ARIMA model for forecasting median home value (per sqft) in San Francisco city

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Data and Plot We have data used is from April 1996 to October 2015

```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(tidyr)
zhvi=read.csv(file="~/Desktop/Reserach Study/City_MedianValuePerSqft_AllHomes.cs
v") %>%
    filter(RegionName=="San Francisco") %>%
    gather(Years,median.ppsf,7:ncol(.))
zhvi$Years=gsub("^X","",zhvi$Years)
tail(zhvi)
```

```
##     RegionID    RegionName State         Metro    CountyName SizeRank
## 230    20330 San Francisco    CA San Francisco San Francisco       12
## 231    20330 San Francisco    CA San Francisco San Francisco       12
## 232    20330 San Francisco    CA San Francisco San Francisco       12
## 233    20330 San Francisco    CA San Francisco San Francisco       12
## 234    20330 San Francisco    CA San Francisco San Francisco       12
## 235    20330 San Francisco    CA San Francisco San Francisco       12
##       Years median.ppsf
## 230 2015.05         851
## 231 2015.06         866
## 232 2015.07         878
## 233 2015.08         889
## 234 2015.09         894
## 235 2015.10         895
```

```
dim(zhvi)
```

```
## [1] 235   8
```

```
ts_pricepersqft=ts(zhvi$median.ppsf,frequency=12,start = c(1996,4))
ts_pricepersqft
```

```
##      Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
## 1996                 198 199 201 202 203 203 203 204 206
## 1997 208 210 212 214 216 218 220 223 225 228 231 233
## 1998 237 240 243 245 247 249 252 255 257 260 264 267
## 1999 270 273 276 278 282 287 292 297 304 311 319 328
## 2000 337 347 355 363 370 377 383 388 393 396 399 401
## 2001 401 401 404 405 404 403 403 404 405 405 403 403
## 2002 405 407 407 409 415 424 431 438 442 444 445 447
## 2003 446 446 445 446 447 449 452 455 459 464 471 480
## 2004 489 498 508 519 527 531 534 538 543 550 559 567
## 2005 576 586 596 603 607 610 614 618 622 625 627 627
## 2006 625 623 621 620 621 621 620 619 619 617 615 613
## 2007 615 618 623 629 634 639 643 647 649 649 646 641
## 2008 638 633 627 621 615 608 601 594 587 583 584 582
## 2009 575 568 561 554 548 544 542 541 541 541 542 545
## 2010 548 551 552 549 547 545 542 540 539 537 535 534
## 2011 532 528 523 520 518 518 517 517 518 519 519 520
## 2012 523 526 529 533 537 543 550 559 569 580 589 597
## 2013 606 615 625 634 645 658 670 681 690 699 704 710
## 2014 717 725 736 748 758 765 770 774 777 780 785 790
## 2015 795 803 816 834 851 866 878 889 894 895
```

```
start(ts_pricepersqft)
```

```
## [1] 1996    4
```

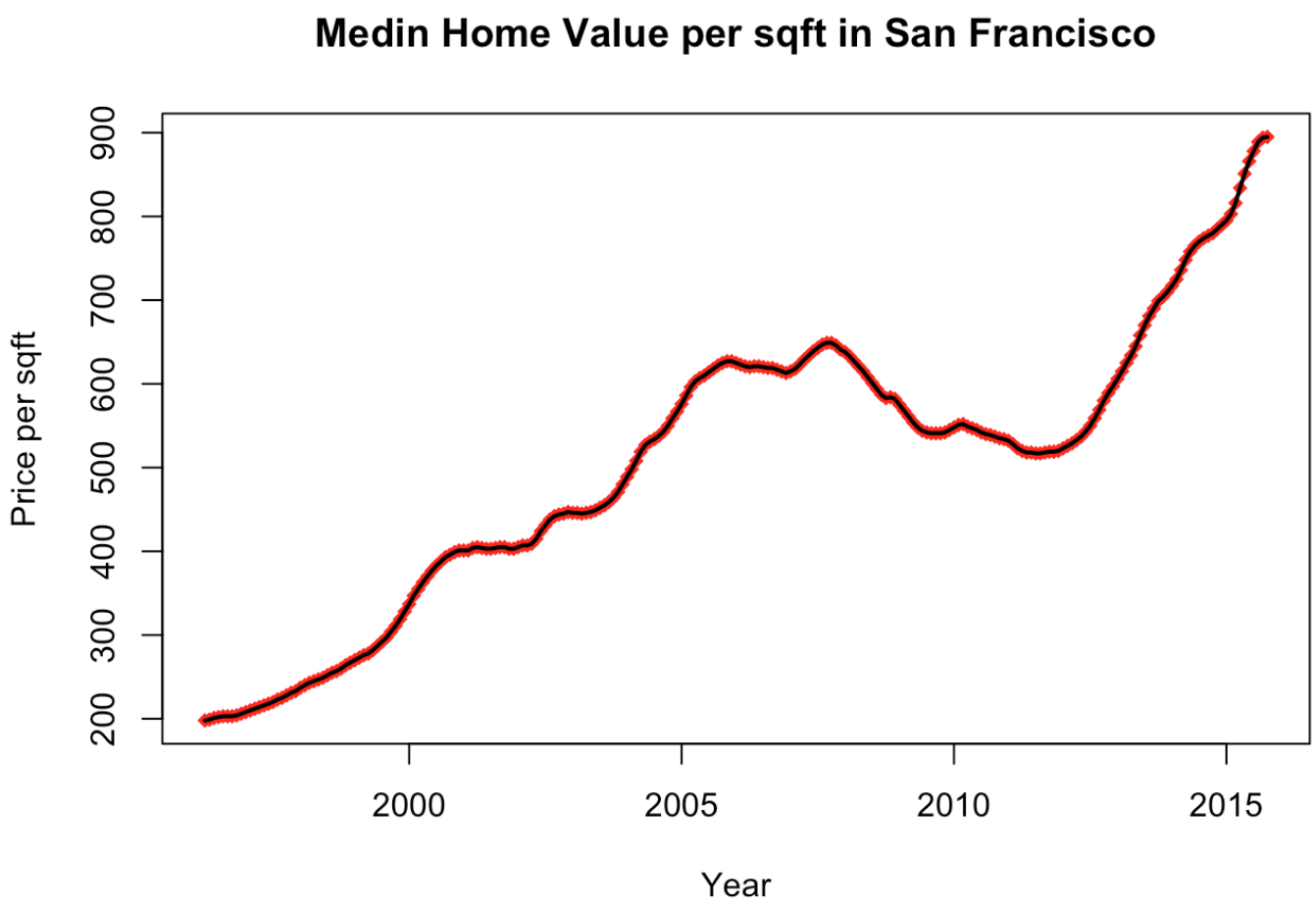
```
end(ts_pricepersqft)
```

```
## [1] 2015   10
```

```
frequency(ts_pricepersqft)
```

```
## [1] 12
```

```
par(mfrow=c(1,1))
plot(ts_pricepersqft,type="b",main="Medin Home Value per sqft in San Francisco",xl
ab="Year",ylab="Price per sqft",pch=18,col="red") # Non stationary series
lines(ts_pricepersqft,lwd=2)
```



First order differences

```
#install.packages("tseries")
#install.packages("astsa")
#install.packages("forecast")
library(tseries)
library(astsa)
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
```

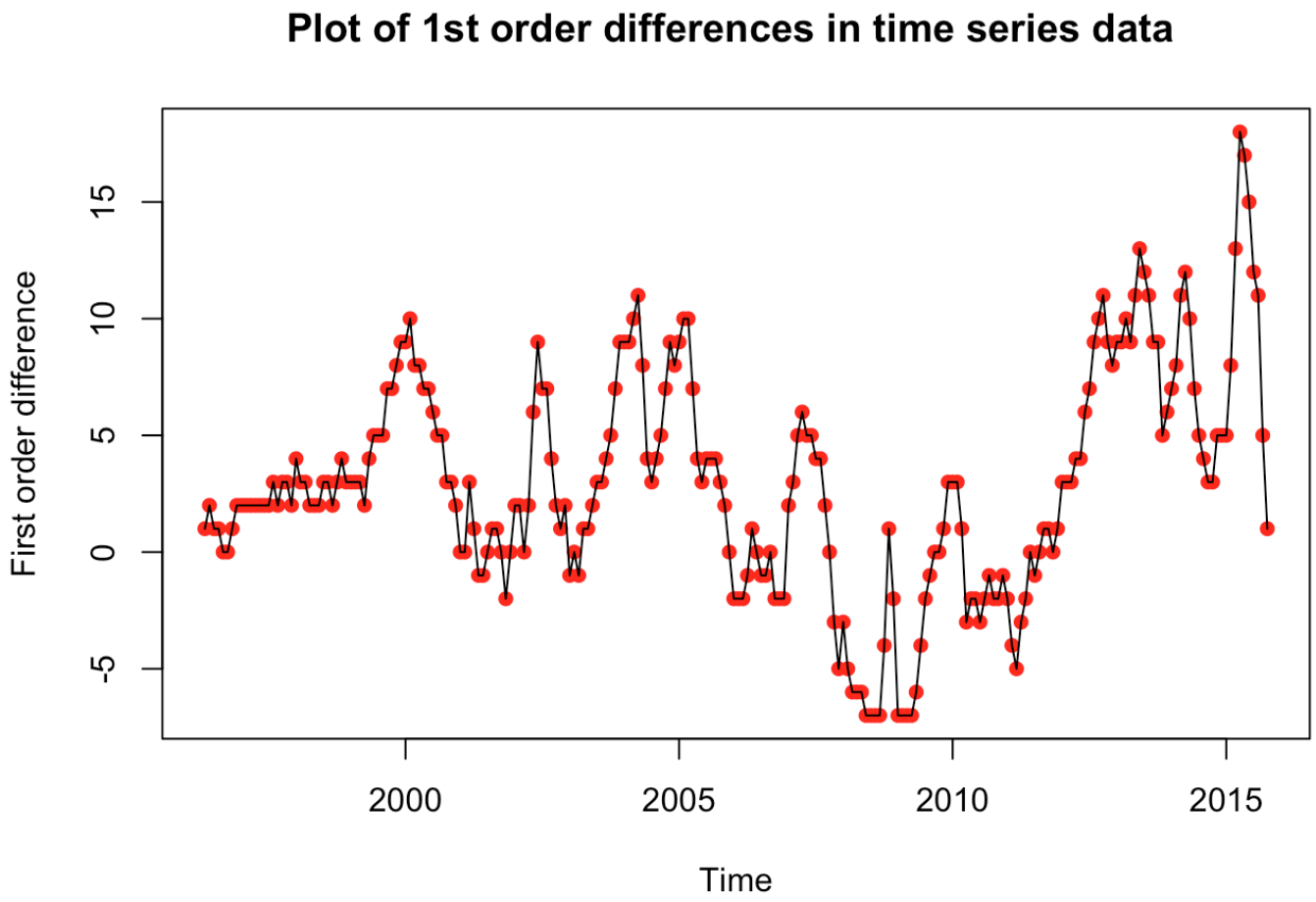
```
## This is forecast 6.2
```

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

```
## The following object is masked from 'package:astsa':
##
##     gas
```

```
diff1_mppsq=diff(ts_pricepersqft,1)

par(mfrow=c(1,1))
plot.ts(diff1_mppsq,type="p",col="red",pch=16,ylab="First order difference",main
="Plot of 1st order differences in time series data ") # still non stationary
lines(diff1_mppsq)
```



