1081.7210 1453.093
## 330       1267.522 1134.927 1400.118 1064.7347 1470.310
## 331       1267.638 1124.016 1411.259 1047.9880 1487.287
## 332       1267.753 1113.206 1422.299 1031.3942 1504.112
## 333       1267.868 1102.455 1433.282 1014.8900 1520.846
## 334       1267.983 1091.731 1444.236  998.4278 1537.539
```

```
plot.forecast(gold.for)
```




```
names(gold.for)
```

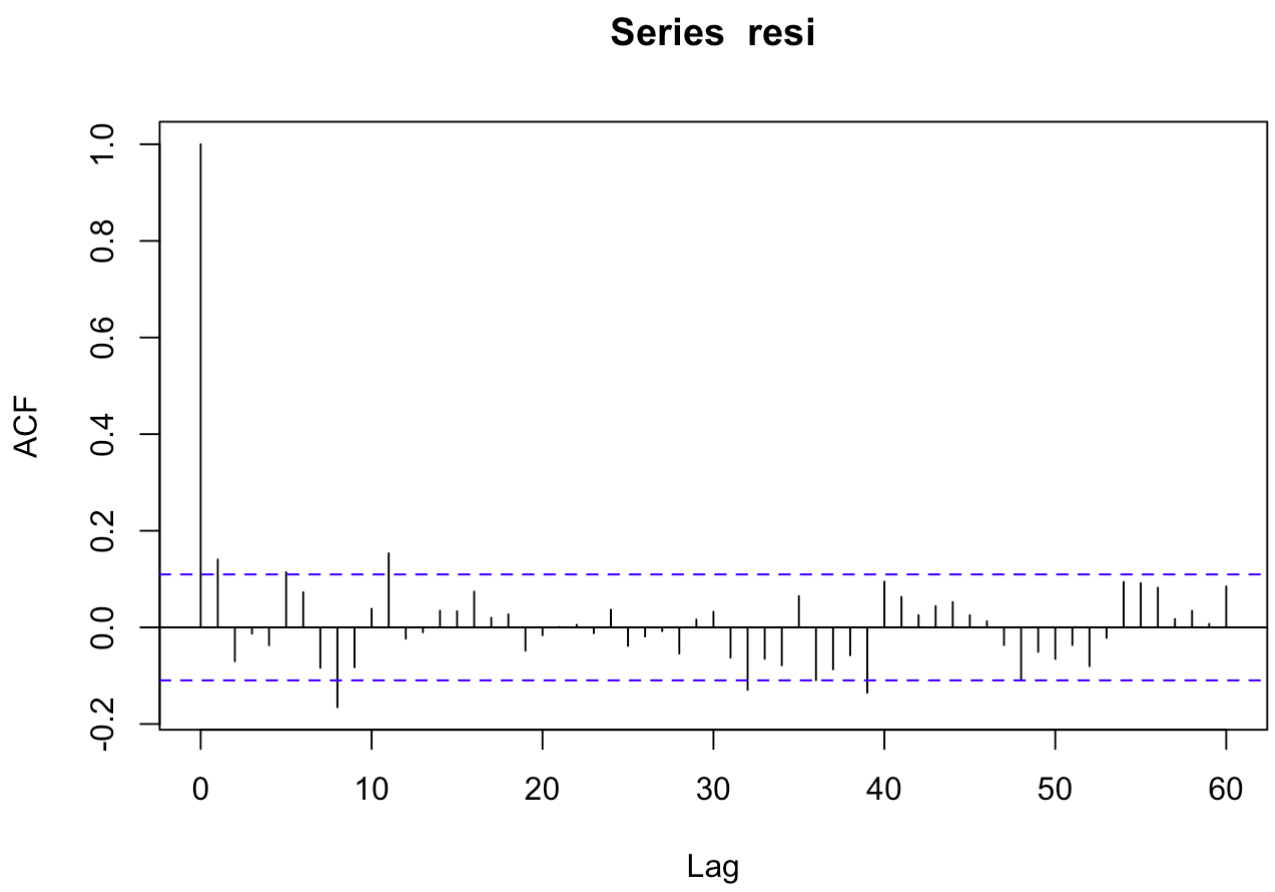
```
##  [1] "method"    "model"     "level"     "mean"      "lower"
##  [6] "upper"     "x"         "xname"     "fitted"    "residuals"
```

```
gold.for$residuals
```

```
## Time Series:
## Start = 1
## End = 322
## Frequency = 1
##   [1]           NA           NA -30.40000000 -24.16566914  -9.22548608
##   [6] -20.49020979   7.47655798  29.12379950  -9.85031775 -12.58556068
##  [11]  -2.39174956  -7.97890219   3.69755787 -22.87690007  -2.49752363
##  [16]  -6.77968563  -2.95980694   8.27984248  -0.81081652 -13.17256062
##  [21]  -8.75105371   9.26183795   0.32484650   0.30951961  -8.40508412
##  [26]  -1.40851598 -10.34205947  -5.95410108  -1.37317506   3.69161400
##  [31]  11.81743650 -10.24013303   2.14301627  -1.25809539  -9.59873601
##  [36]   0.05415094  -5.54840401   0.81338044   1.27500357  12.51484644
##  [41]  24.82437175   3.35310983  18.79490361 -15.79187633 -25.14678503
##  [46]   8.43968898   8.74148811   8.22904778   1.94078537  -6.75078464
##  [51]   0.76773045  -8.26849256   3.02163093   2.97906453  -1.46149350
##  [56]  -6.39253741  10.20907488  -3.27260904  -6.71820101  -6.10122327
##  [61]  -1.41335575  -2.64667089   4.97820417   8.14332286  -6.94089488
##  [66]   1.58658998  -2.28826841  -3.28030347  -1.22553241  -0.56770941
##  [71]   1.65907622   1.48079779  11.41093088   4.07254107 -10.01960930
##  [76]  -4.24686474  -1.74648944  -7.26408668  -2.12135301   3.57873653
##  [81]  -4.49011519  -2.27826286  -3.27077001  -8.81644874 -13.40047162
##  [86]  -7.36821143   6.67943506  -6.13571362   0.75378123  -1.58178363
##  [91] -15.20715202   2.11035086   0.91078042   4.16780804 -17.02883722
##  [96] -14.62538371   3.76467021  11.58704578   1.04034653  14.99126097
## [101]  -7.31605575  -4.57087008   3.04479242  -6.49886678   7.50776234
## [106]   9.15353158   0.02165023  -0.57937127  -2.75203541   2.17781095
## [111]   0.57505761  -1.55207472  -4.27884483 -12.97696064  -2.46468252
## [116]   3.45160598  10.68875252  48.18443649 -17.58899852  -9.35911552
## [121]   2.38246568  16.67005633 -13.21646920  -5.79289060  -3.31957080
## [126]  11.83705298  -3.32144210  -6.16473003   0.42613387  -2.49397195
## [131]  -2.67630153   6.94997156  -4.87794156  -2.24779083   2.55826429
## [136]  -1.16243957  13.29240658  -1.43475490  -1.86706038   5.82103114
## [141]  11.64638362  -0.20311531  -6.79353193   0.12700006   6.02100795
## [146]  14.13692513  -1.93008236   8.16098266  10.97593170   5.35806599
## [151]  -9.49473794  -4.14675782   7.84889424  -3.82143179   1.35887077
## [156]  11.59475661  23.24769355  -0.74917765 -21.21383000 -14.21292042
## [161]  26.35767268  -1.68593335  -7.70638775   6.85721455  16.93367789
## [166]  -3.16528582   8.08405849  13.80263696   2.85140182 -12.98313284
## [171]  -1.67056349  -6.79174307 -22.57129548   6.59366194   3.38256020
## [176]  -0.07703554   2.32659915  12.61682570  15.72153943  -1.22023324
## [181] -21.96266027  -3.42641944   8.23524567  -8.15330917  -9.96862026
## [186]   6.60171855  -8.70976331  11.30118018  15.56796862  10.43344172
## [191]   2.94117174  29.40240156  34.41513933  -1.90863358  -4.81858055
## [196]  46.90876941  55.79552284 -90.73701795  30.24413024  -9.78284639
## [201] -42.62127275 -18.61031858  36.66775228  -5.06230327  -5.42345400
## [206]  26.93243506 -17.63828937  17.49391927 -20.33147771 -18.27219922
## [211]   3.78991851  -6.08889718  41.39838878  34.04513264  42.23881737
## [216] -14.55409182  75.63259841  18.36410598  30.89765191 -75.36015913
## [221] -34.10452092 -10.69540359  39.30922626 -113.64545914 -16.58344634
## [226] -30.00100724 -50.98550163  52.32009305  37.25152976  77.39393046
## [231] -29.65766502 -43.45835896  31.09209055   8.32510552 -20.66768907
## [236]   7.00745251  38.67682733  36.25197974  71.74154114  -7.74336367
## [241] -31.77801678 -36.17866842   6.02831120  23.24388381  43.44719237
```

```
## [246]   12.19726971  -55.77822109    9.55350337   41.50275059   55.34457046
## [251]    9.63330647    1.97878842  -53.01457465   -0.01324437   34.98738052
## [256]   31.83660817   17.13449535   -1.97394331   23.91919115  161.69063740
## [261]  -12.83823993 -135.03250691   51.83858821 -111.10725675  -15.36500125
## [266]   68.05994925  -90.45125093  -41.08358578  -80.04518266   -0.46849596
## [271]  -14.44639141   21.13521730  106.53801683  -14.48865308  -42.20505037
## [276]  -46.91373438  -29.60025356  -54.10365629  -42.85094103 -113.92915067
## [281]  -72.35375275  -68.43996261  -49.81083266   68.63933887    6.70080196
## [286]  -27.91535485  -34.39825436  -42.77527812   29.04294232   64.47264007
## [291]   40.33069609  -33.77218424   -6.57874720   -3.16834917   37.28113968
## [296]  -11.37785668  -53.04102737   -9.63844900  -39.08368832   34.96035577
## [301]   56.91085850  -20.07430599  -43.02716137   26.90294341    7.53361045
## [306]  -11.62183988  -44.97349897   -3.85156221   15.83016195   42.88326426
## [311]  -67.54005118   -8.15338079   38.73131150  110.30389323   48.99954198
## [316]   -3.71235128   17.56280464   16.63415751   59.74932576   -0.16976312
## [321]  -19.06175336  -62.46238293
```

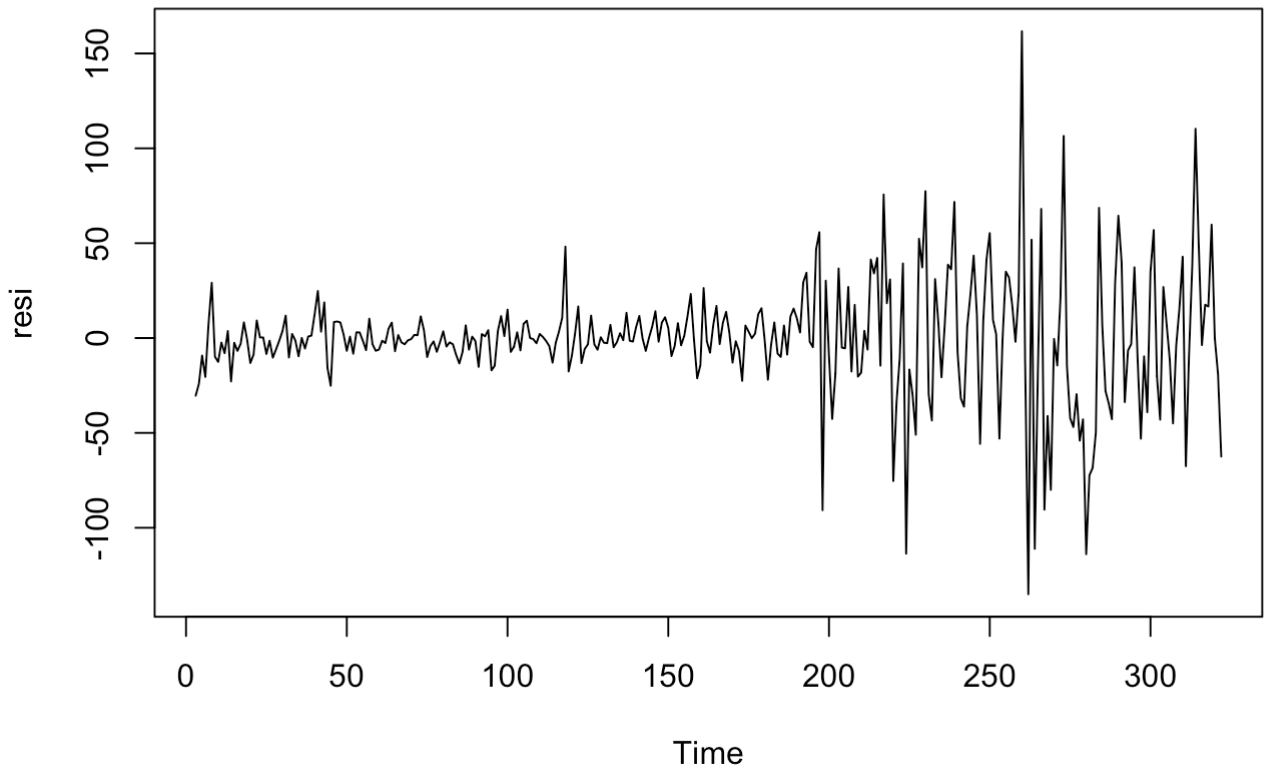
```
resi<-na.omit(gold.for$residuals)
?acf
acf(resi, lag.max = 60)
```