ADF Test

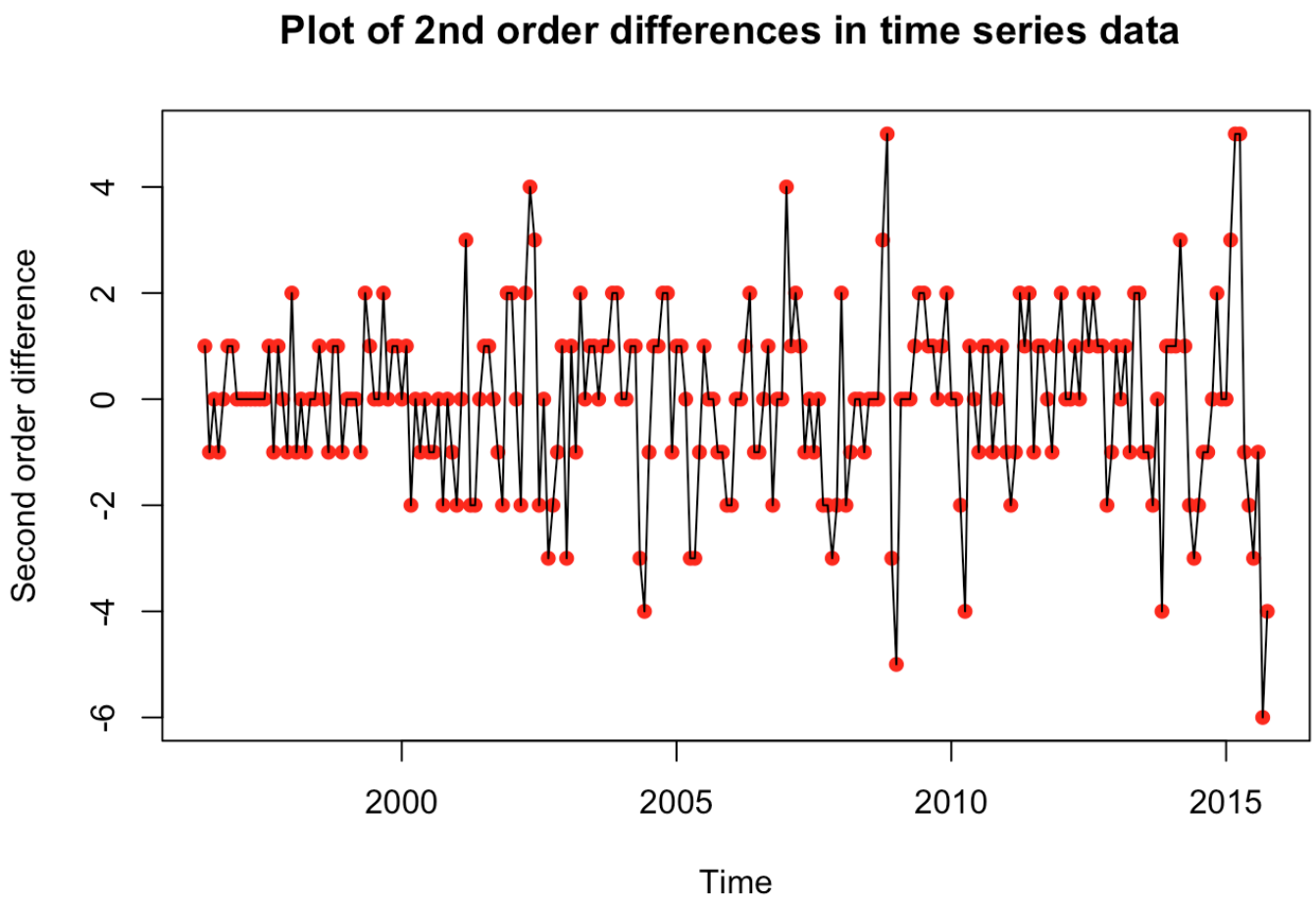
```
## Warning in kpss.test(diff1_mppsq, null = "Trend"): p-value smaller than
## printed p-value
```

```
##
##  KPSS Test for Trend Stationarity
##
## data:  diff1_mppsq
## KPSS Trend = 0.50195, Truncation lag parameter = 3, p-value = 0.01
```

```
##
##  Augmented Dickey-Fuller Test
##
## data:  diff1_mppsq
## Dickey-Fuller = -2.757, Lag order = 6, p-value = 0.2577
## alternative hypothesis: stationary
```

Still non stationary, 2nd order diff

```
diff1_mppsq=diff(ts_pricepersqft,differences = 2)
plot.ts(diff(ts_pricepersqft,differences = 2),type="p",col="red",pch=16,ylab="Seco
nd order difference",main="Plot of 2nd order differences in time series data ") #
still non stationary
lines(diff(ts_pricepersqft,differences = 2))
```




```
kpss.test(diff(ts_pricepersqft,differences = 2),null = "Trend") # for Trend
```

```
## Warning in kpss.test(diff(ts_pricepersqft, differences = 2), null =
## "Trend"): p-value greater than printed p-value
```

```
##
##  KPSS Test for Trend Stationarity
##
## data:  diff(ts_pricepersqft, differences = 2)
## KPSS Trend = 0.028802, Truncation lag parameter = 3, p-value = 0.1
```

```
adf.test(diff(ts_pricepersqft,differences=2),alternative = "stationary") # for sta
tionarity
```

```
## Warning in adf.test(diff(ts_pricepersqft, differences = 2), alternative =
## "stationary"): p-value smaller than printed p-value
```

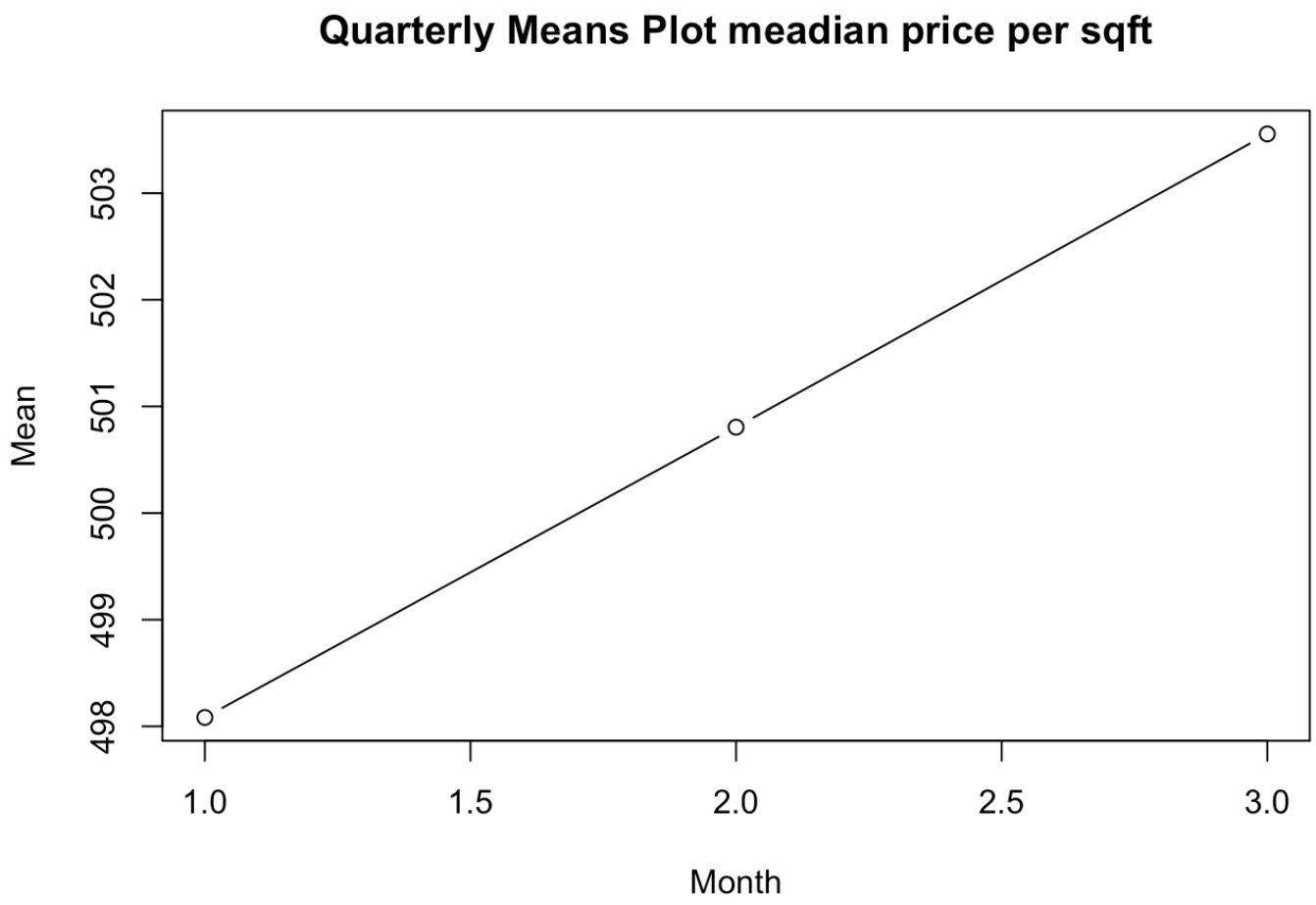
```
##
##  Augmented Dickey-Fuller Test
##
## data:  diff(ts_pricepersqft, differences = 2)
## Dickey-Fuller = -6.7551, Lag order = 6, p-value = 0.01
## alternative hypothesis: stationary
```

Check Monthly Seasonality

```
ppsm=matrix(ts_pricepersqft[10:225],ncol=12,byrow=T)
col.means=apply(ppsm,2,mean)
plot(col.means,type="b", main="Monthly Means Plot meadian price per sqft", xlab="M
onth", ylab="Mean") # This shows there is just trend  and nomonthly seasonality
```

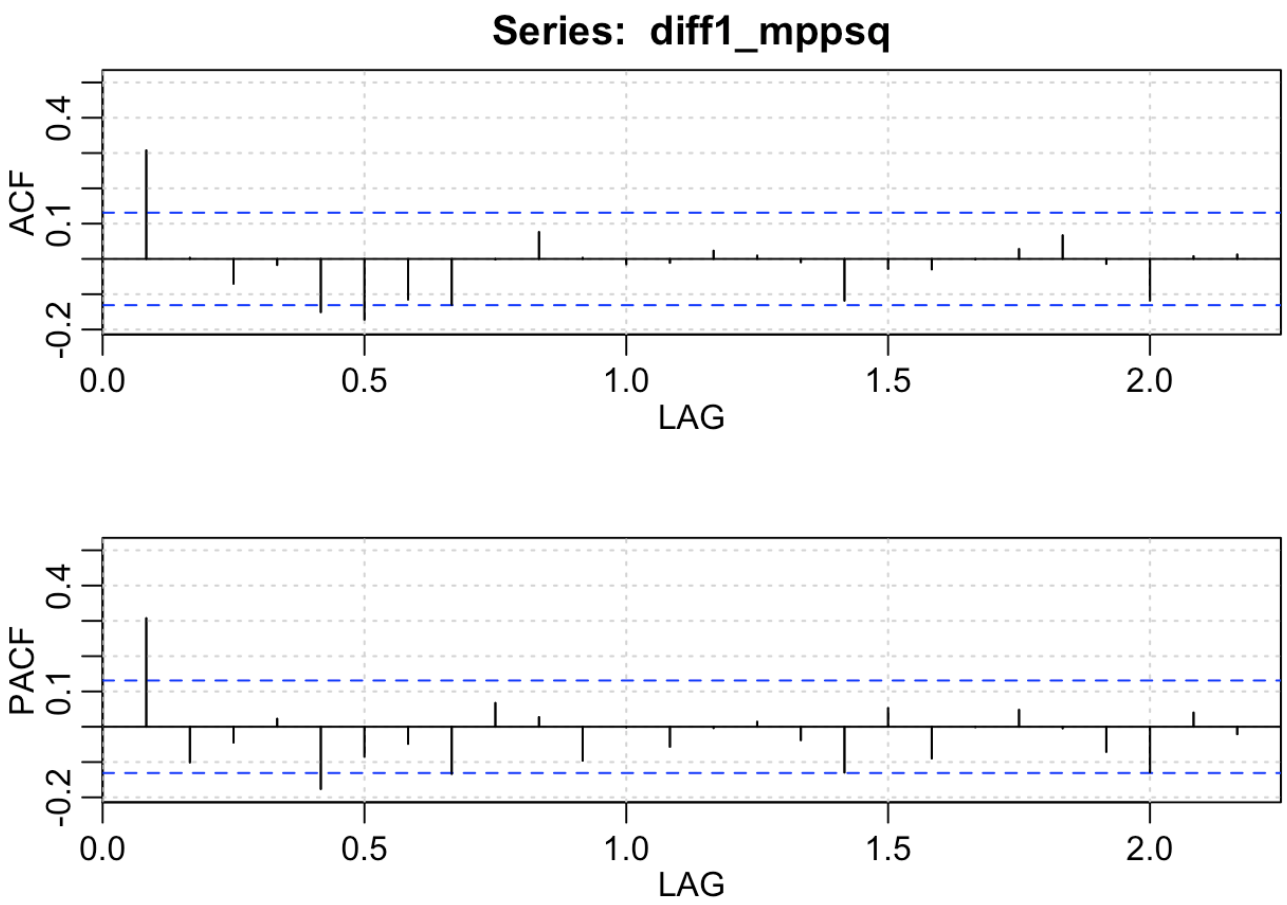
Check quarterly seasonality

```
ppsq=matrix(ts_pricepersqft[10:225],ncol=3,byrow=T)
col.meansq=apply(ppsq,2,mean)
plot(col.meansq,type="b", main="Quarterly Means Plot meadian price per sqft", xlab
="Month", ylab="Mean")
```