```
Box.test(resi, lag=20, type="Ljung-Box")
```

```
##
##  Box-Ljung test
##
## data:  resi
## X-squared = 40.519, df = 20, p-value = 0.004292
```

```
plot.ts(resi)
```

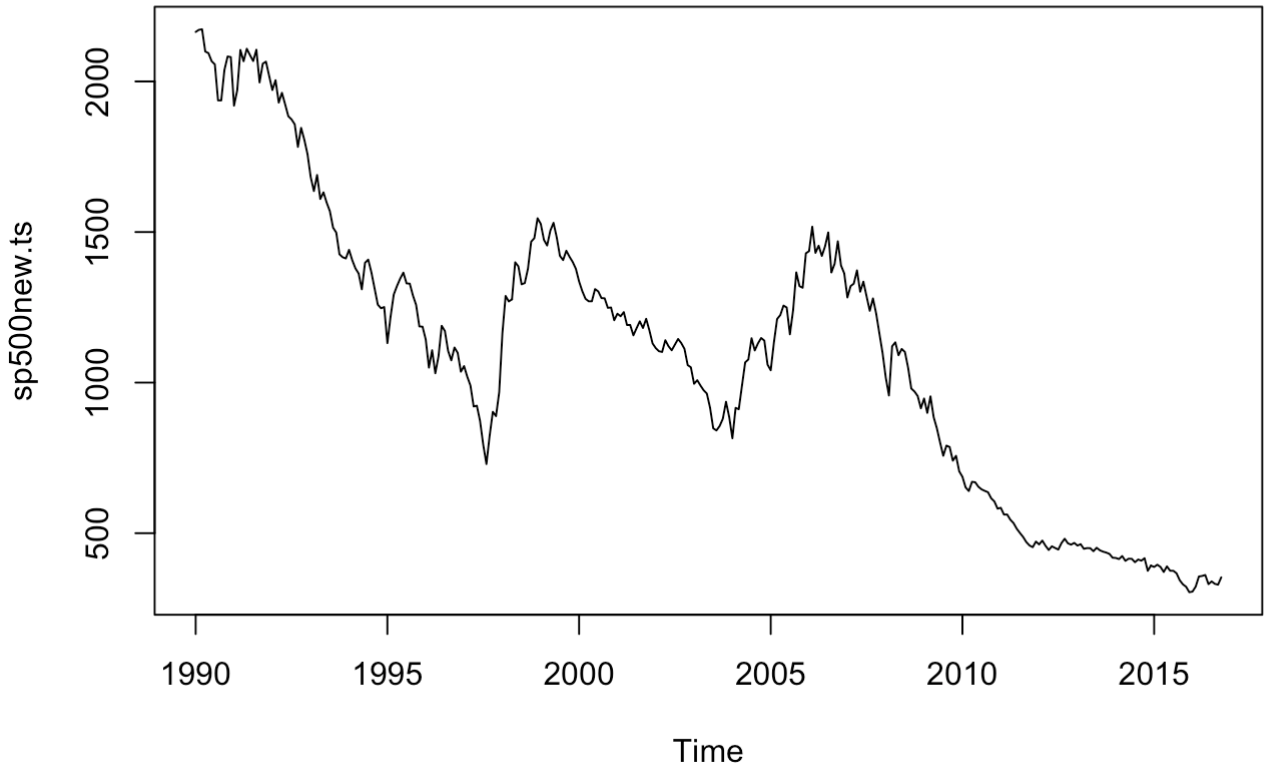



```
url<-"http://chart.finance.yahoo.com/table.csv?s=^GSPC&a=0&b=1&c=1990&d=9&e=31&f=2016&g=
m&ignore=.csv"
```

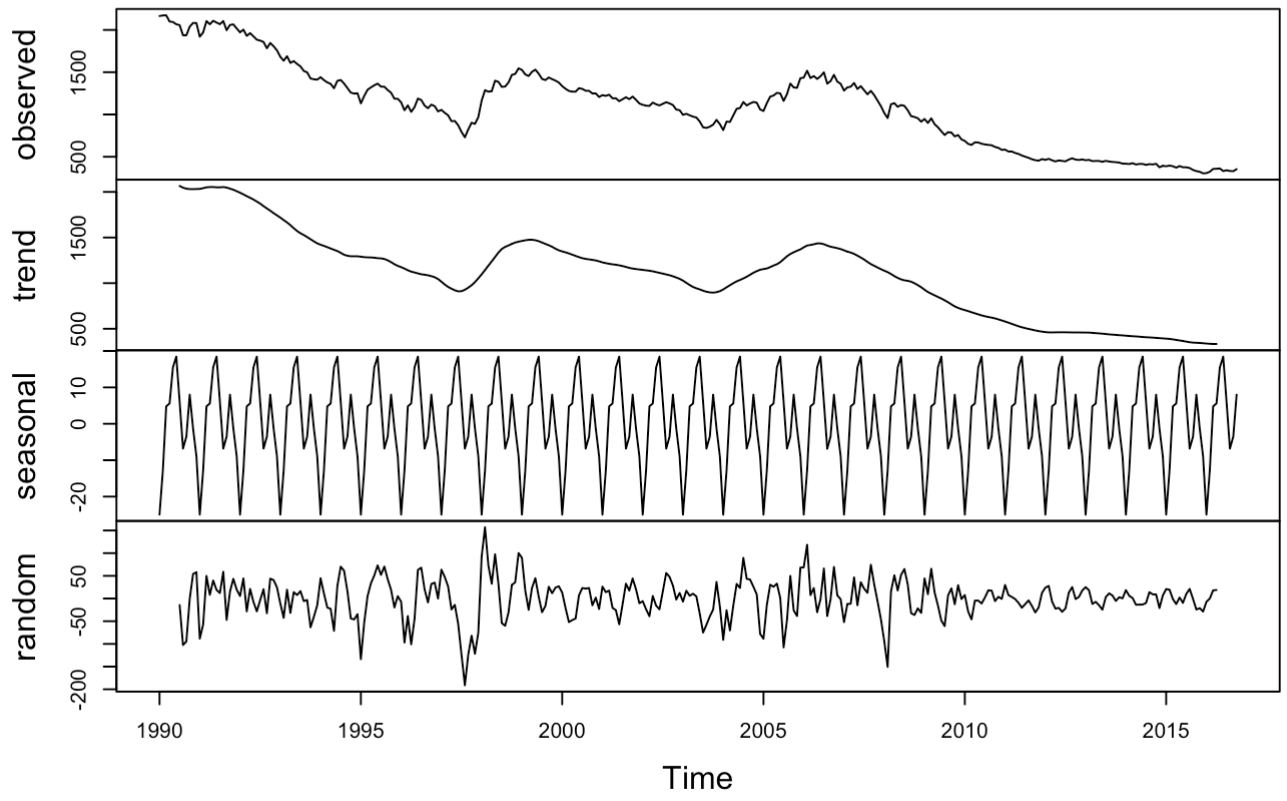
```
sp500new<-read.csv(url,header=T,stringsAsFactors=F)
head(sp500new,6)
```

```
##         Date    Open    High     Low   Close     Volume Adj.Close
## 1 2016-10-03 2164.33 2169.60 2114.72 2126.15 3672334700   2126.15
## 2 2016-09-01 2171.33 2187.87 2119.12 2168.27 3878265700   2168.27
## 3 2016-08-01 2173.15 2193.81 2147.58 2170.95 3451160800   2170.95
## 4 2016-07-01 2099.34 2177.09 2074.02 2173.60 3678454500   2173.60
## 5 2016-06-01 2093.94 2120.55 1991.68 2098.86 4157978100   2098.86
## 6 2016-05-02 2067.17 2103.48 2025.91 2096.95 3971333800   2096.95
```

```
sp500new.ts<-ts(sp500new$Open,start=c(1990),frequency = 12)
plot(sp500new.ts)
```



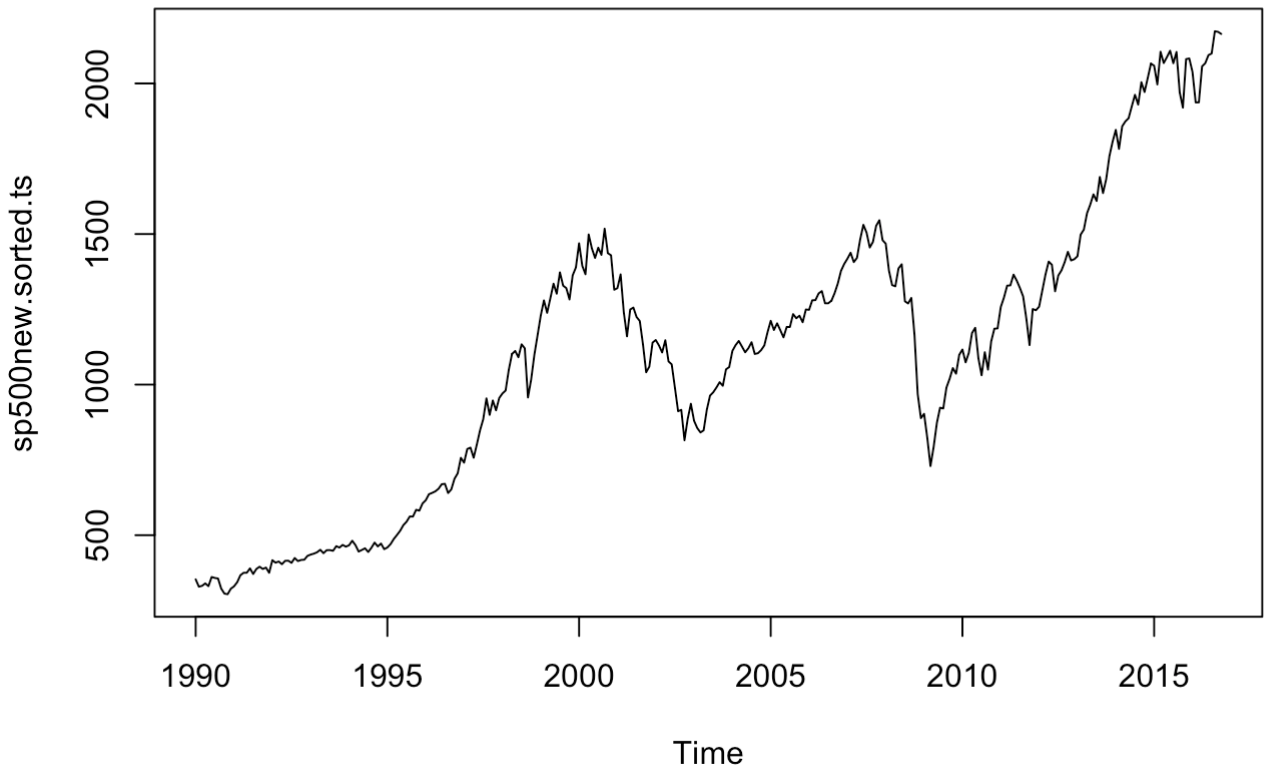

```
sp500new.ts.d<-decompose(sp500new.ts)
plot(sp500new.ts.d)
```



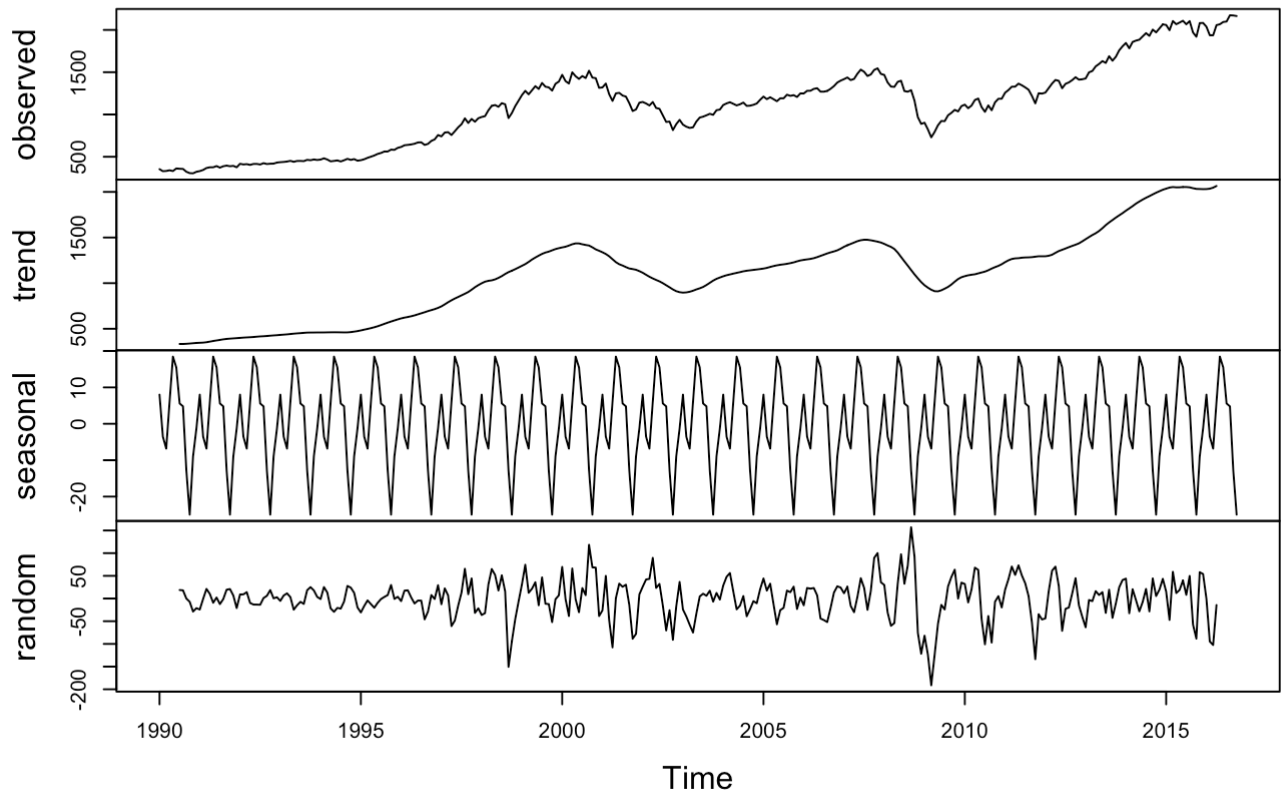

```
library(base)
library(zoo)

sp500new.sorted<-sp500new[order(as.Date(sp500new$Date, format="%Y-%m-%d")),]

sp500new.sorted.ts<-ts(sp500new.sorted$Open,start=c(1990),frequency = 12)
str(sp500new.sorted)
```

```
## 'data.frame':    322 obs. of  7 variables:
##  $ Date     : chr  "1990-01-02" "1990-02-01" "1990-03-01" "1990-04-02" ...
##  $ Open     : num  353 329 332 340 331 ...
##  $ High     : num  361 336 344 347 362 ...
##  $ Low      : num  320 322 331 328 331 ...
##  $ Close    : num  329 332 340 331 361 ...
##  $ Volume   : num  1.81e+08 1.66e+08 1.56e+08 1.46e+08 1.71e+08 ...
##  $ Adj.Close: num  329 332 340 331 361 ...
```

```
plot(sp500new.sorted.ts)
```

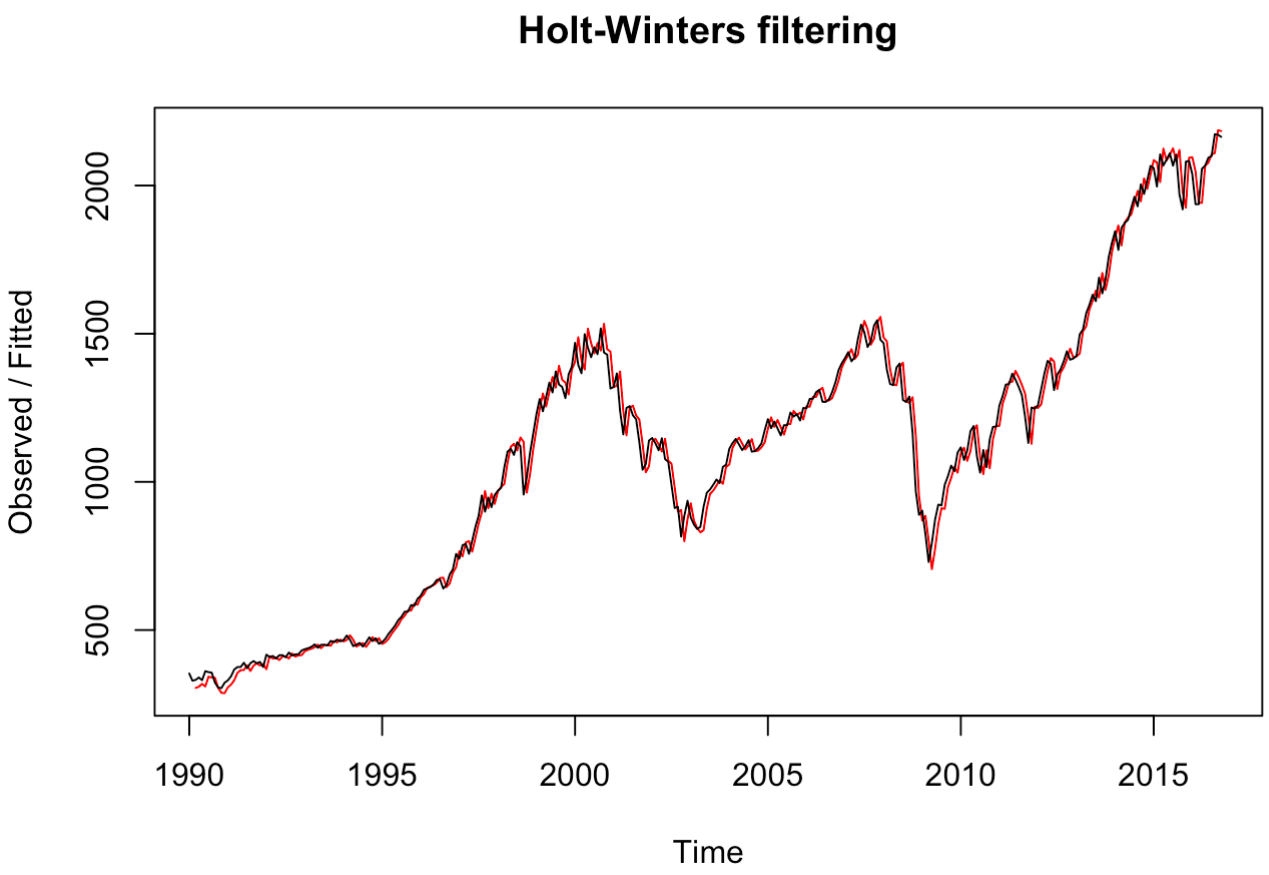



```
sp500new.sorted.ts.d<-decompose(sp500new.sorted.ts)
plot(sp500new.sorted.ts.d)
```



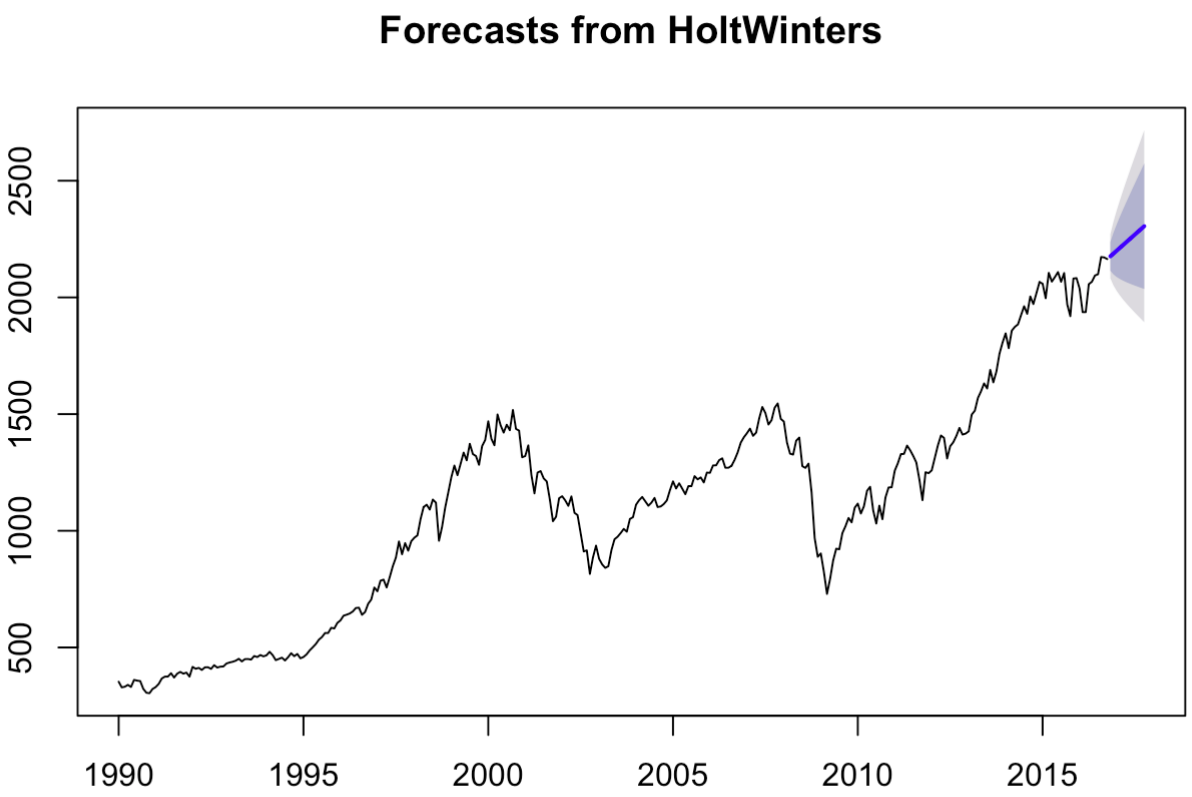