ACF and PACF

```
acf2(diff1_mppsq)
```


Series: diff1_mppsq
ACF
0.4
0.1
-0.2
0.0
0.5
1.0
1.5
2.0
LAG
PACF
0.4
0.1
-0.2
0.0
0.5
1.0
1.5
2.0
LAG

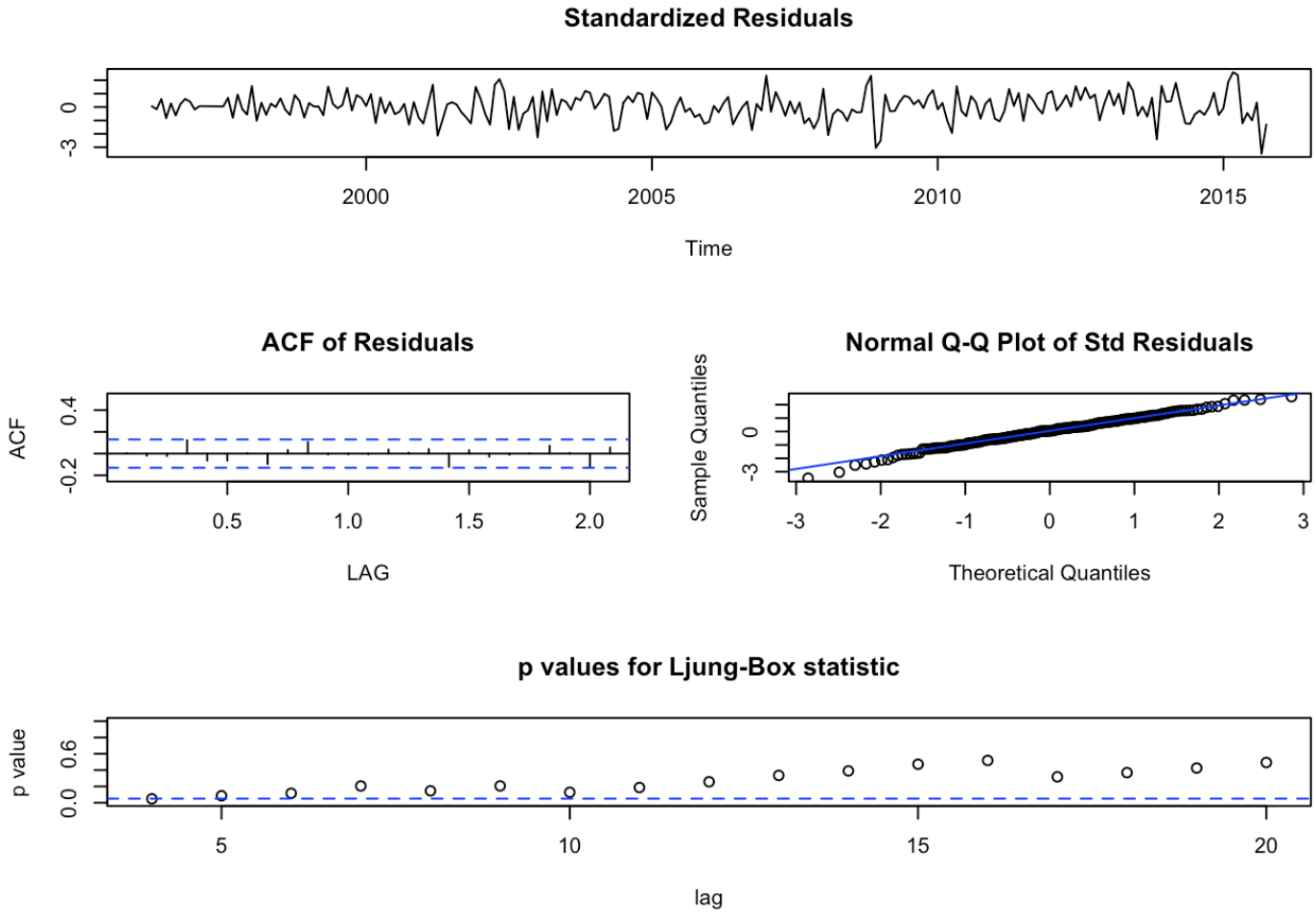
```
##          ACF  PACF
##  [1,]  0.31  0.31
##  [2,]  0.00 -0.10
##  [3,] -0.07 -0.04
##  [4,] -0.02  0.02
##  [5,] -0.15 -0.18
##  [6,] -0.17 -0.09
##  [7,] -0.11 -0.05
##  [8,] -0.13 -0.13
##  [9,]  0.00  0.07
## [10,]  0.08  0.03
## [11,]  0.00 -0.10
## [12,] -0.02  0.00
## [13,] -0.01 -0.06
## [14,]  0.02  0.00
## [15,]  0.01  0.01
## [16,] -0.01 -0.04
## [17,] -0.12 -0.13
## [18,] -0.03  0.05
## [19,] -0.03 -0.09
## [20,]  0.00  0.00
## [21,]  0.03  0.05
## [22,]  0.07  0.00
## [23,] -0.01 -0.07
## [24,] -0.12 -0.13
## [25,]  0.01  0.04
## [26,]  0.01 -0.02
```

Final ARIMA model after multipe trials

```
sarima(ts_pricepersqft,2,2,1)
```

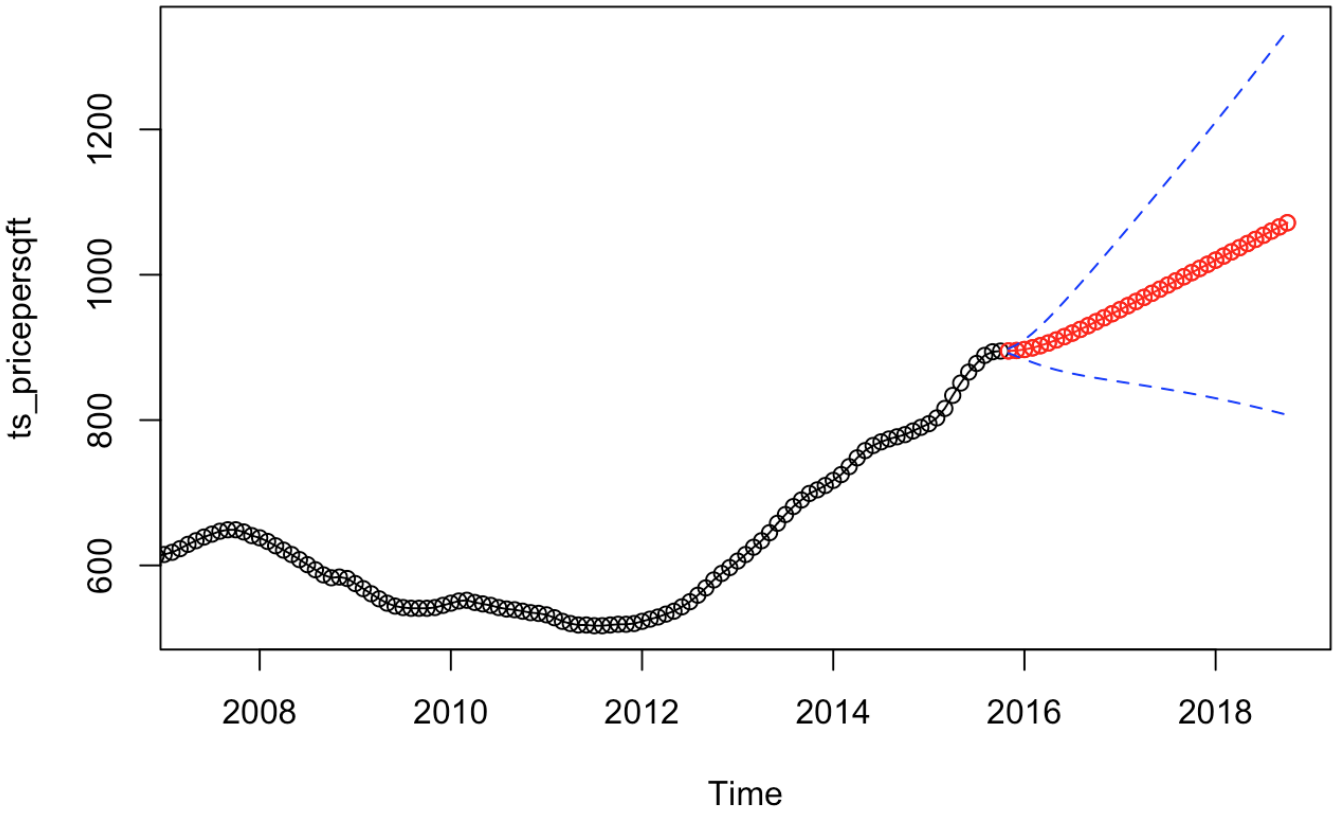
```
## initial  value 0.511085
## iter   2 value 0.494723
## iter   3 value 0.456838
## iter   4 value 0.455611
## iter   5 value 0.455567
## iter   6 value 0.455546
## iter   7 value 0.455198
## iter   8 value 0.454896
## iter   9 value 0.454811
## iter  10 value 0.454660
## iter  11 value 0.454652
## iter  12 value 0.454637
## iter  13 value 0.454575
## iter  14 value 0.454459
## iter  15 value 0.454035
## iter  16 value 0.453896
## iter  17 value 0.453718
## iter  18 value 0.453685
## iter  19 value 0.453666
## iter  20 value 0.453244
## iter  21 value 0.452698
## iter  22 value 0.452381
## iter  23 value 0.450493
## iter  24 value 0.450026
## iter  25 value 0.449660
## iter  26 value 0.448271
## iter  27 value 0.447552
## iter  28 value 0.447012
## iter  29 value 0.446778
## iter  30 value 0.446251
## iter  31 value 0.445225
## iter  32 value 0.444958
## iter  33 value 0.444788
## iter  34 value 0.444702
## iter  35 value 0.444658
## iter  36 value 0.444654
## iter  37 value 0.444654
## iter  38 value 0.444654
## iter  39 value 0.444654
## iter  39 value 0.444654
## iter  39 value 0.444654
## final  value 0.444654
## converged
## initial  value 0.437437
## iter   2 value 0.437149
## iter   3 value 0.436562
## iter   4 value 0.435987
## iter   5 value 0.435275
## iter   6 value 0.434863
## iter   7 value 0.434795
```

```
## iter   8 value 0.434784
## iter   9 value 0.434783
## iter  10 value 0.434783
## iter  11 value 0.434783
## iter  12 value 0.434783
## iter  13 value 0.434783
## iter  14 value 0.434783
## iter  15 value 0.434783
## iter  15 value 0.434783
## final  value 0.434783
## converged
```



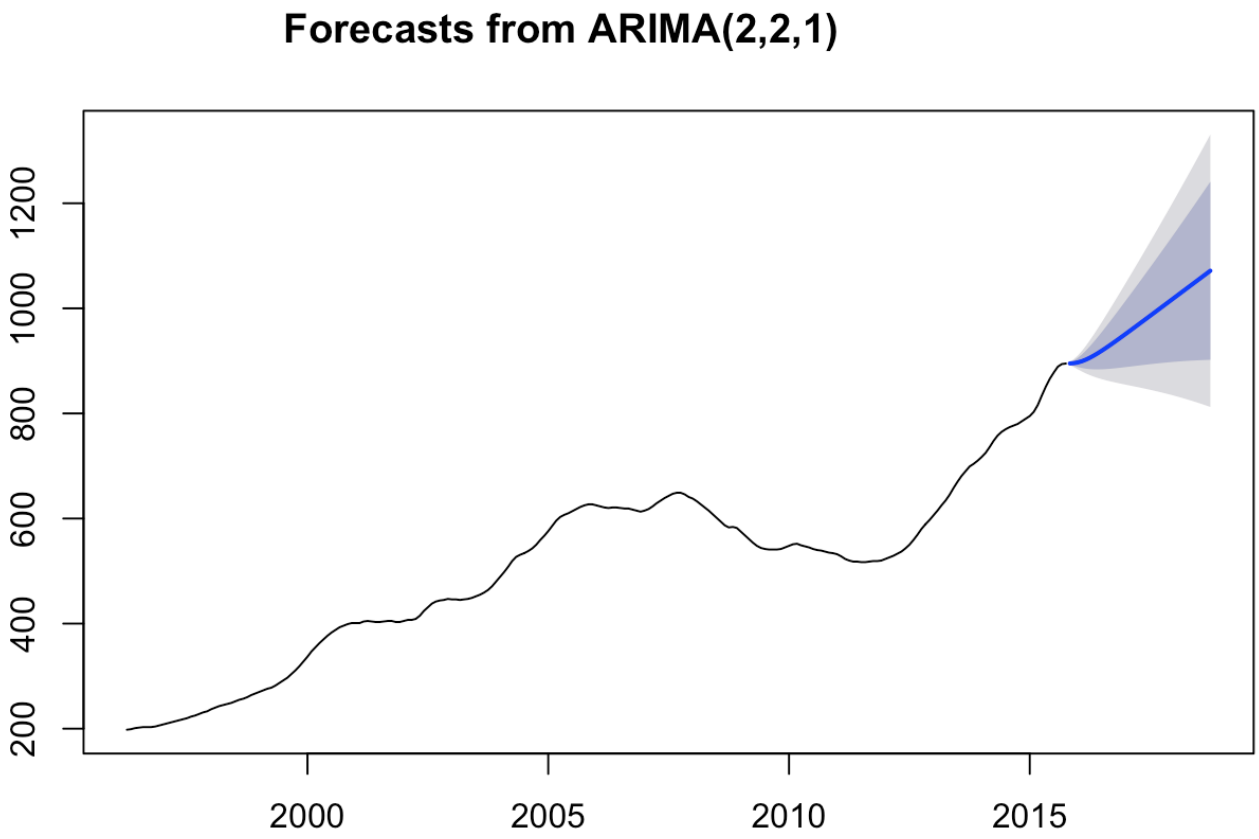
```
## $fit
##
## Call:
## stats::arima(x = xdata, order = c(p, d, q), seasonal = list(order = c(P, D,
##     Q), period = S), include.mean = !no.constant, optim.control = list(trace =
trc,
##     REPORT = 1, reltol = tol))
##
## Coefficients:
##          ar1      ar2      ma1
##       1.2357  -0.3668  -0.9411
## s.e.  0.0843   0.0636   0.0715
##
## sigma^2 estimated as 2.381:  log likelihood = -431.92,  aic = 871.83
##
## $AIC
## [1] 1.892877
##
## $AICc
## [1] 1.902128
##
## $BIC
## [1] 0.9370419
```

```
sarima.for(ts_pricepersqft,36,2,2,1)
```


ts_pricepersqft
600
800
1000
1200
2008
2010
2012
2014
2016
2018
Time

```
## $pred
##            Jan       Feb       Mar       Apr       May       Jun       Jul
## 2015                                                                       
## 2016  897.1198  899.3885  902.4286  906.1027  910.2771  914.8374  919.6908
## 2017  951.9155  957.5254  963.1630  968.8211  974.4943  980.1788  985.8716
## 2018 1020.1140 1025.8276 1031.5419 1037.2568 1042.9720 1048.6876 1054.4034
##            Aug       Sep       Oct       Nov       Dec
## 2015                                 895.1514  895.7213
## 2016  924.7649  930.0042  935.3667  940.8208  946.3429
## 2017  991.5706  997.2740 1002.9809 1008.6903 1014.4015
## 2018 1060.1194 1065.8355 1071.5517                     
##
## $se
##             Jan        Feb        Mar        Apr        May        Jun
## 2015                                                                  
## 2016   6.747676   9.980676  13.415091  16.959502  20.559093  24.182627
## 2017  49.608973  53.264603  56.936010  60.626322  64.338343  68.074544
## 2018  95.053035  99.039332 103.060989 107.118459 111.212104 115.342212
##             Jul        Aug        Sep        Oct        Nov        Dec
## 2015                                                 1.542914   3.861890
## 2016  27.813631  31.444663  35.073647  38.701585  42.331125  45.965693
## 2017  71.837084  75.627830  79.448383  83.300110  87.184171  91.101540
## 2018 119.508999 123.712626 127.953205 132.230803
```

```
plot(forecast(Arima(ts_pricepersqft,order = c(2,2,1)), h=36))
```




```
fit6=Arima(ts_pricepersqft,order = c(2,2,1))
```

Diagnostics

```
library(FitAR)
```

```
## Loading required package: lattice
```

```
## Loading required package: leaps
```

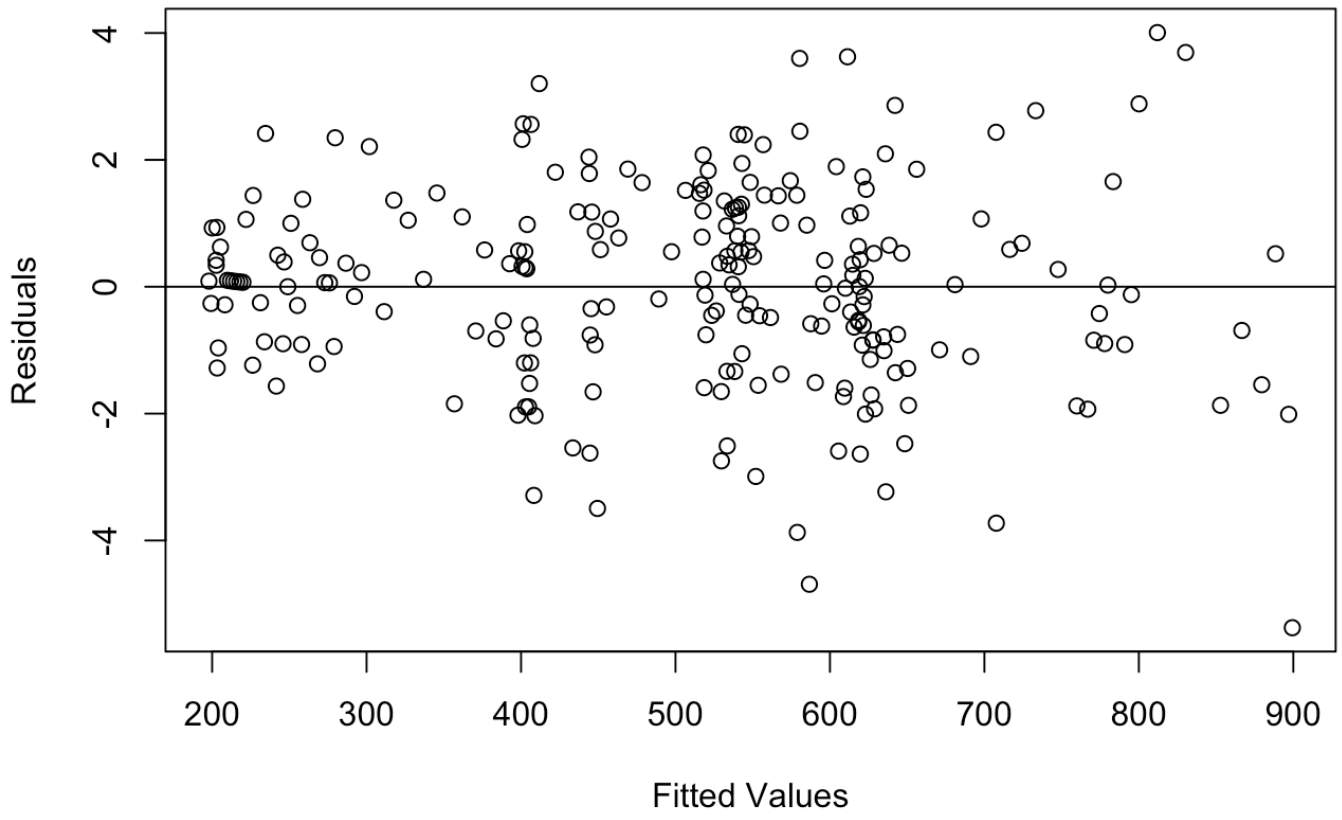
```
## Loading required package: ltsa
```

```
## Loading required package: bestglm
```

```
##
## Attaching package: 'FitAR'
```

```
## The following object is masked from 'package:forecast':
##
##     BoxCox
```

```
fit6=Arima(ts_pricepersqft,order = c(2,2,1))
plot(fitted(fit6), fit6$residuals,xlab="Fitted Values",ylab="Residuals") # Constan
t variance
abline(h=0)
```




```
cbind(fitted(fit6),fit6$x,residuals(fit6))
```

```
##          fitted(fit6) fit6$x residuals(fit6)
## Apr 1996     197.9115    198    0.0885482816
## May 1996     199.2634    199   -0.2634078002
## Jun 1996     200.0730    201    0.9270234923
## Jul 1996     203.2808    202   -1.2807829481
## Aug 1996     202.5824    203    0.4175950525
## Sep 1996     203.9646    203   -0.9646377582
## Oct 1996     202.6614    203    0.3385963804
## Nov 1996     203.0653    204    0.9347325156
## Dec 1996     205.3745    206    0.6254814026
## Jan 1997     208.2840    208   -0.2840224299
## Feb 1997     209.8987    210    0.1012510328
## Mar 1997     211.9062    212    0.0937789268
## Apr 1997     213.9130    214    0.0870352304
## May 1997     215.9191    216    0.0809181884
## Jun 1997     217.9247    218    0.0753451084
## Jul 1997     219.9298    220    0.0702480391
## Aug 1997     221.9383    223    1.0617405454
## Sep 1997     226.2361    225   -1.2360893584
## Oct 1997     226.5612    228    1.4388038617
## Nov 1997     231.2517    231   -0.2517442873
## Dec 1997     233.8675    233   -0.8674925284
## Jan 1998     234.5838    237    2.4162114052
## Feb 1998     241.5660    240   -1.5660015366
## Mar 1998     242.5027    243    0.4973395421
## Apr 1998     245.8982    245   -0.8982393261
## May 1998     246.6090    247    0.3910100242
## Jun 1998     248.9993    249    0.0007222281
## Jul 1998     251.0003    252    0.9997143139
## Aug 1998     255.2955    255   -0.2954684655
## Sep 1998     257.9103    257   -0.9103388296
## Oct 1998     258.6213    260    1.3786514169
## Nov 1998     263.3063    264    0.6937275178
## Dec 1998     268.2157    267   -1.2157252551
## Jan 1999     269.5413    270    0.4587140950
## Feb 1999     272.9353    273    0.0646681426
## Mar 1999     275.9392    276    0.0608127117
## Apr 1999     278.9425    278   -0.9424878114
## May 1999     279.6517    282    2.3482882485
## Jun 1999     286.6288    287    0.3711630154
## Jul 1999     292.1528    292   -0.1527911796
## Aug 1999     296.7770    297    0.2230000785
## Sep 1999     301.7906    304    2.2094409608
## Oct 1999     311.3923    311   -0.3922845973
## Nov 1999     317.6357    319    1.3642987619
## Dec 1999     326.9520    328    1.0479972905
## Jan 2000     336.8827    337    0.1172988421
## Feb 2000     345.5230    347    1.4770435951
## Mar 2000     356.8456    355   -1.8455730351
## Apr 2000     361.8987    363    1.1012900237
```