```
sp500new.holt.F <- HoltWinters(sp500new.sorted.ts, gamma=FALSE)
```

```
plot(sp500new.holt.F)
```



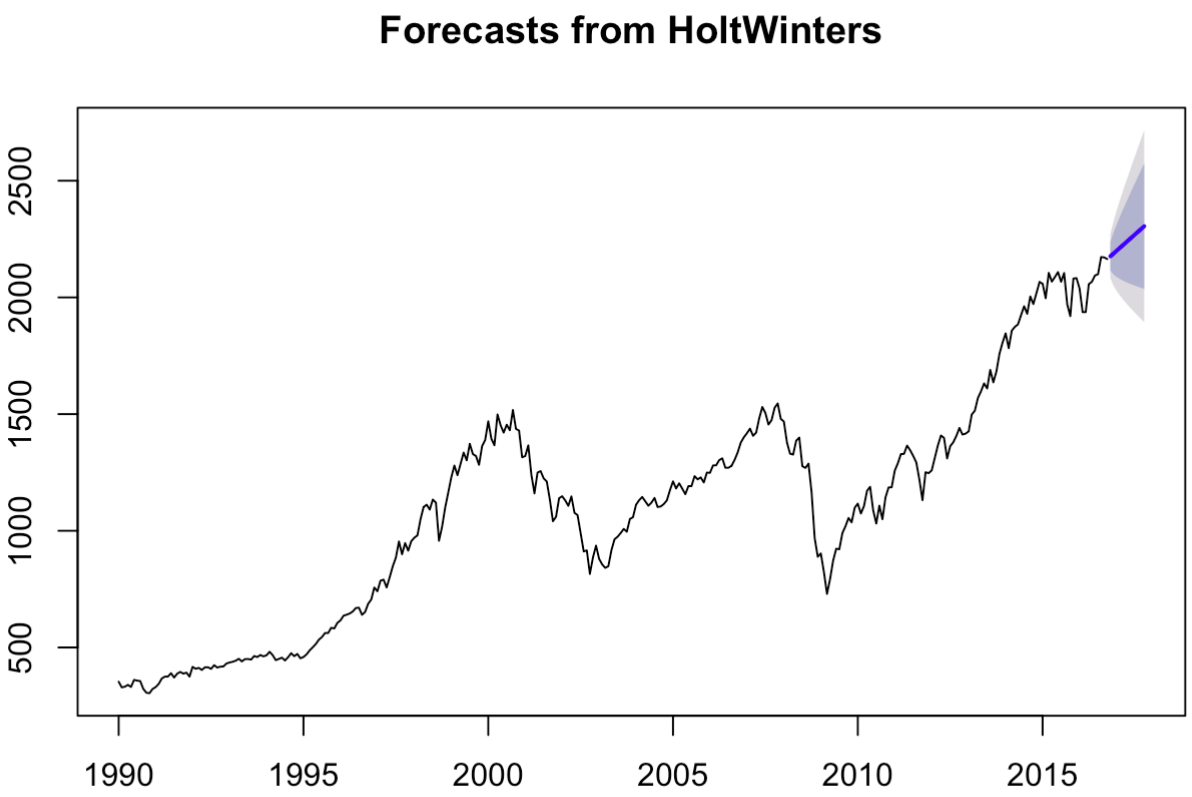

```
sp500new.forecasts.F <- forecast.HoltWinters(sp500new.holt.F, h=12)
```

```
plot.forecast(sp500new.forecasts.F)
```



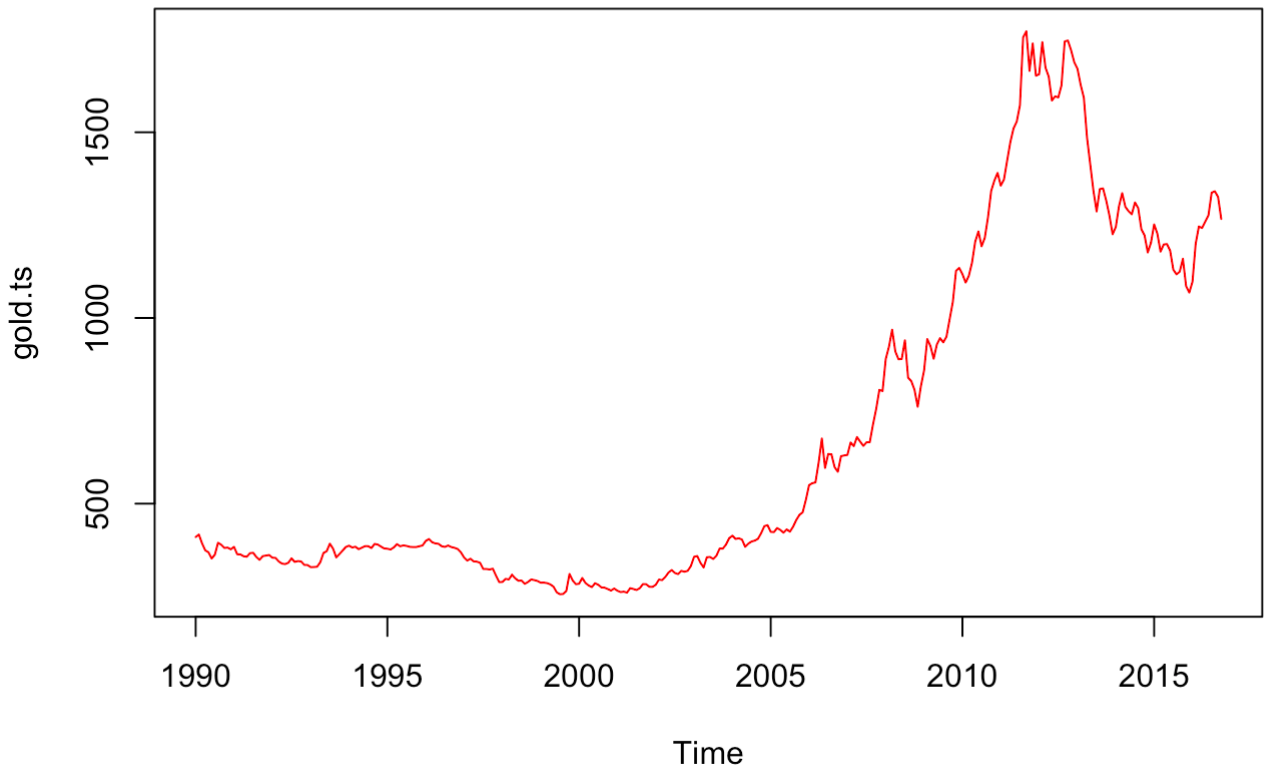

```
sp500new.forecasts.F <- forecast.HoltWinters(sp500new.holt.F, h=12)
```

```
plot.forecast(sp500new.forecasts.F)
```

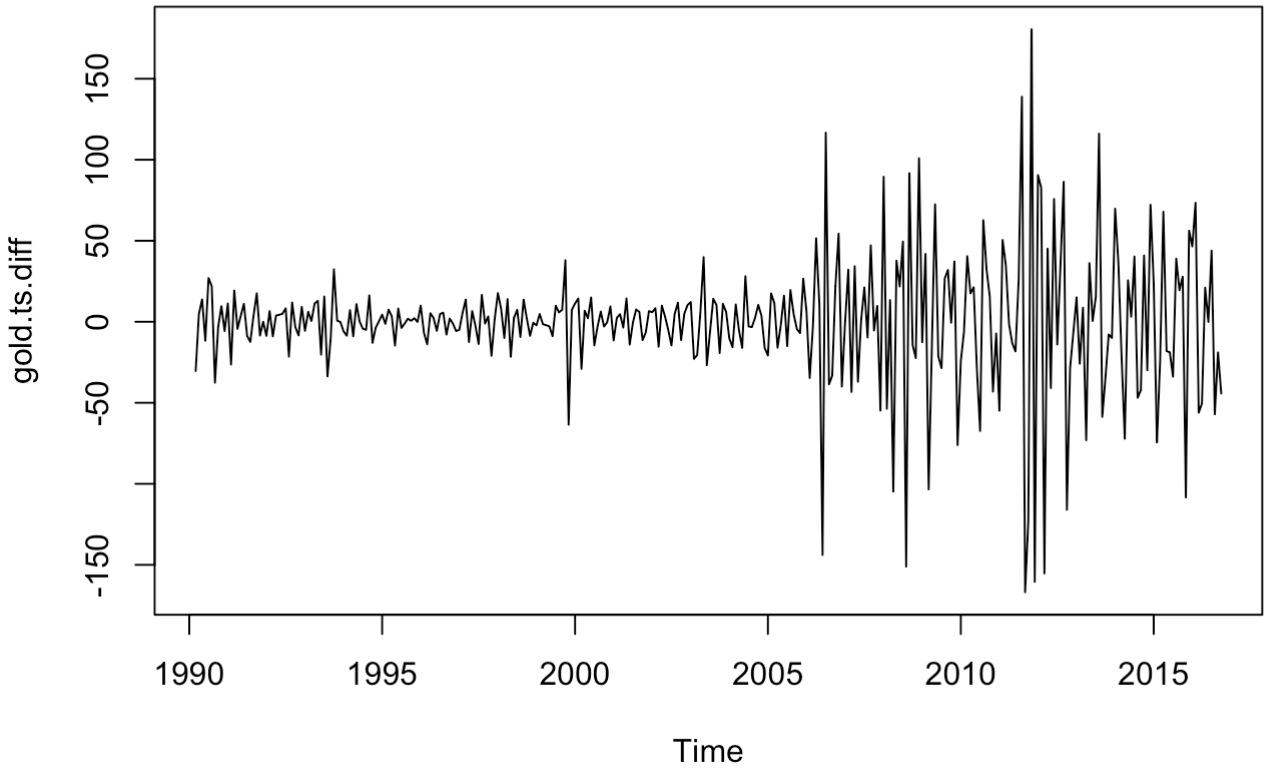


FOR GOLD-ARIMA

```
plot.ts(gold.ts,col="red")
```

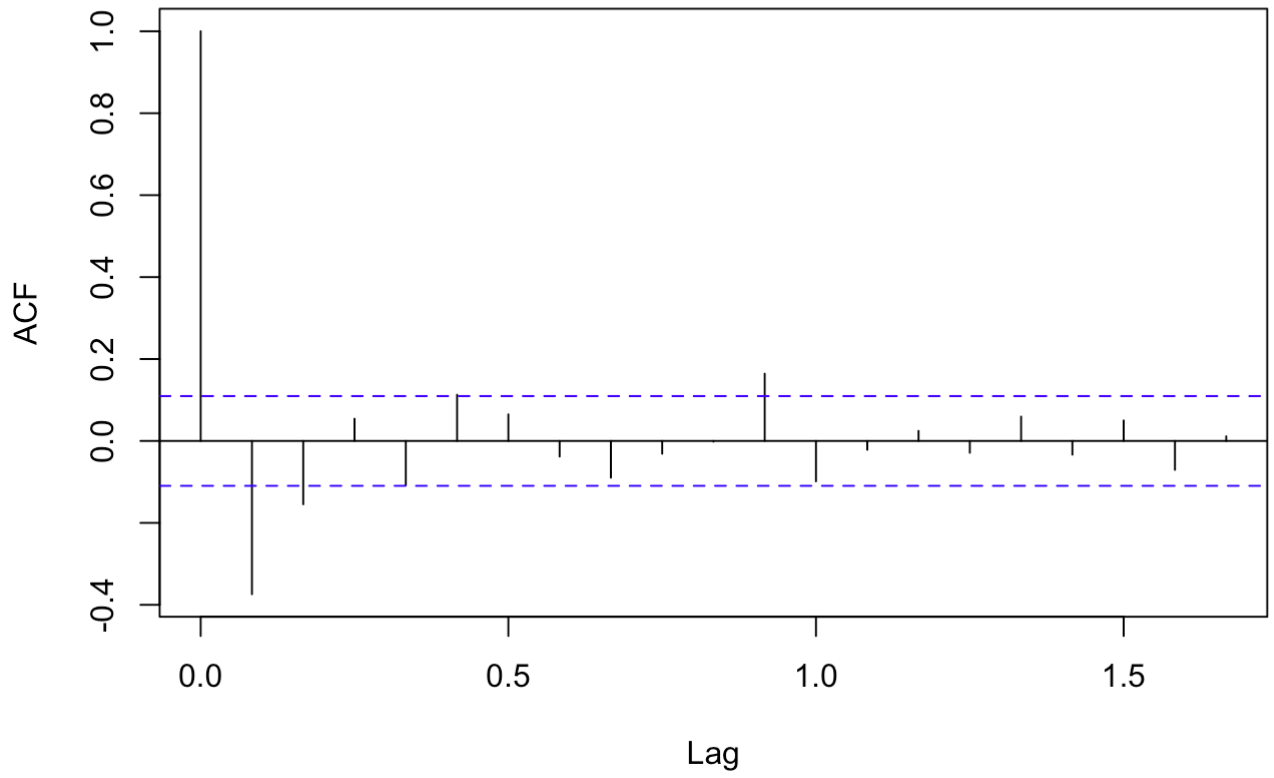



```
gold.ts.diff<-diff(gold.ts,differences = 2)
plot.ts(gold.ts.diff)
```



d=2

```
acf(gold.ts.diff,lag.max = 20)
```

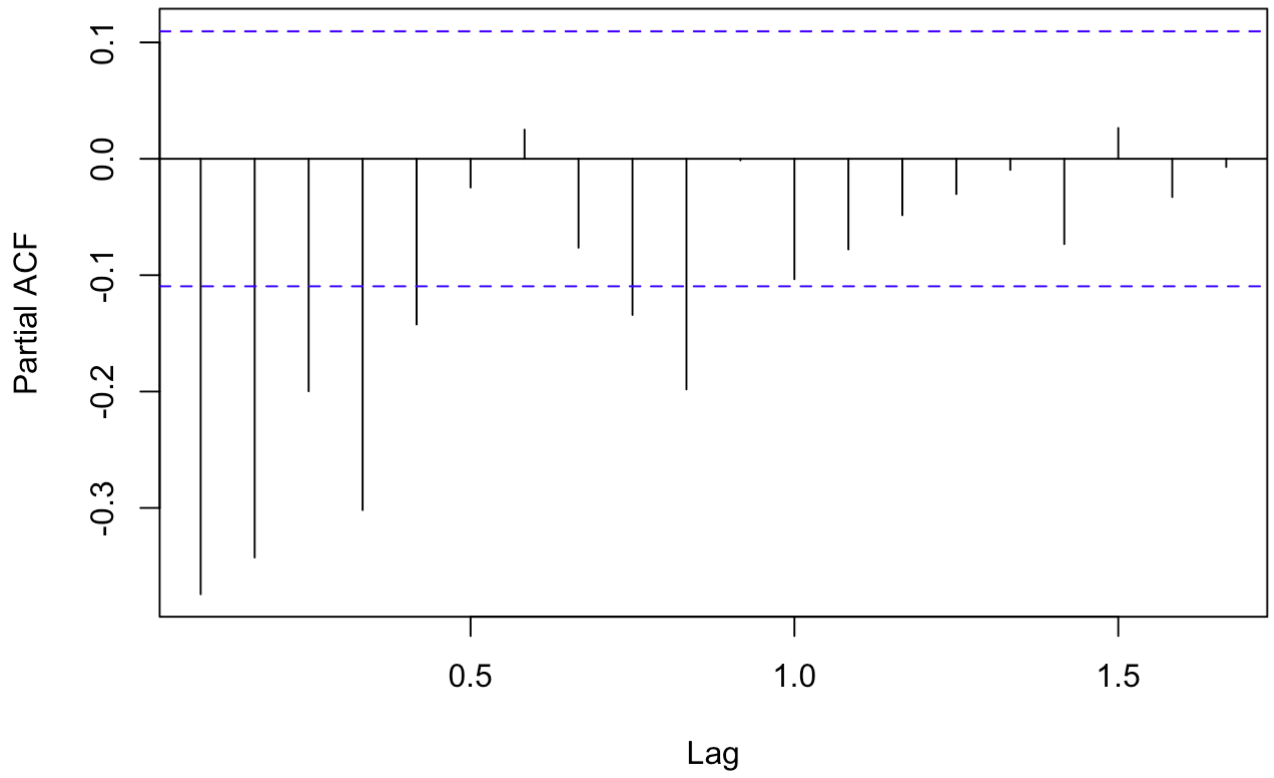



```
acf(gold.ts.diff,lag.max = 20,plot=FALSE)
```

```
##
## Autocorrelations of series 'gold.ts.diff', by lag
##
## 0.0000 0.0833 0.1667 0.2500 0.3333 0.4167 0.5000 0.5833 0.6667 0.7500
##  1.000 -0.374 -0.155  0.054 -0.108  0.113  0.065 -0.038 -0.090 -0.031
## 0.8333 0.9167 1.0000 1.0833 1.1667 1.2500 1.3333 1.4167 1.5000 1.5833
## -0.002  0.164 -0.099 -0.022  0.025 -0.029  0.059 -0.034  0.050 -0.071
## 1.6667
##  0.011
```

q=3 as it tails of to zero after lag 1 and lag 2 (0,3)