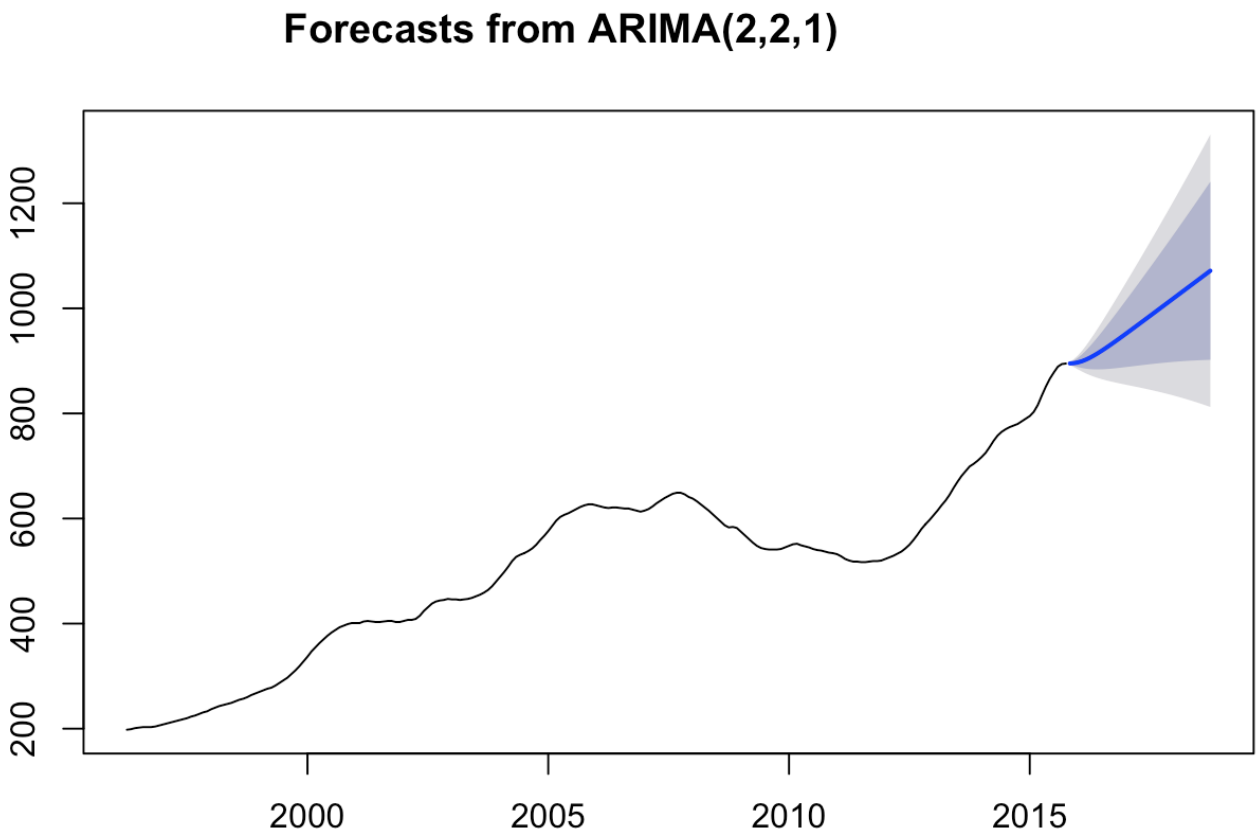
```
## May 2000     370.6972    370   -0.6972099698
## Jun 2000     376.4205    377    0.5795115529
## Jul 2000     383.8214    383   -0.8214123541
## Aug 2000     388.5373    388   -0.5373210236
## Sep 2000     392.6368    393    0.3631783171
## Oct 2000     398.0250    396   -2.0249567133
## Nov 2000     398.4343    399    0.5656527911
## Dec 2000     402.2013    401   -1.2012533193
## Jan 2001     402.8948    401   -1.8947770713
## Feb 2001     400.6787    401    0.3213479182
## Mar 2001     401.4312    404    2.5687562745
## Apr 2001     408.2895    405   -3.2894703774
## May 2001     405.5239    404   -1.5239478878
## Jun 2001     402.6965    403    0.3035133157
## Jul 2001     402.4480    403    0.5520183254
## Aug 2001     403.7162    404    0.2838478847
## Sep 2001     405.6017    405   -0.6017121355
## Oct 2001     406.1995    405   -1.1994547995
## Nov 2001     404.8931    403   -1.8931399819
## Dec 2001     400.6772    403    2.3228492667
## Jan 2002     404.0189    405    0.9811166330
## Feb 2002     407.8144    407   -0.8143583080
## Mar 2002     409.0328    407   -2.0327748555
## Apr 2002     406.4418    409    2.5582431681
## May 2002     411.7974    415    3.2026460837
## Jun 2002     422.1950    424    1.8050196937
## Jul 2002     433.5410    431   -2.5410166153
## Aug 2002     436.8196    438    1.1803532388
## Sep 2002     444.6228    442   -2.6227690009
## Oct 2002     444.7613    444   -0.7613447404
## Nov 2002     445.3456    445   -0.3456169279
## Dec 2002     445.8232    447    1.1767778581
## Jan 2003     449.4950    446   -3.4949796480
## Feb 2003     444.2154    446    1.7846128032
## Mar 2003     446.6566    445   -1.6565552439
## Apr 2003     443.9565    446    2.0434611151
## May 2003     447.9150    447   -0.9149935770
## Jun 2003     448.1275    449    0.8725036037
## Jul 2003     451.4145    452    0.5854667219
## Aug 2003     455.3179    455   -0.3178598898
## Sep 2003     457.9323    459    1.0676644924
## Oct 2003     463.2309    464    0.7691338971
## Nov 2003     469.1450    471    1.8549894647
## Dec 2003     478.3588    480    1.6412437394
## Jan 2004     489.1931    489   -0.1931081522
## Feb 2004     497.4481    498    0.5518740201
## Mar 2004     506.4806    508    1.5193713416
## Apr 2004     517.8058    519    1.1942380972
## May 2004     529.7449    527   -2.7449411343
## Jun 2004     533.5095    531   -2.5095229507
## Jul 2004     533.5195    534    0.4804617520
```

```
## Aug 2004     536.7794    538    1.2205970006
## Sep 2004     542.4537    543    0.5462555526
## Oct 2004     548.3548    550    1.6452381907
## Nov 2004     557.5562    559    1.4438465761
## Dec 2004     568.3789    567   -1.3788792996
## Jan 2005     574.3284    576    1.6715884802
## Feb 2005     585.0293    586    0.9706863074
## Mar 2005     595.9553    596    0.0446726241
## Apr 2005     605.5912    603   -2.5911535404
## May 2005     608.7316    607   -1.7315979394
## Jun 2005     610.0231    610   -0.0230792631
## Jul 2005     612.8865    614    1.1135164696
## Aug 2005     618.5545    618   -0.5545183602
## Sep 2005     622.1551    622   -0.1550557816
## Oct 2005     626.1459    625   -1.1459238688
## Nov 2005     627.8428    627   -0.8427850700
## Dec 2005     628.9243    627   -1.9243040306
## Jan 2006     626.7065    625   -1.7064773008
## Feb 2006     622.8683    623    0.1317160044
## Mar 2006     621.6097    621   -0.6096506190
## Apr 2006     619.5737    620    0.4262542471
## May 2006     619.8345    621    1.1654998167
## Jun 2006     623.0076    621   -2.0076377022
## Jul 2006     620.9201    620   -0.9201396817
## Aug 2006     618.9971    619    0.0028970456
## Sep 2006     618.3641    619    0.6359217595
## Oct 2006     619.6372    617   -2.6371808354
## Nov 2006     614.6438    615    0.3562394517
## Dec 2006     613.3984    613   -0.3983502985
## Jan 2007     611.3749    615    3.6251101965
## Feb 2007     618.5310    618   -0.5309897526
## Mar 2007     621.2681    623    1.7318505668
## Apr 2007     628.4746    629    0.5253582803
## May 2007     635.0076    634   -1.0076234554
## Jun 2007     638.3458    639    0.6541748751
## Jul 2007     643.7512    643   -0.7511568699
## Aug 2007     646.4713    647    0.5287324122
## Sep 2007     650.8692    649   -1.8692115020
## Oct 2007     650.2878    649   -1.2878247974
## Nov 2007     648.4743    646   -2.4742877022
## Dec 2007     642.3552    641   -1.3552243408
## Jan 2008     635.9045    638    2.0954775262
## Feb 2008     636.2328    633   -3.2328442472
## Mar 2008     627.8375    627   -0.8375382079
## Apr 2008     621.2862    621   -0.2861708946
## May 2008     615.6361    615   -0.6361217614
## Jun 2008     609.5987    608   -1.5986579010
## Jul 2008     601.2689    601   -0.2688557539
## Aug 2008     594.6198    594   -0.6198263816
## Sep 2008     587.5833    587   -0.5833222247
## Oct 2008     580.5490    583    2.4510320494
```

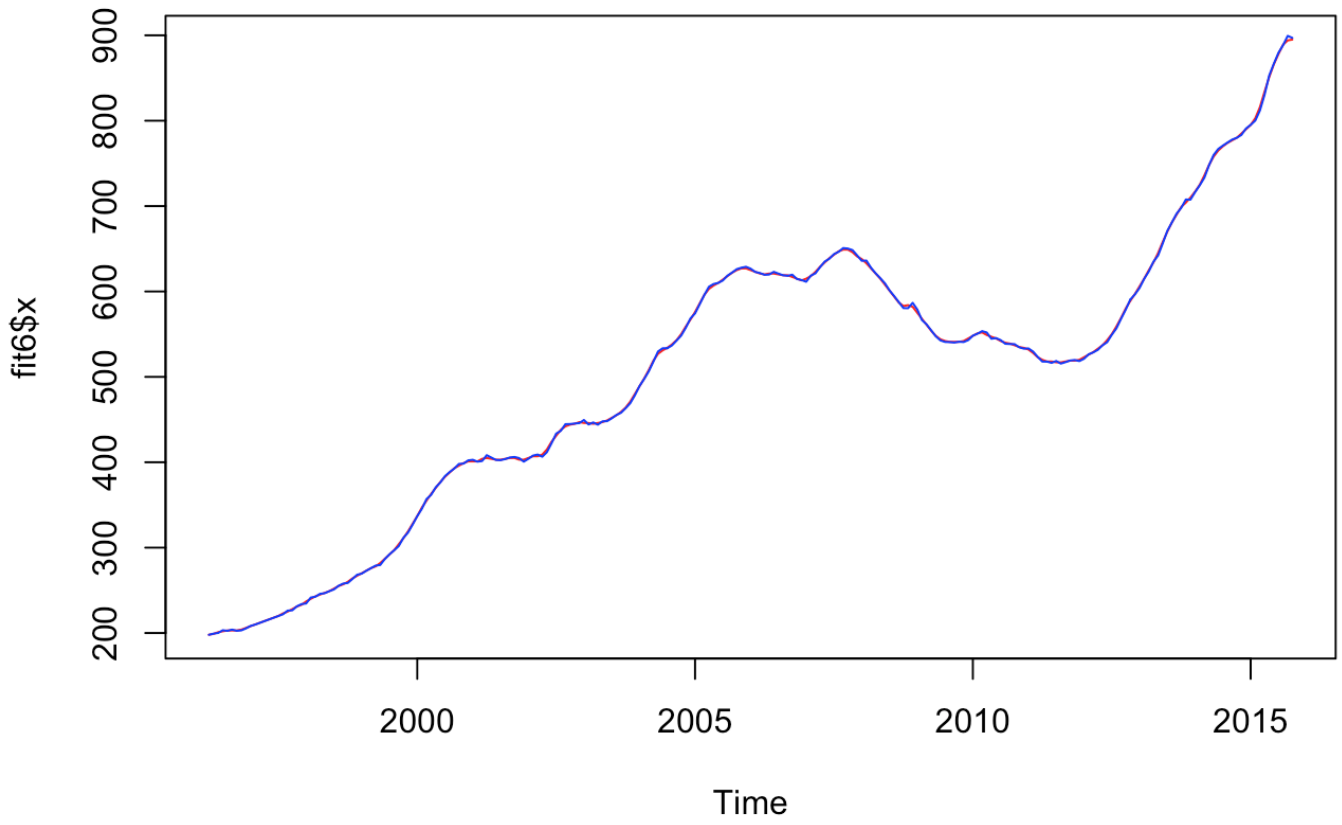
```
## Nov 2008     580.4003    584    3.5997289869
## Dec 2008     586.6901    582   -4.6901126824
## Jan 2009     578.8729    575   -3.8729175239
## Feb 2009     566.5670    568    1.4330133566
## Mar 2009     561.4854    561   -0.4854060812
## Apr 2009     554.4568    554   -0.4568184958
## May 2009     547.4299    548    0.5700854475
## Jun 2009     542.6991    544    1.3008602156
## Jul 2009     540.8802    542    1.1197507518
## Aug 2009     540.6839    541    0.3161122414
## Sep 2009     540.2045    541    0.7954538750
## Oct 2009     541.1202    541   -0.1202395790
## Nov 2009     540.7464    542    1.2536464933
## Dec 2009     543.0558    545    1.9441635053
## Jan 2010     548.2748    548   -0.2748327677
## Feb 2010     550.5250    551    0.4749626040
## Mar 2010     553.5530    552   -1.5530099213
## Apr 2010     551.9902    549   -2.9902456487
## May 2010     544.6051    547    2.3948551463
## Jun 2010     545.4491    545   -0.4490570224
## Jul 2010     543.0558    542   -1.0558055216
## Aug 2010     538.7580    540    1.2420257876
## Sep 2010     538.4336    539    0.5664225286
## Oct 2010     538.3358    537   -1.3357823156
## Nov 2010     534.6547    535    0.3453426557
## Dec 2010     533.0418    534    0.9581993259
## Jan 2011     533.3339    532   -1.3338835481
## Feb 2011     529.6529    528   -1.6528704031
## Mar 2011     523.4510    523   -0.4510295939
## Apr 2011     517.9224    520    2.0775746171
## May 2011     517.8829    518    0.1171118826
## Jun 2011     516.3918    518    1.6081734760
## Jul 2011     518.5910    517   -1.5910349451
## Aug 2011     515.5281    517    1.4719275792
## Sep 2011     517.2172    518    0.7827844465
## Oct 2011     519.1322    519   -0.1321628520
## Nov 2011     519.7576    519   -0.7575745685
## Dec 2011     518.4773    520    1.5226926782
## Jan 2012     521.1694    523    1.8305597774
## Feb 2012     526.3817    526   -0.3817458990
## Mar 2012     528.6257    529    0.3743460323
## Apr 2012     531.6477    533    1.3522992357
## May 2012     536.9630    537    0.0370061771
## Jun 2012     540.5984    543    2.4016313921
## Jul 2012     549.2111    550    0.7888882677
## Aug 2012     556.7596    559    2.2403861526
## Sep 2012     567.9961    569    1.0039440946
## Oct 2012     578.5572    580    1.4427764465
## Nov 2012     590.5110    589   -1.5110405289
## Dec 2012     596.5839    597    0.4160566542
## Jan 2013     604.1064    606    1.8935945456
```

```
## Feb 2013     614.8204    615    0.1796176895
## Mar 2013     623.4642    625    1.5358439187
## Apr 2013     634.7903    634   -0.7902588505
## May 2013     642.1413    645    2.8587379724
## Jun 2013     656.1477    658    1.8522692753
## Jul 2013     670.9945    670   -0.9945103009
## Aug 2013     680.9667    681    0.0333204033
## Sep 2013     691.0998    690   -1.0997961109
## Oct 2013     697.9305    699    1.0694718503
## Nov 2013     707.7271    704   -3.7271231257
## Dec 2013     707.5650    710    2.4349847778
## Jan 2014     716.4113    717    0.5887092081
## Feb 2014     724.3148    725    0.6851918085
## Mar 2014     733.2240    736    2.7759921469
## Apr 2014     747.7276    748    0.2723554958
## May 2014     759.8789    758   -1.8789211907
## Jun 2014     766.9302    765   -1.9301579837
## Jul 2014     770.8431    770   -0.8431406912
## Aug 2014     774.4226    774   -0.4225975620
## Sep 2014     777.8957    777   -0.8956678318
## Oct 2014     779.9741    780    0.0259276393
## Nov 2014     783.3424    785    1.6575959898
## Dec 2014     790.9113    790   -0.9113277918
## Jan 2015     795.1240    795   -0.1240465778
## Feb 2015     800.1167    803    2.8832590417
## Mar 2015     811.9935    816    4.0065003337
## Apr 2015     830.3073    834    3.6927022058
## May 2015     852.8690    851   -1.8690057181
## Jun 2015     866.6893    866   -0.6892583489
## Jul 2015     879.5442    878   -1.5441686659
## Aug 2015     888.4799    889    0.5201161085
## Sep 2015     899.3753    894   -5.3752791575
## Oct 2015     897.0116    895   -2.0116080937
```

```
plot(forecast(fit6, h=36))
```




```
plot(fit6$x, col='red')
lines(fitted(fit6), col='blue')
```