```
pacf(gold.ts.diff,lag.max = 20)
```




```
pacf(gold.ts.diff,lag.max = 20,plot=FALSE)
```

```
##
## Partial autocorrelations of series 'gold.ts.diff', by lag
##
## 0.0833 0.1667 0.2500 0.3333 0.4167 0.5000 0.5833 0.6667 0.7500 0.8333
## -0.374 -0.343 -0.200 -0.302 -0.142 -0.025  0.025 -0.076 -0.134 -0.198
## 0.9167 1.0000 1.0833 1.1667 1.2500 1.3333 1.4167 1.5000 1.5833 1.6667
## -0.001 -0.103 -0.078 -0.048 -0.030 -0.009 -0.073  0.026 -0.033 -0.007
```

p=5 as it tails of to zero after lag 4 (5,0)

(p,d,q) (0,2,3)

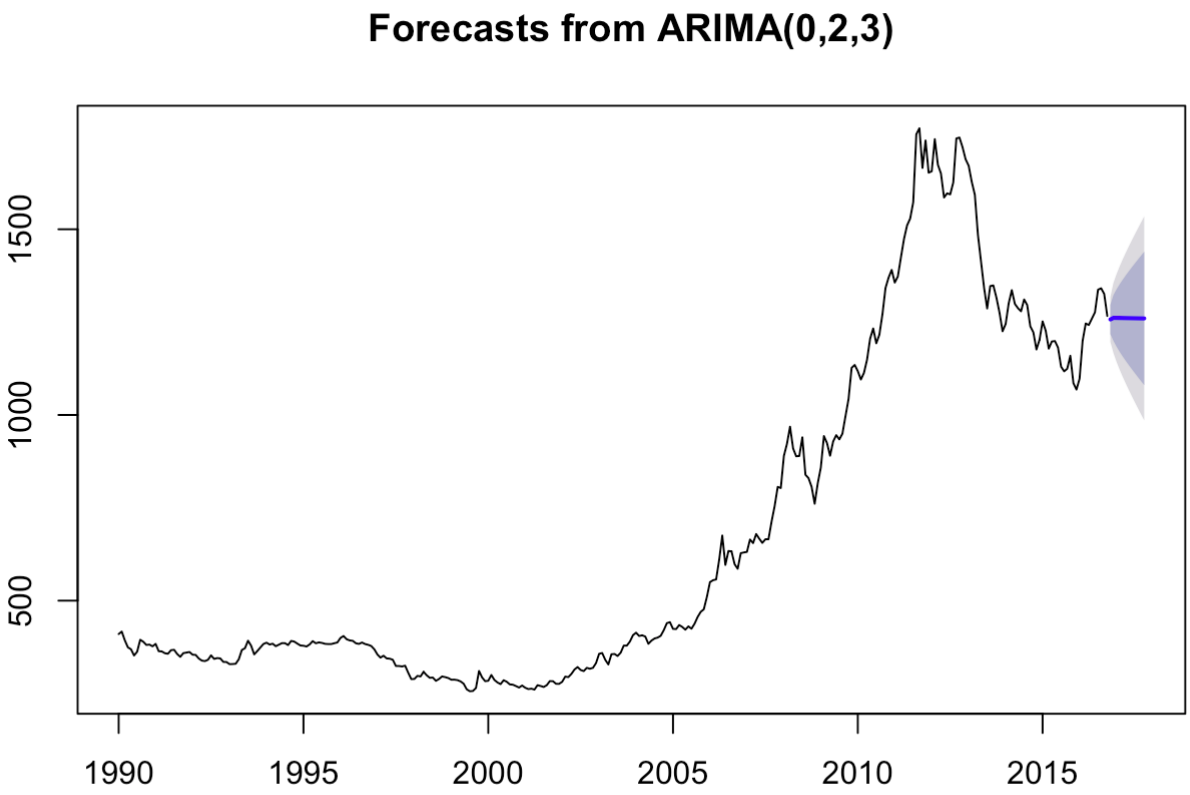
```
gold.ts.arima<- arima (gold.ts,order=c(0,2,3))
gold.ts.arima
```

```
##
## Call:
## arima(x = gold.ts, order = c(0, 2, 3))
##
## Coefficients:
##           ma1      ma2     ma3
##       -0.7928  -0.2384  0.0702
## s.e.   0.0562   0.0761  0.0620
##
## sigma^2 estimated as 941.9:  log likelihood = -1550.98,  aic = 3109.96
```

```
library(forecast)
gold.ts.arima.for<- forecast.Arima(gold.ts.arima,h=12)
gold.ts.arima.for
```

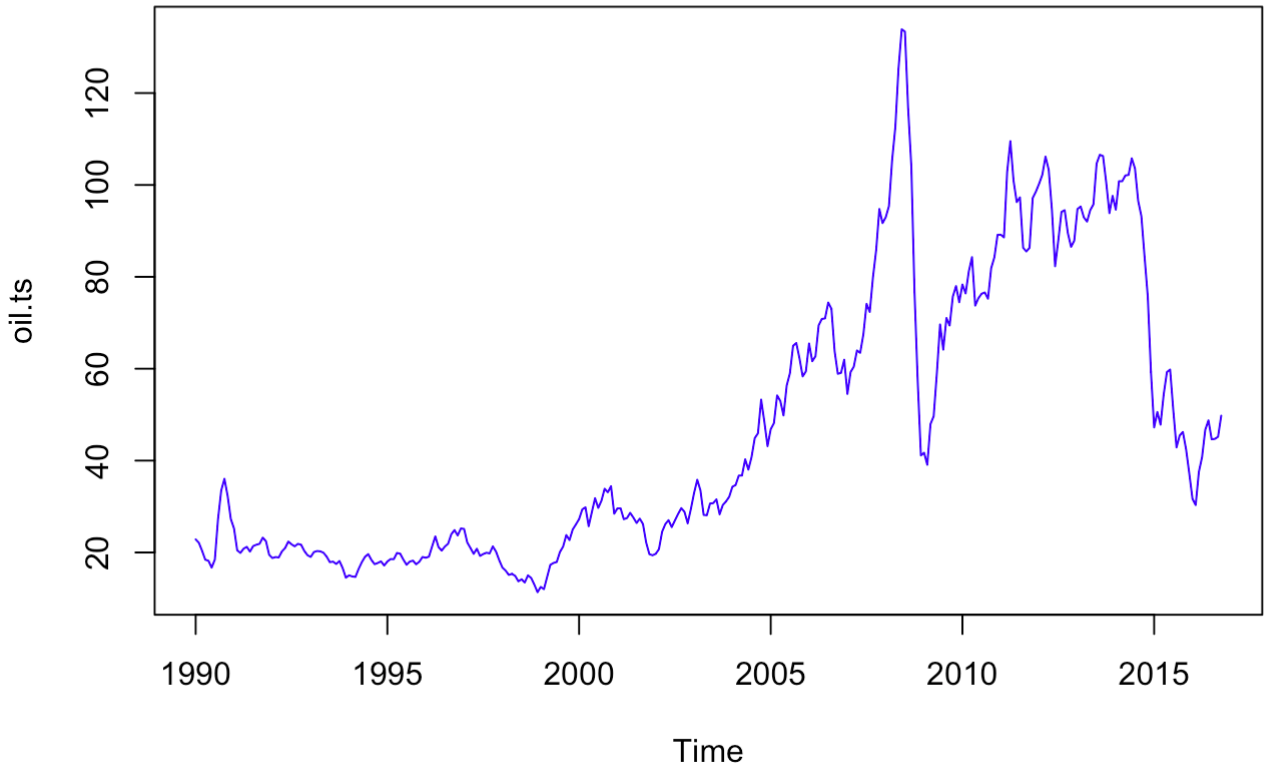
```
##          Point Forecast    Lo 80    Hi 80     Lo 95    Hi 95
## Nov 2016       1257.210 1217.879 1296.541 1197.0589 1317.361
## Dec 2016       1261.298 1199.642 1322.954 1167.0033 1355.592
## Jan 2017       1261.162 1184.083 1338.241 1143.2797 1379.044
## Feb 2017       1261.026 1170.331 1351.720 1122.3204 1399.731
## Mar 2017       1260.890 1157.646 1364.133 1102.9928 1418.787
## Apr 2017       1260.754 1145.658 1375.849 1084.7308 1436.776
## May 2017       1260.618 1134.153 1387.083 1067.2060 1454.029
## Jun 2017       1260.481 1122.992 1397.971 1050.2090 1470.754
## Jul 2017       1260.345 1112.083 1408.608 1033.5978 1487.093
## Aug 2017       1260.209 1101.360 1419.058 1017.2710 1503.148
## Sep 2017       1260.073 1090.775 1429.371 1001.1539 1518.992
## Oct 2017       1259.937 1080.290 1439.585  985.1898 1534.684
```

```
plot.forecast(gold.ts.arima.for)
```

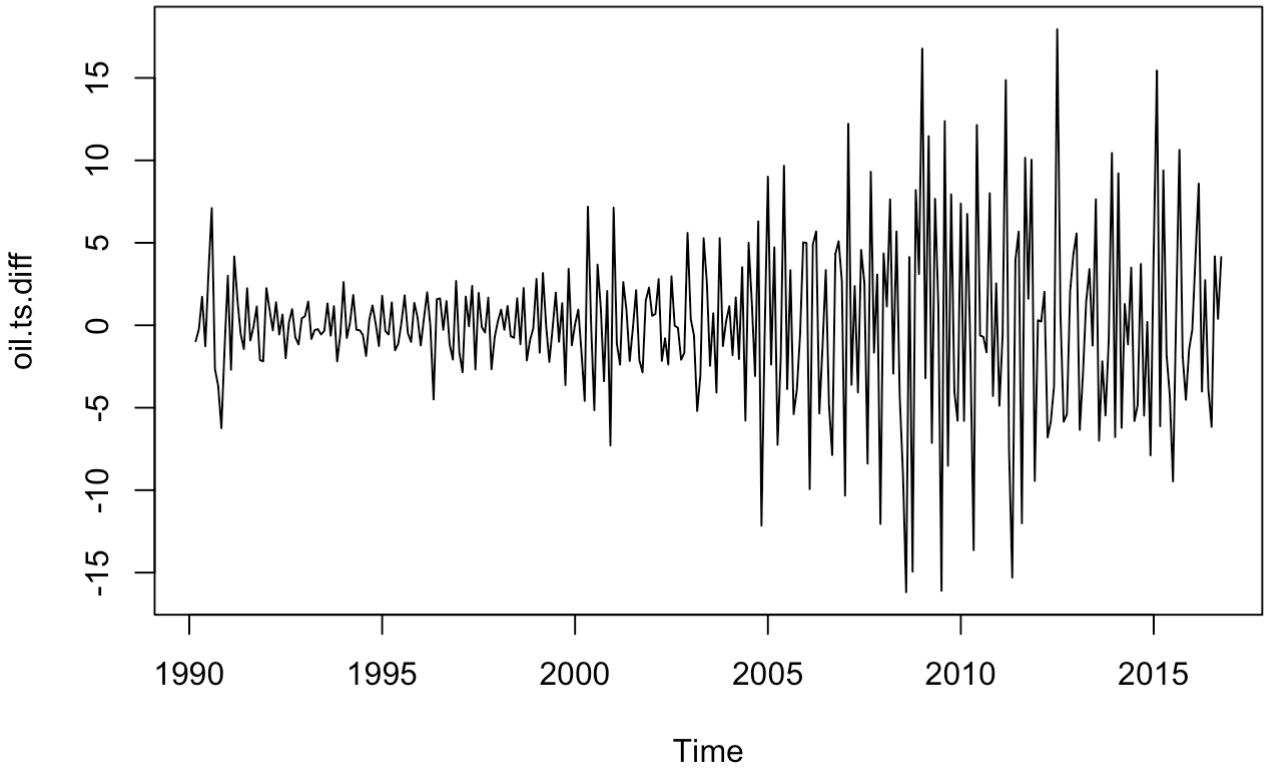


FOR OIL-ARIMA