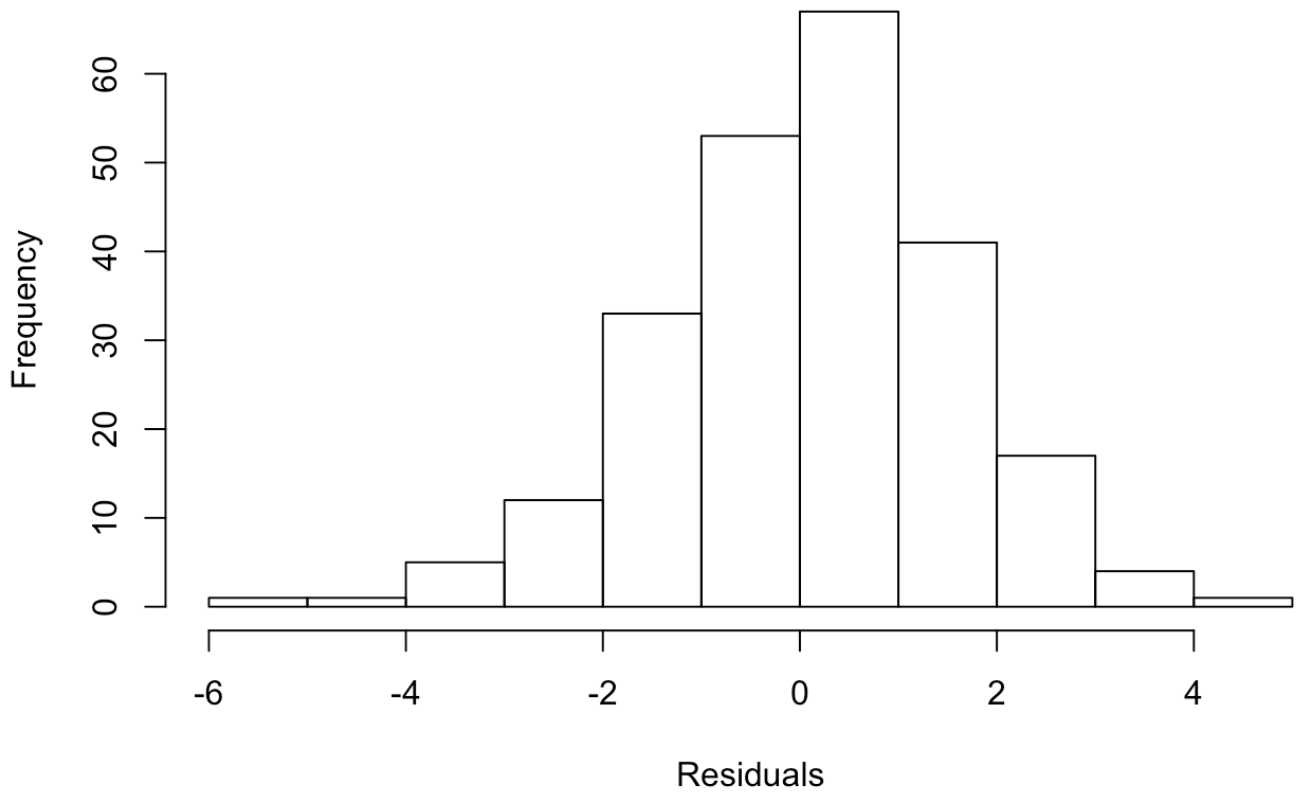



```
library(car)
```

```
##
## Attaching package: 'car'
```

```
## The following object is masked from 'package:FitAR':
##
##     Boot
```

```
hist(residuals(fit6),xlab="Residuals",main="Histogram of forecast residuals of ARI
MA(2,2,1)" )
```



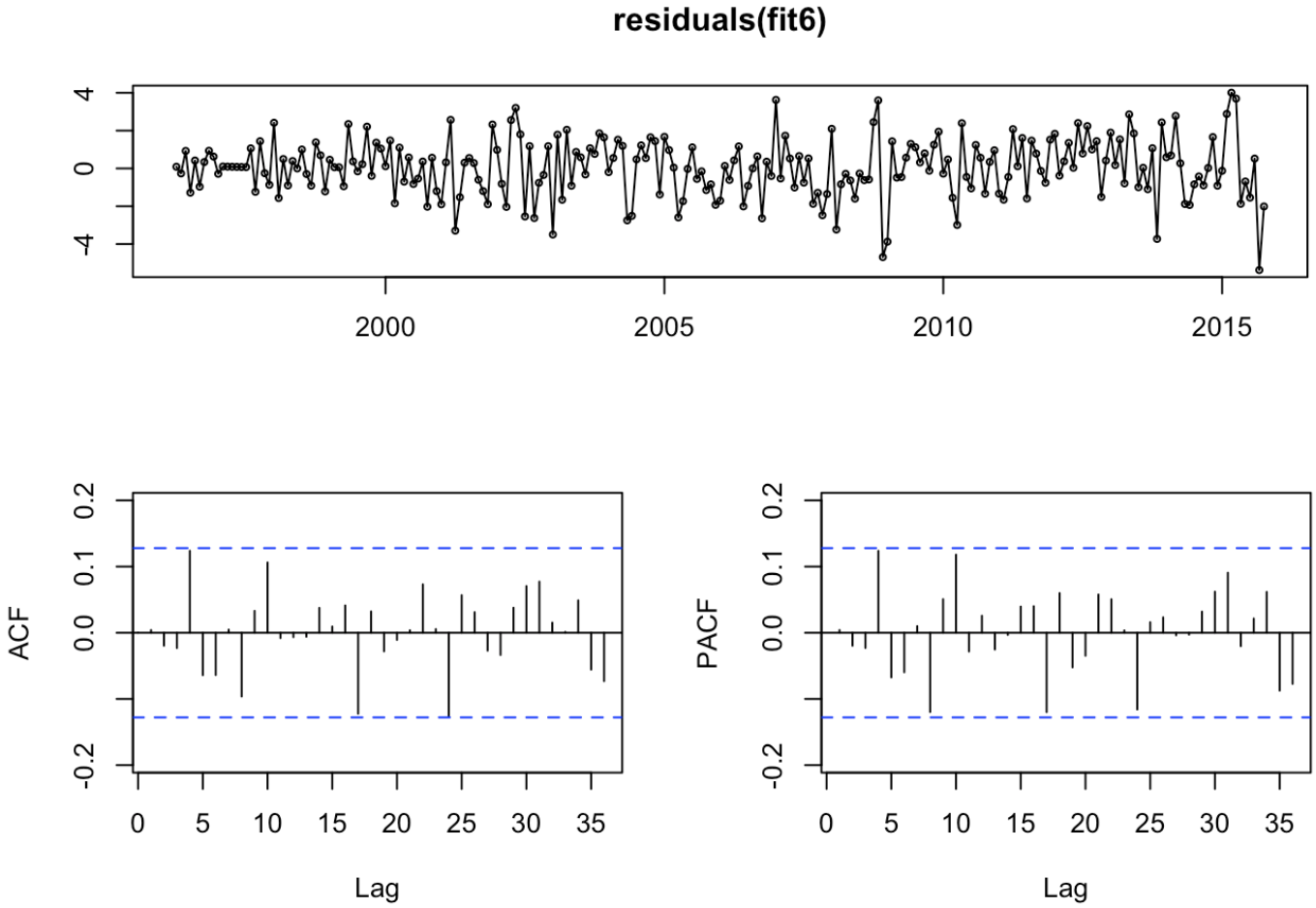

```
shapiro.test(residuals(fit6))
```

```
##
##  Shapiro-Wilk normality test
##
## data:  residuals(fit6)
## W = 0.99269, p-value = 0.2989
```

```
dwt(as.vector(residuals(fit6)), alt="two.sided") # DUrbing watson test
```

```
## [1] 1.982399
```

```
d = sum((fit6$residuals - lag(fit6$residuals))^2, na.rm = TRUE) /
       sum(fit6$residuals^2, na.rm = TRUE)
tsdisplay(residuals(fit6))
```