```
plot.ts(oil.ts,col="blue")
```

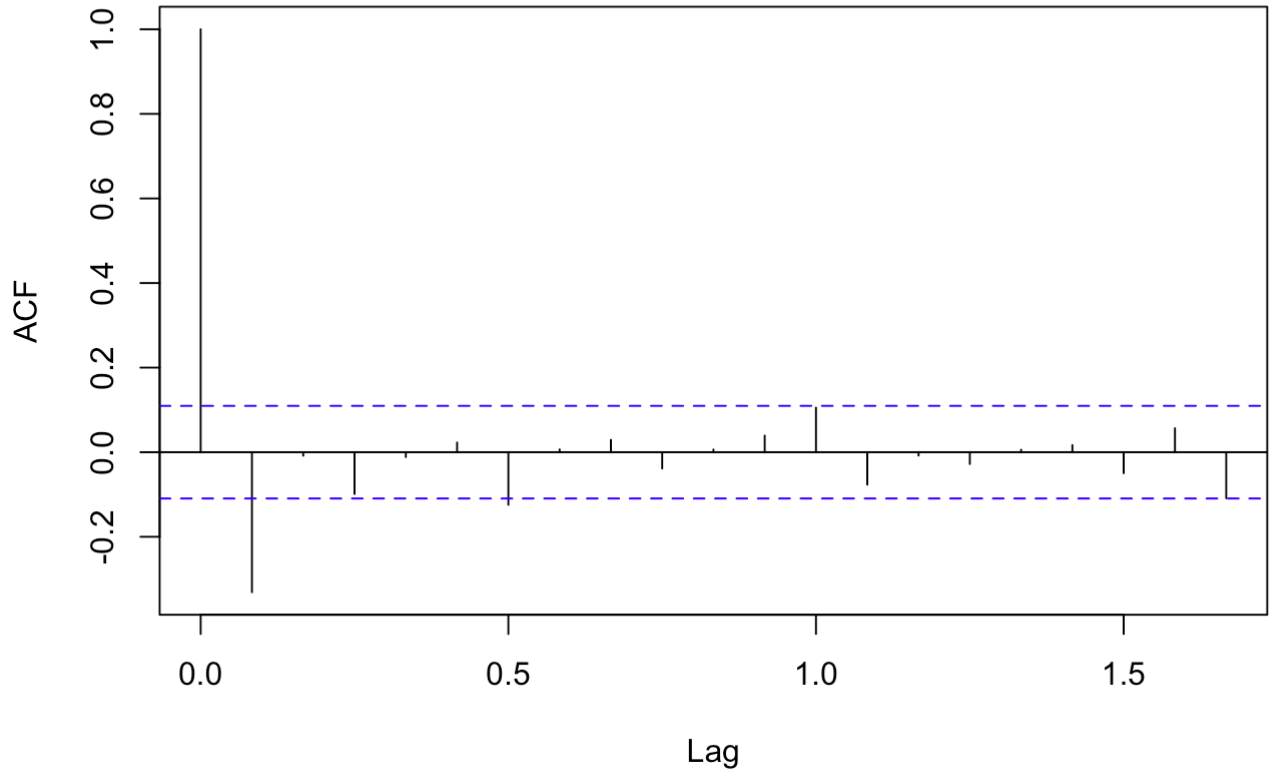



```
oil.ts.diff<-diff(oil.ts,differences = 2)
plot.ts(oil.ts.diff)
```



d=2

```
acf(oil.ts.diff,lag.max = 20)
```

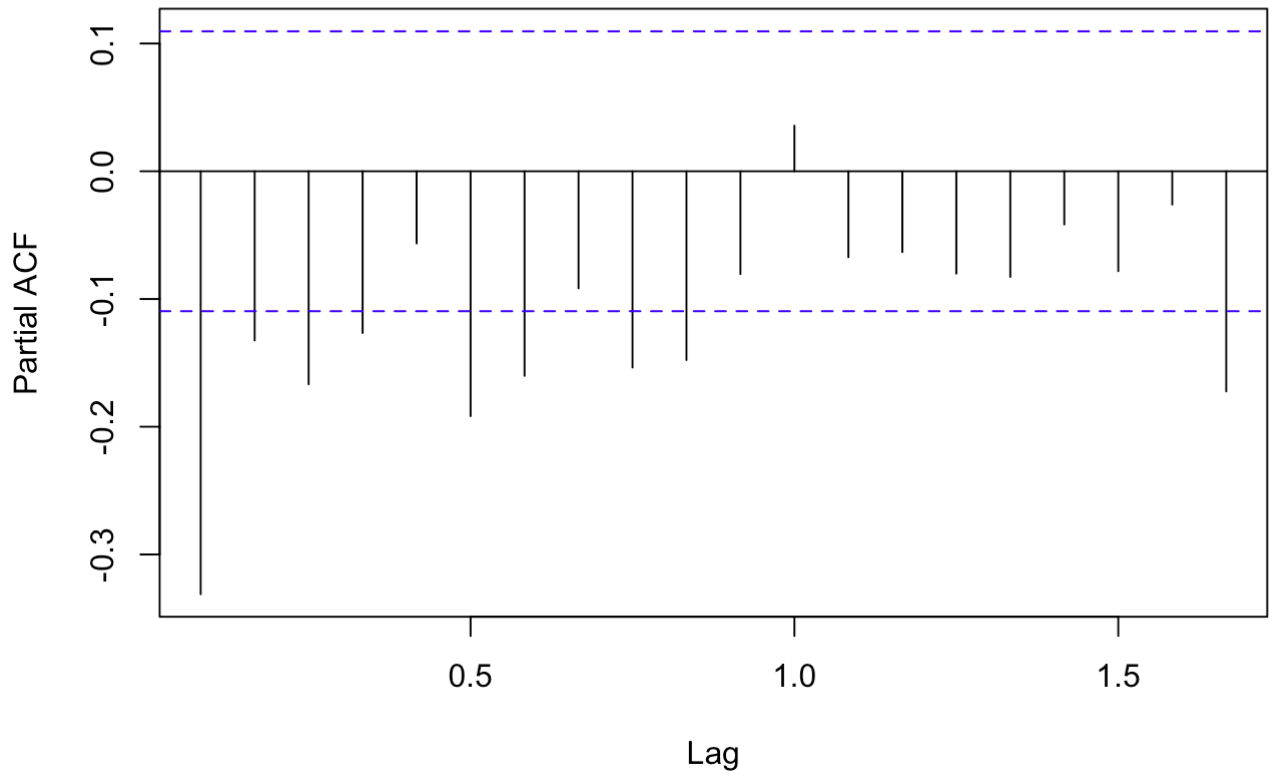



```
acf(oil.ts.diff,lag.max = 20,plot=FALSE)
```

```
##
## Autocorrelations of series 'oil.ts.diff', by lag
##
## 0.0000 0.0833 0.1667 0.2500 0.3333 0.4167 0.5000 0.5833 0.6667 0.7500
##  1.000 -0.331 -0.008 -0.099 -0.012  0.023 -0.124  0.007  0.029 -0.039
## 0.8333 0.9167 1.0000 1.0833 1.1667 1.2500 1.3333 1.4167 1.5000 1.5833
##  0.006  0.039  0.105 -0.077 -0.008 -0.028  0.006  0.017 -0.050  0.057
## 1.6667
## -0.109
```

q=2 as it tails of to zero after lag 1 (0,2)

```
pacf(oil.ts.diff,lag.max = 20)
```




```
pacf(oil.ts.diff,lag.max = 20,plot=FALSE)
```

```
##
## Partial autocorrelations of series 'oil.ts.diff', by lag
##
## 0.0833 0.1667 0.2500 0.3333 0.4167 0.5000 0.5833 0.6667 0.7500 0.8333
## -0.331 -0.132 -0.167 -0.127 -0.057 -0.192 -0.160 -0.092 -0.154 -0.148
## 0.9167 1.0000 1.0833 1.1667 1.2500 1.3333 1.4167 1.5000 1.5833 1.6667
## -0.080  0.036 -0.067 -0.063 -0.080 -0.083 -0.042 -0.078 -0.026 -0.172
```

p=4 as it tails of to zero after lag 3 (4,0)

(p,d,q) (0,2,2)

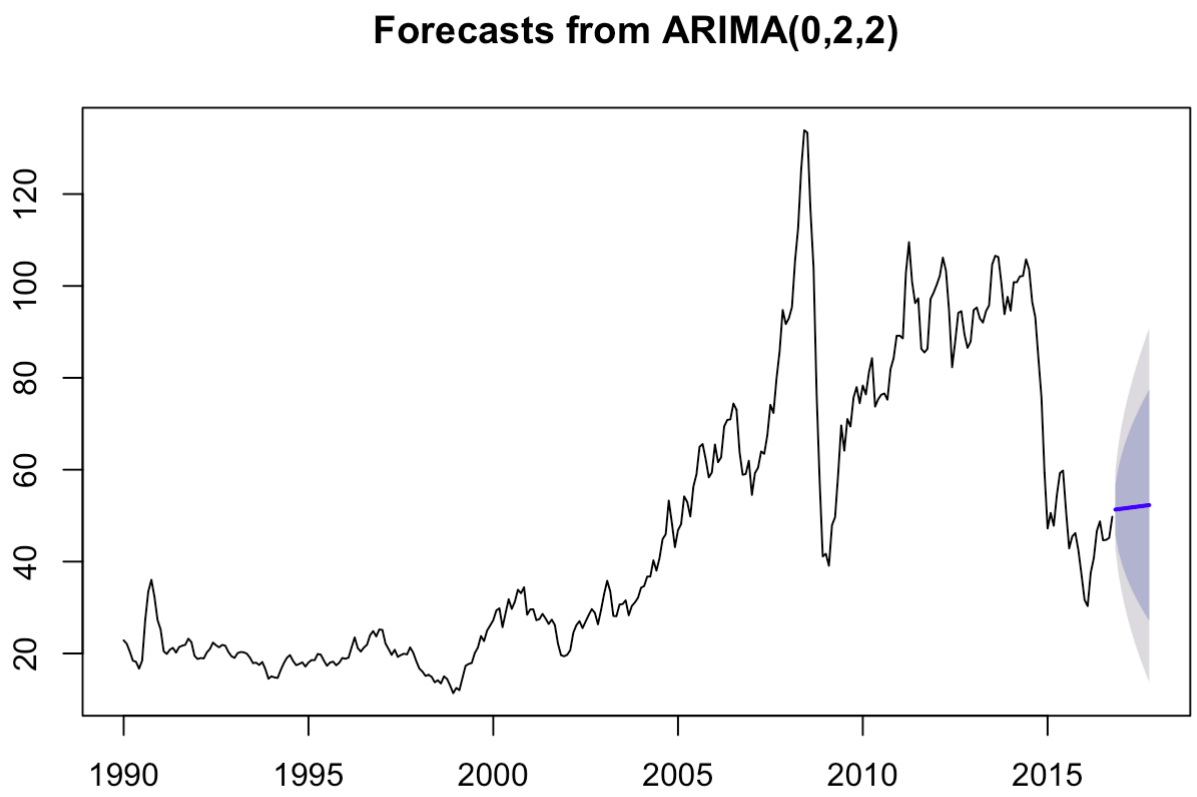
```
oil.ts.arima<- arima (oil.ts,order=c(0,2,2))
oil.ts.arima
```

```
##
## Call:
## arima(x = oil.ts, order = c(0, 2, 2))
##
## Coefficients:
##           ma1      ma2
##       -0.6777  -0.3223
## s.e.   0.0460   0.0451
##
## sigma^2 estimated as 18.37:  log likelihood = -922.45,  aic = 1850.9
```

```
library(forecast)
oil.ts.arima.for<- forecast.Arima(oil.ts.arima,h=12)
oil.ts.arima.for
```

```
##          Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
## Nov 2016       51.32856 45.82709 56.83004 42.91478 59.74234
## Dec 2016       51.41650 42.28246 60.55054 37.44719 65.38581
## Jan 2017       51.50444 39.80301 63.20587 33.60865 69.40023
## Feb 2017       51.59238 37.78136 65.40340 30.47025 72.71451
## Mar 2017       51.68032 36.03125 67.32939 27.74713 75.61350
## Apr 2017       51.76826 34.46593 69.07059 25.30663 78.22989
## May 2017       51.85620 33.03663 70.67576 23.07416 80.63824
## Jun 2017       51.94414 31.71274 72.17554 21.00288 82.88539
## Jul 2017       52.03208 30.47352 73.59063 19.06111 85.00304
## Aug 2017       52.12002 29.30421 74.93583 17.22625 87.01379
## Sep 2017       52.20795 28.19381 76.22210 15.48149 88.93442
## Oct 2017       52.29589 27.13391 77.45788 13.81396 90.77783
```

```
plot.forecast(oil.ts.arima.for)
```

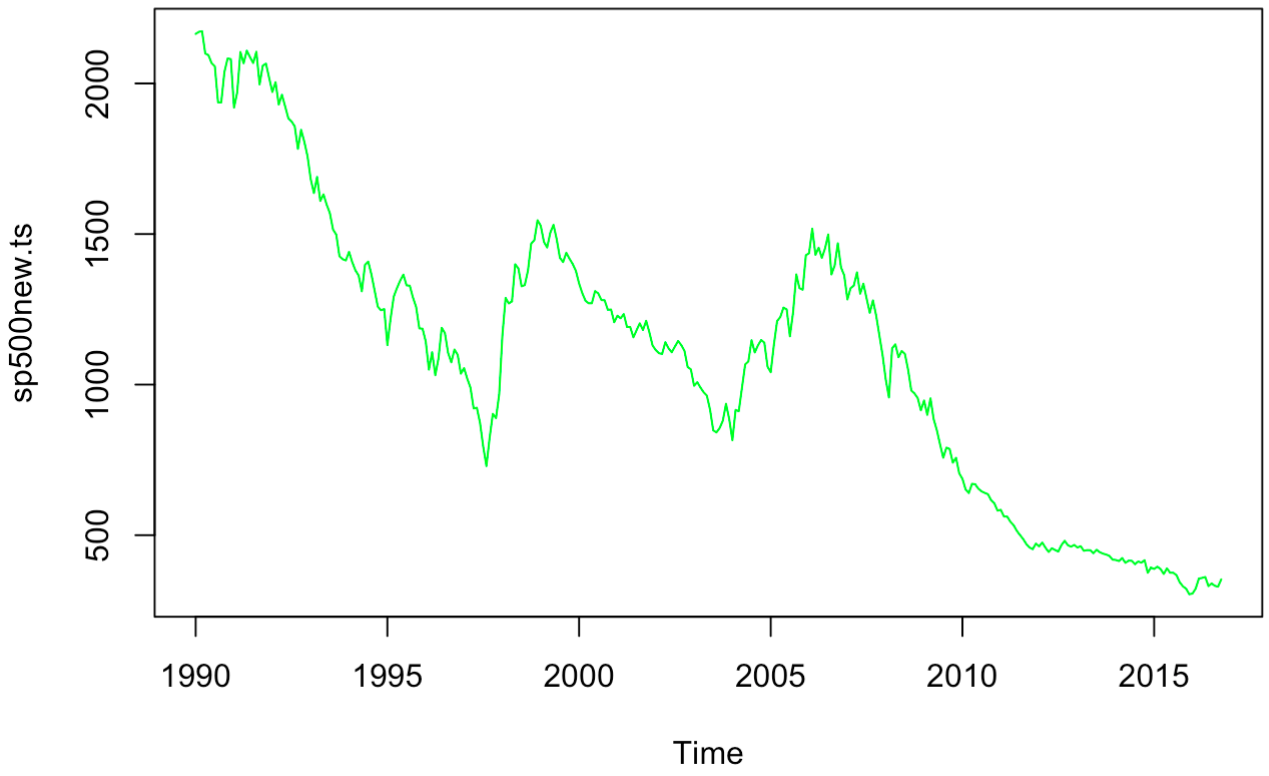


FOR SP500-ARIMA

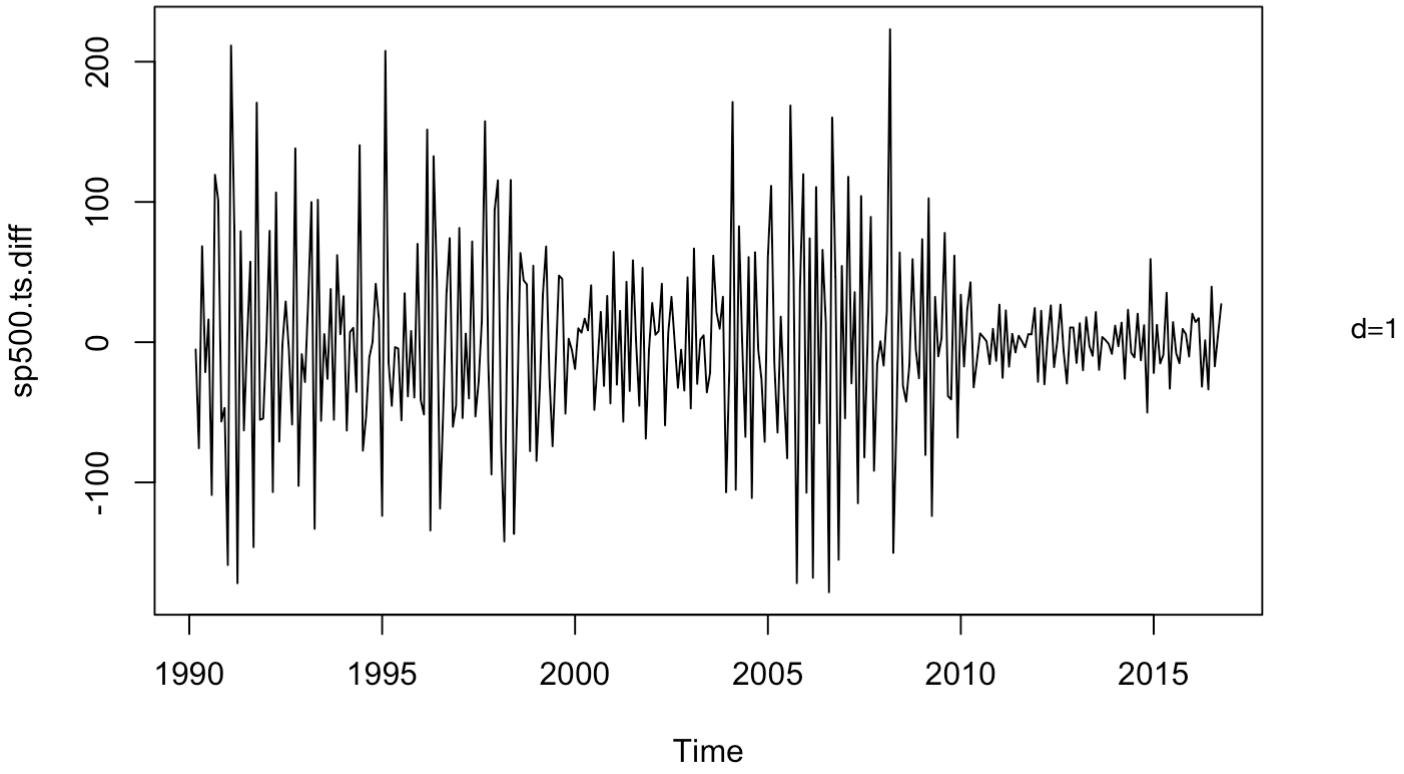
```
sp500new<-read.csv(url,header=T,stringsAsFactors=F)
head(sp500new,6)
```

```
##         Date    Open    High     Low   Close     Volume Adj.Close
## 1 2016-10-03 2164.33 2169.60 2114.72 2126.15 3672334700   2126.15
## 2 2016-09-01 2171.33 2187.87 2119.12 2168.27 3878265700   2168.27
## 3 2016-08-01 2173.15 2193.81 2147.58 2170.95 3451160800   2170.95
## 4 2016-07-01 2099.34 2177.09 2074.02 2173.60 3678454500   2173.60
## 5 2016-06-01 2093.94 2120.55 1991.68 2098.86 4157978100   2098.86
## 6 2016-05-02 2067.17 2103.48 2025.91 2096.95 3971333800   2096.95
```

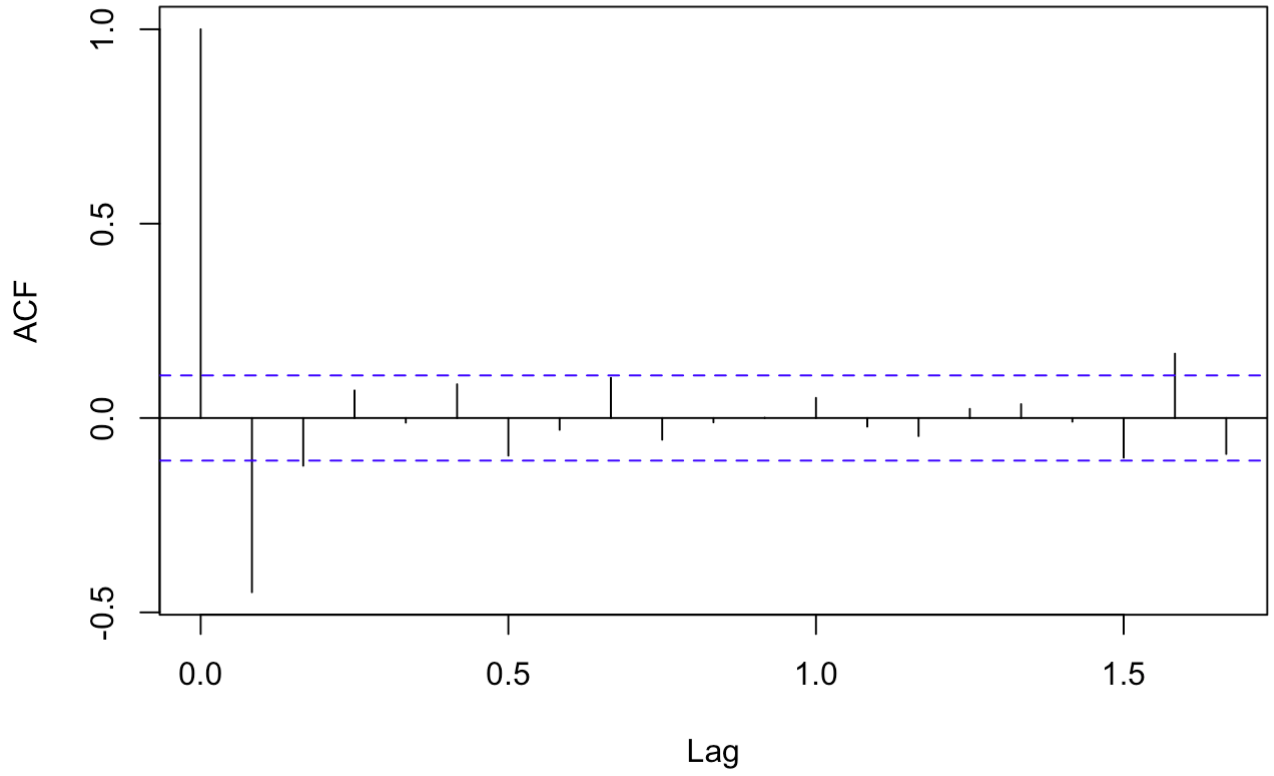
```
sp500new.ts<-ts(sp500new$Open,start=c(1990),frequency = 12)
plot.ts(sp500new.ts,col="green")
```