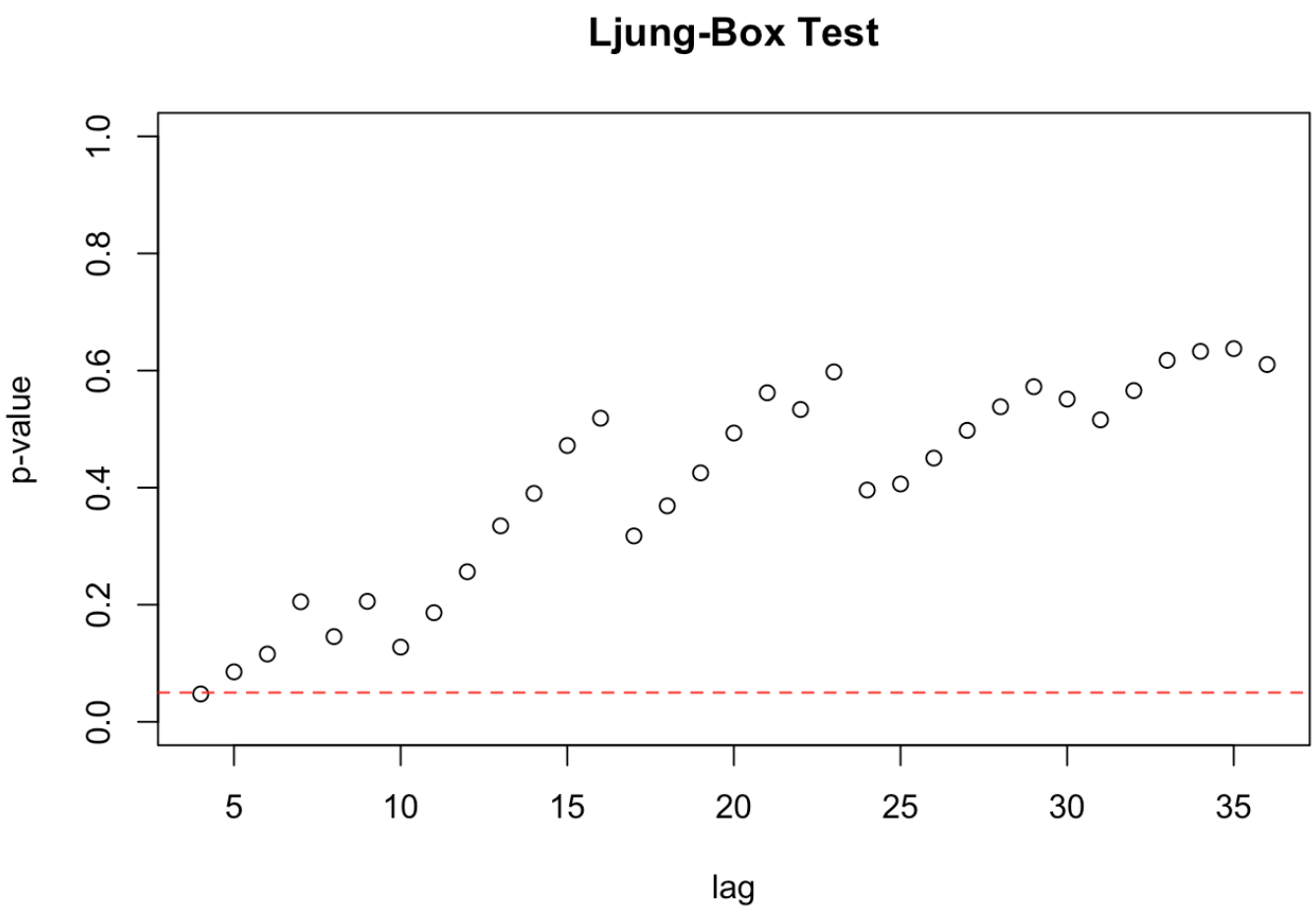

```
Box.test(residuals(Arima(ts_pricepersqft,order = c(2,2,1))),lag = 36,fitdf =3,type
= "Ljung-Box")
```

```
##
##  Box-Ljung test
##
## data:  residuals(Arima(ts_pricepersqft, order = c(2, 2, 1)))
## X-squared = 30.139, df = 33, p-value = 0.6103
```

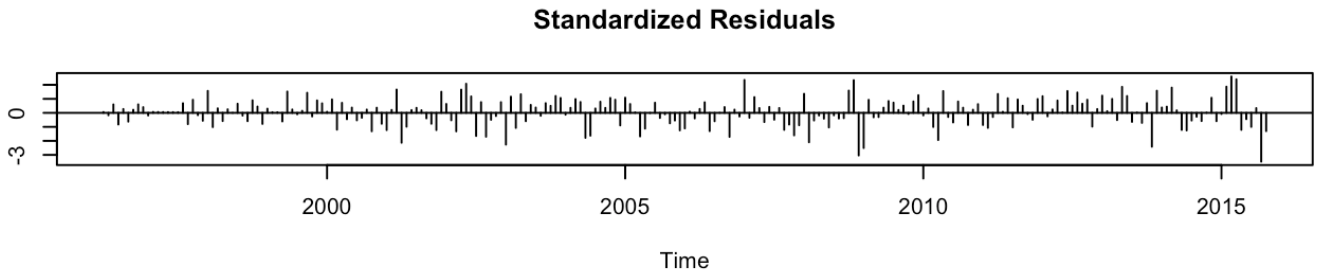
```
Box.test(residuals(Arima(ts_pricepersqft,order = c(2,2,1))),lag = 36,fitdf =3,type
= "Box-Pierce")
```

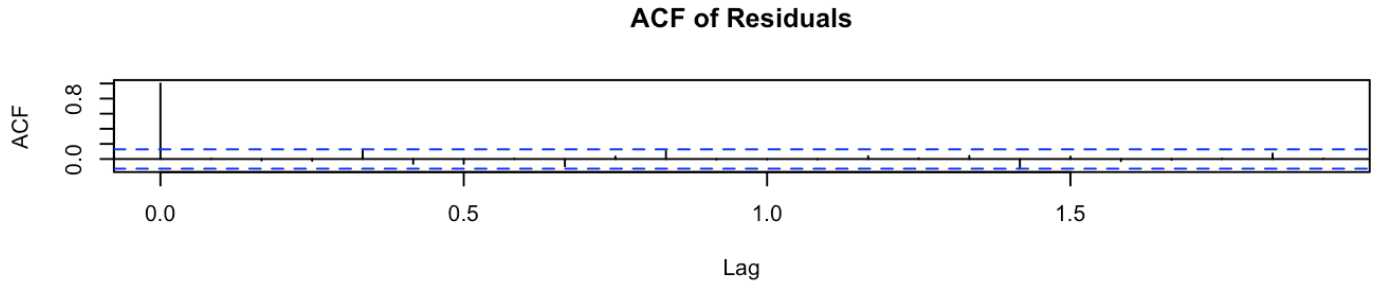
```
##
##  Box-Pierce test
##
## data:  residuals(Arima(ts_pricepersqft, order = c(2, 2, 1)))
## X-squared = 27.575, df = 33, p-value = 0.734
```

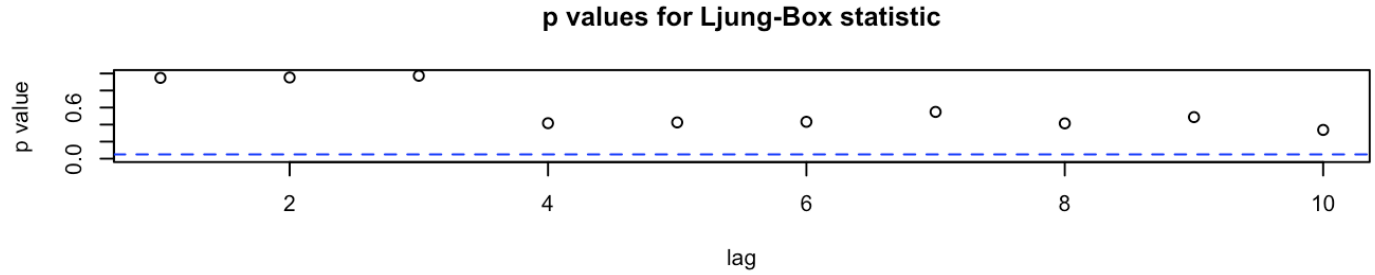
```
LBQPlot(residuals(Arima(ts_pricepersqft,order = c(2,2,1))), lag.max = 36,k = 3)
```



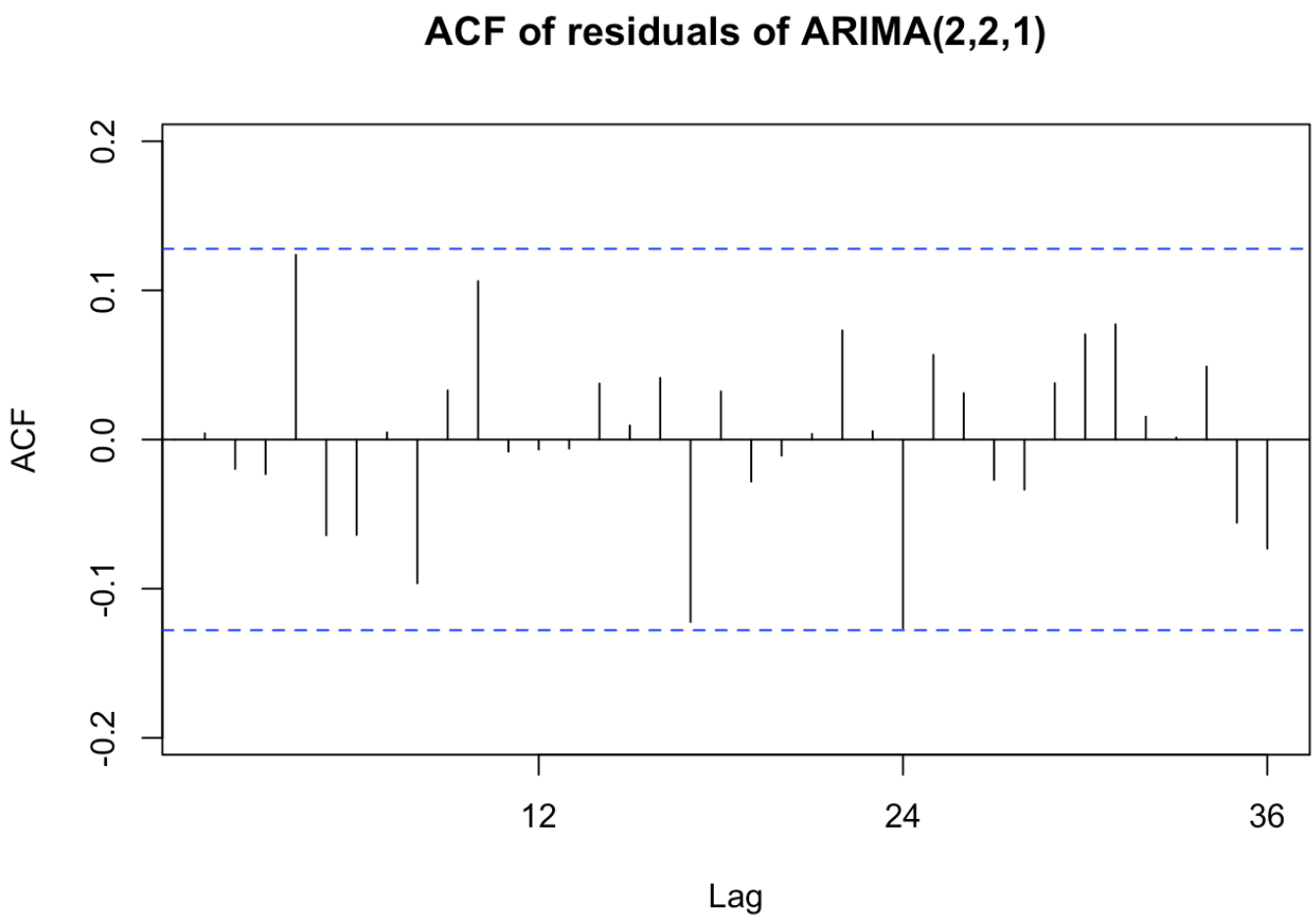

```
tsdiag(Arima(ts_pricepersqft,order = c(2,2,1)),which=1)
```



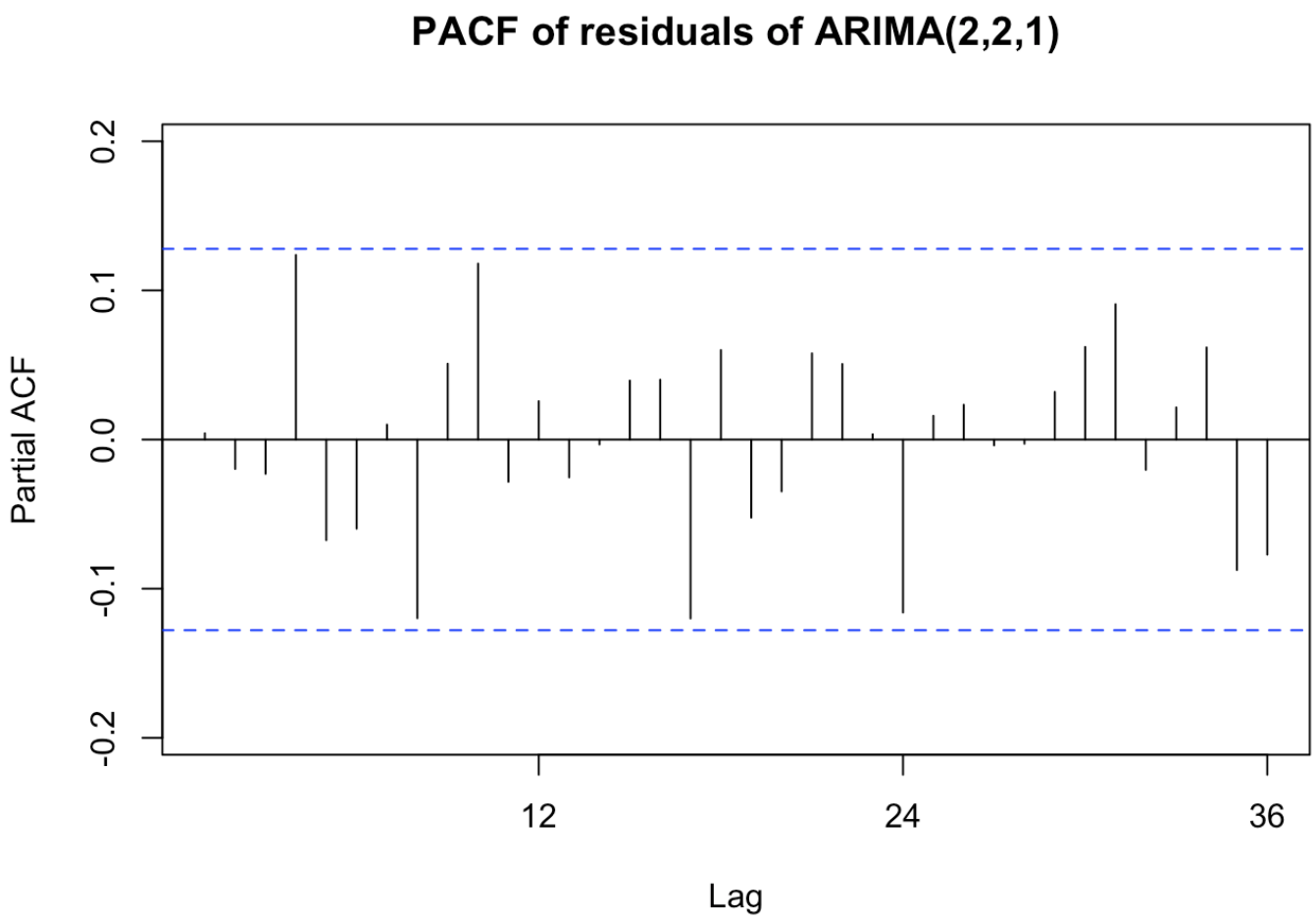




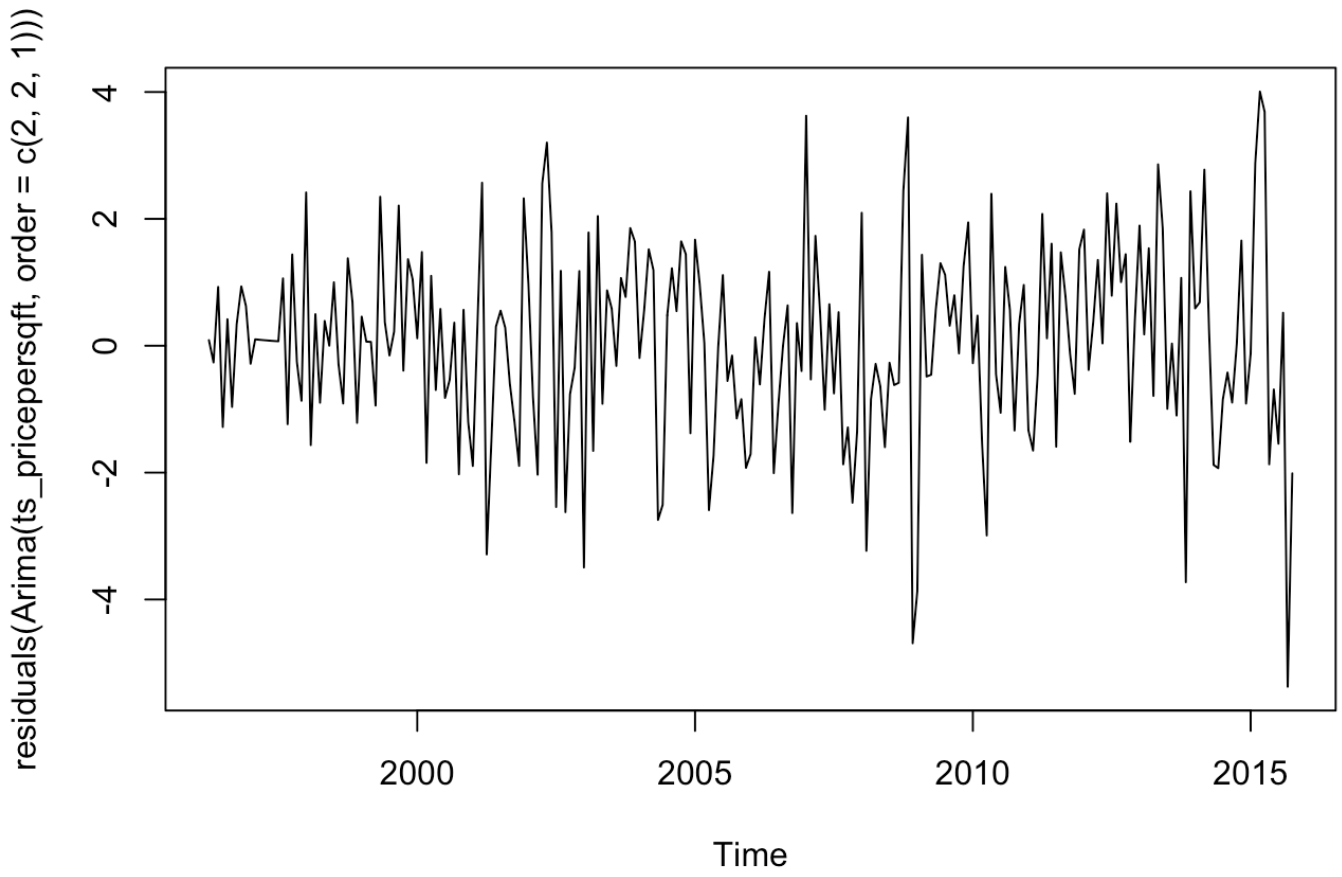

```
Acf(residuals(Arima(ts_pricepersqft,order = c(2,2,1))),lag.max = 36,main="ACF of r
esiduals of ARIMA(2,2,1)")
```




```
Pacf(residuals(Arima(ts_pricepersqft,order = c(2,2,1))),lag.max = 36,main="PACF of
residuals of ARIMA(2,2,1)")
```



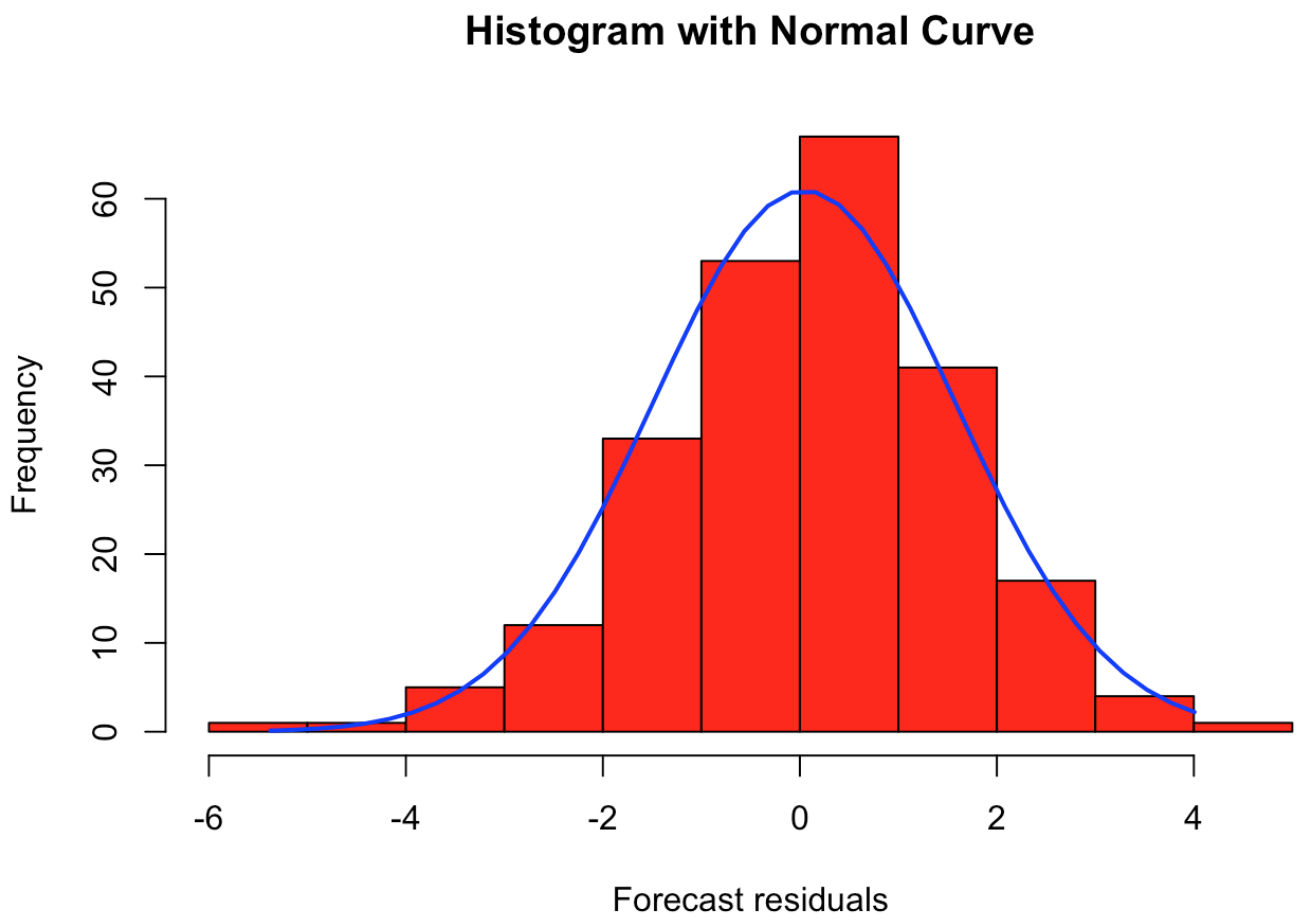

```
plot(residuals(Arima(ts_pricepersqft,order = c(2,2,1))),type="l")
```




```
2*(1-pnorm(abs(fit6$coef)/sqrt(diag(fit6$var.coef))))# check if the coeffocoents o
f AR and MA are significant
```

```
##          ar1          ar2          ma1
## 0.000000e+00 8.255667e-09 0.000000e+00
```

```
x <- residuals(fit6)
h<-hist(x, breaks=10, col="red", xlab="Forecast residuals",
      main="Histogram with Normal Curve")
xfit<-seq(min(x),max(x),length=40)
yfit<-dnorm(xfit,mean=mean(x),sd=sd(x))
yfit <- yfit*diff(h$mids[1:2])*length(x)
lines(xfit, yfit, col="blue", lwd=2)
```


Histogram with Normal Curve
Frequency
0
10
20
30
40
50
60
-6
-4
-2
0
2
4
Forecast residuals