```
sp500.ts.diff<-diff(sp500new.ts,differences = 2)
plot.ts(sp500.ts.diff)
```




```
acf(sp500.ts.diff,lag.max = 20) # plot a correlogram
```

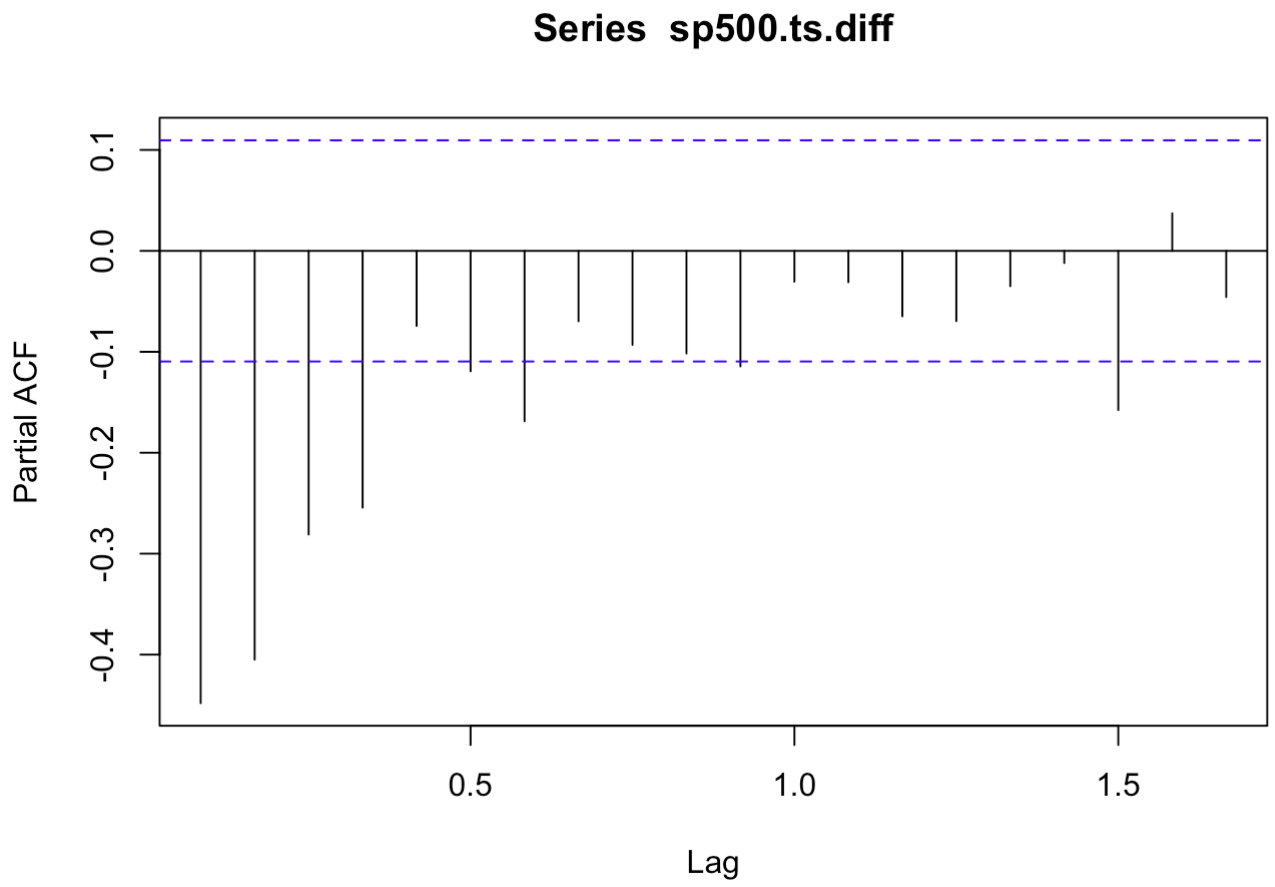



```
acf(sp500.ts.diff,lag.max = 20,plot=FALSE) # get the autocorrelation values
```

```
##
## Autocorrelations of series 'sp500.ts.diff', by lag
##
## 0.0000 0.0833 0.1667 0.2500 0.3333 0.4167 0.5000 0.5833 0.6667 0.7500
##  1.000 -0.448 -0.123  0.071 -0.012  0.087 -0.097 -0.030  0.103 -0.056
## 0.8333 0.9167 1.0000 1.0833 1.1667 1.2500 1.3333 1.4167 1.5000 1.5833
## -0.011  0.001  0.052 -0.022 -0.046  0.023  0.036 -0.009 -0.102  0.166
## 1.6667
## -0.093
```

q=1 as it tails of to zero after lag 0 (0,1)

```
pacf(sp500.ts.diff,lag.max = 20)
```




```
pacf(sp500.ts.diff,lag.max = 20,plot=FALSE)
```

```
##
## Partial autocorrelations of series 'sp500.ts.diff', by lag
##
## 0.0833 0.1667 0.2500 0.3333 0.4167 0.5000 0.5833 0.6667 0.7500 0.8333
## -0.448 -0.405 -0.281 -0.254 -0.074 -0.119 -0.169 -0.070 -0.093 -0.102
## 0.9167 1.0000 1.0833 1.1667 1.2500 1.3333 1.4167 1.5000 1.5833 1.6667
## -0.114 -0.030 -0.031 -0.065 -0.070 -0.035 -0.012 -0.158  0.037 -0.046
```

p= as it tails of to zero at lag 0 (0,0)

(p,d,q) (0,2,0)

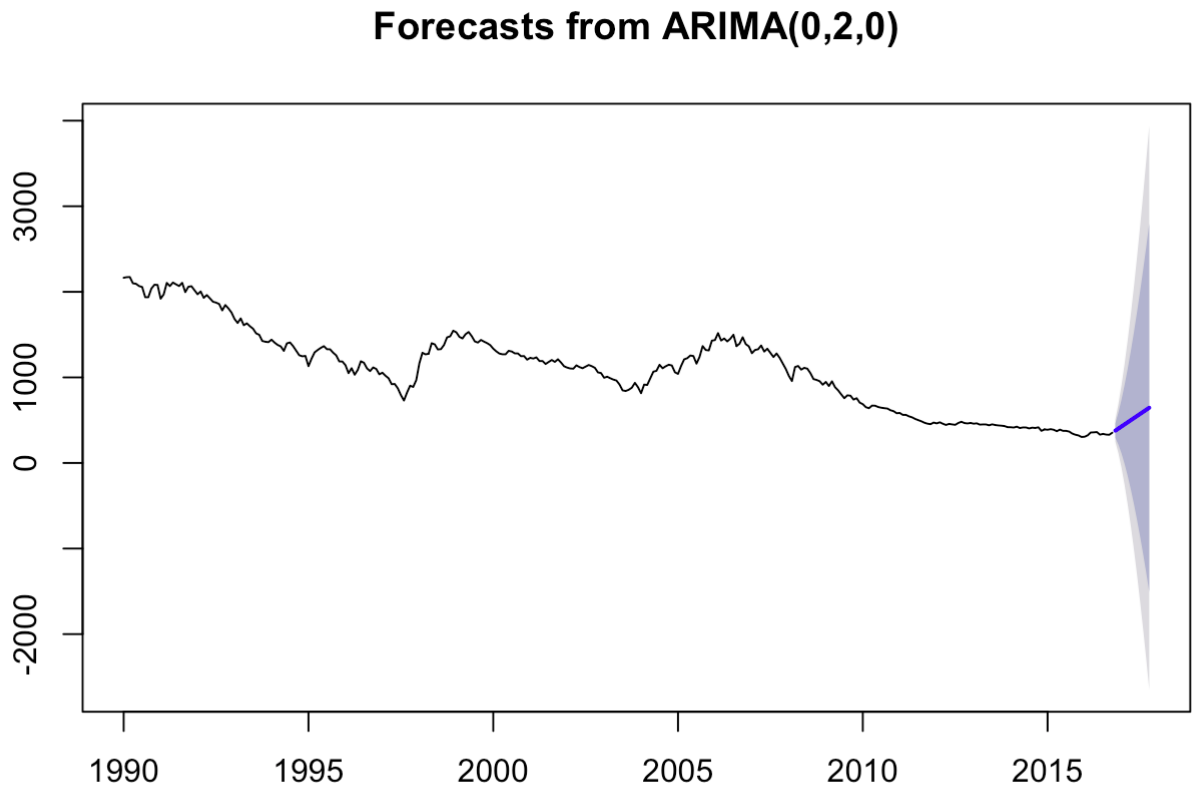
```
sp500.ts.arima<- arima (sp500new.ts,order=c(0,2,0))
sp500.ts.arima
```

```
##
## Call:
## arima(x = sp500new.ts, order = c(0, 2, 0))
##
##
## sigma^2 estimated as 4333:  log likelihood = -1793.9,  aic = 3589.8
```

```
library(forecast)
sp500.ts.arima.for<- forecast.Arima(sp500.ts.arima,h=12)
sp500.ts.arima.for
```

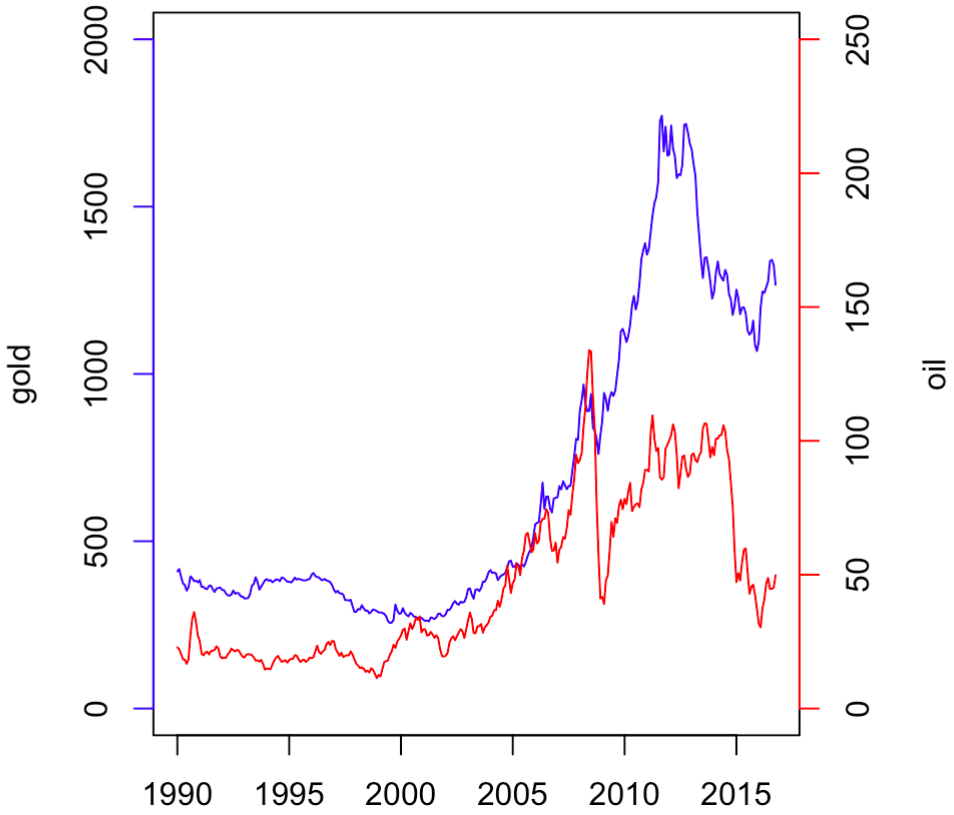
```
##          Point Forecast       Lo 80     Hi 80       Lo 95     Hi 95
## Nov 2016       377.7200   293.36258  462.0774   248.70647  506.7335
## Dec 2016       402.0400   213.41109  590.6689   113.55697  690.5230
## Jan 2017       426.3600   110.72346  741.9966   -56.36443  909.0845
## Feb 2017       450.6800   -11.36458  912.7246  -255.95621 1157.3163
## Mar 2017       475.0000  -150.61132 1100.6114  -481.78996 1431.7900
## Apr 2017       499.3200  -305.39843 1304.0385  -731.39065 1730.0307
## May 2017       523.6400  -474.49037 1521.7705 -1002.86869 2050.1488
## Jun 2017       547.9600  -656.90486 1752.8250 -1294.72181 2390.6419
## Jul 2017       572.2801  -851.83704 1996.3972 -1605.71910 2750.2792
## Aug 2017       596.6001 -1058.61197 2251.8121 -1934.82830 3128.0284
## Sep 2017       620.9201 -1276.65309 2518.4932 -2281.16764 3523.0078
## Oct 2017       645.2401 -1505.46049 2795.9406 -2643.97259 3934.4527
```

```
plot.forecast(sp500.ts.arima.for)
```



Q1

```
par(mar=c(2, 10, 4, 8) + 0.1)
plot(gold.ts,col="blue",ylim=c(0,2000),axes=F,ylab="")
box()
axis(2,col = "blue")
mtext("gold",side=2,line=3)
par(new=T)
plot(oil.ts,axes=F,col="red",ylab="",ylim=c(0,250))
axis(4,col="red")
mtext("oil",side=4,line = 3)
axis(1,ylim=c(1990,2016))
```




```
cor(gold$Value,oil$VALUE)
```

```
## [1] 0.8219019
```

Correlation is a statistical technique that shows how strongly the variables are related to each other.

The value of correlation coefficient between gold and oil within the period of 1990 to 2016 is 0.82.

As seen in the above graph, price moving in recent years (esp. in 2008) was different; in some part of the year even reverse.

Q2

1. From the forecast plots, we can infer that investing in Gold between the second and third quarter 2017 (approx. $1300) would yield a profit of 8-9% when sold in October 2017(approx. $1500)
2. Similarly, we see that investing in Oil in February 2017 (approx. $50) would yield a profit of 4% when sold in July-August 2017(approx. $60)
3. We also see that investing in S&P500 in January 2017 (approx. $2100) would yield a profit of 5-6% when sold at about the month of October 2017(approx. $2200)

Therefore, investing in gold would be the best bet.