Alaphabet Time Series Analysis

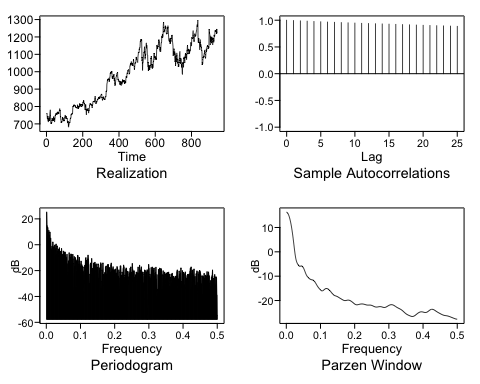
Daniel Byrne

10/29/2019

## Google Closing Stock Price

Wandering in the time series realization and slowly damping ACF indicate the presence of at least one unit root.

googl = GOOGL$GOOGL.Close   
plotts.sample.wge(googl)



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## [111] -15.0785902 -15.0976131 -15.1397002 -15.2031060 -15.2859474  
## [116] -15.3863913 -15.5027711 -15.6336251 -15.7776548 -15.9336117  
## [121] -16.1001347 -16.2755632 -16.4577656 -16.6440185 -16.8309795  
## [126] -17.0147830 -17.1912765 -17.3563902 -17.5065935 -17.6393626  
## [131] -17.7535581 -17.8496184 -17.9295165 -17.9964810 -18.0545447  
## [136] -18.1080154 -18.1609653 -18.2168147 -18.2780524 -18.3461043  
## [141] -18.4213446 -18.5032273 -18.5905132 -18.6815579 -18.7746227  
## [146] -18.8681633 -18.9610517 -19.0526954 -19.1430316 -19.2324006  
## [151] -19.3213216 -19.4102155 -19.4991262 -19.5874908 -19.6740067  
## [156] -19.7566268 -19.8327021 -19.8992682 -19.9534446 -19.9928885  
## [161] -20.0162192 -20.0233263 -20.0154920 -19.9953017 -19.9663661  
## [166] -19.9329212 -19.8993869 -19.8699606 -19.8482973 -19.8372977  
## [171] -19.8390082 -19.8546162 -19.8845218 -19.9284633 -19.9856749  
## [176] -20.0550570 -20.1353370 -20.2252050 -20.3234056 -20.4287778  
## [181] -20.5402373 -20.6567074 -20.7770117 -20.8997512 -21.0231919  
## [186] -21.1451925 -21.2631977 -21.3743188 -21.4755056 -21.5638019  
## [191] -21.6366499 -21.6921965 -21.7295393 -21.7488611 -21.7514202  
## [196] -21.7393998 -21.7156470 -21.6833565 -21.6457570 -21.6058451  
## [201] -21.5661997 -21.5288828 -21.4954231 -21.4668651 -21.4438611  
## [206] -21.4267844 -21.4158391 -21.4111505 -21.4128214 -21.4209474  
## [211] -21.4355924 -21.4567301 -21.4841655 -21.5174498 -21.5558096  
## [216] -21.5981049 -21.6428329 -21.6881859 -21.7321678 -21.7727622  
## [221] -21.8081364 -21.8368538 -21.8580631 -21.8716304 -21.8781900  
## [226] -21.8791028 -21.8763281 -21.8722319 -21.8693593 -21.8702048  
## [231] -21.8770039 -21.8915659 -21.9151542 -21.9484164 -21.9913603  
## [236] -22.0433703 -22.1032573 -22.1693370 -22.2395308 -22.3114838  
## [241] -22.3826965 -22.4506615 -22.5130033 -22.5676111 -22.6127602  
## [246] -22.6472136 -22.6702996 -22.6819570 -22.6827462 -22.6738230  
## [251] -22.6568751 -22.6340251 -22.6077057 -22.5805155 -22.5550642  
## [256] -22.5338163 -22.5189425 -22.5121841 -22.5147368 -22.5271578  
## [261] -22.5493011 -22.5802854 -22.6185010 -22.6616645 -22.7069244  
## [266] -22.7510252 -22.7905240 -22.8220484 -22.8425733 -22.8496799  
## [271] -22.8417638 -22.8181560 -22.7791415 -22.7258743 -22.6602119  
## [276] -22.5845019 -22.5013594 -22.4134665 -22.3234169 -22.2336126  
## [281] -22.1462115 -22.0631166 -21.9859930 -21.9162991 -21.8553205  
## [286] -21.8041971 -21.7639372 -21.7354170 -21.7193651 -21.7163351  
## [291] -21.7266697 -21.7504628 -21.7875224 -21.8373426 -21.8990873  
## [296] -21.9715918 -22.0533851 -22.1427358 -22.2377225 -22.3363270  
## [301] -22.4365441 -22.5365023 -22.6345816 -22.7295176 -22.8204801  
## [306] -22.9071145 -22.9895444 -23.0683336 -23.1444162 -23.2190022  
## [311] -23.2934734 -23.3692775 -23.4478309 -23.5304351 -23.6182078  
## [316] -23.7120301 -23.8125068 -23.9199375 -24.0342970 -24.1552252  
## [321] -24.2820252 -24.4136752 -24.5488545 -24.6859905 -24.8233284  
## [326] -24.9590243 -25.0912605 -25.2183734 -25.3389829 -25.4521056  
## [331] -25.5572347 -25.6543713 -25.7439985 -25.8269962 -25.9045082  
## [336] -25.9777739 -26.0479476 -26.1159249 -26.1821942 -26.2467303  
## [341] -26.3089393 -26.3676632 -26.4212450 -26.4676538 -26.5046584  
## [346] -26.5300348 -26.5417838 -26.5383311 -26.5186828 -26.4825150  
## [351] -26.4301876 -26.3626871 -26.2815140 -26.1885400 -26.0858606  
## [356] -25.9756642 -25.8601300 -25.7413625 -25.6213562 -25.5019859  
## [361] -25.3850113 -25.2720874 -25.1647715 -25.0645238 -24.9726966  
## [366] -24.8905140 -24.8190429 -24.7591583 -24.7115046 -24.6764583  
## [371] -24.6540913 -24.6441394 -24.6459758 -24.6585918 -24.6805863  
## [376] -24.7101671 -24.7451658 -24.7830718 -24.8210899 -24.8562249  
## [381] -24.8853980 -24.9055933 -24.9140305 -24.9083518 -24.8868052  
## [386] -24.8484022 -24.7930274 -24.7214812 -24.6354481 -24.5373925  
## [391] -24.4303979 -24.3179689 -24.2038227 -24.0916888 -23.9851342  
## [396] -23.8874219 -23.8014043 -23.7294503 -23.6734006 -23.6345458  
## [401] -23.6136225 -23.6108230 -23.6258180 -23.6577898 -23.7054785  
## [406] -23.7672408 -23.8411243 -23.9249566 -24.0164481 -24.1133055  
## [411] -24.2133478 -24.3146174 -24.4154742 -24.5146632 -24.6113482  
## [416] -24.7051055 -24.7958809 -24.8839158 -24.9696508 -25.0536207  
## [421] -25.1363517 -25.2182711 -25.2996370 -25.3804935 -25.4606512  
## [426] -25.5396945 -25.6170133 -25.6918539 -25.7633865 -25.8307818  
## [431] -25.8932916 -25.9503255 -26.0015168 -26.0467716 -26.0862957  
## [436] -26.1205971 -26.1504626 -26.1769119 -26.2011322 -26.2244014  
## [441] -26.2480043 -26.2731504 -26.3008987 -26.3320958 -26.3673303  
## [446] -26.4069075 -26.4508461 -26.4988975 -26.5505862 -26.6052694  
## [451] -26.6622103 -26.7206582 -26.7799263 -26.8394582 -26.8988729  
## [456] -26.9579816 -27.0167716 -27.0753588 -27.1339124 -27.1925628  
## [461] -27.2513030 -27.3098985 -27.3678181 -27.4241977 -27.4778474  
## [466] -27.5273042 -27.5709326 -27.6070624 -27.6341516 -27.6509506  
## [471] -27.6566446

Overfitting indicates the possible presence of at least one unit root.

best = est.ar.wge(googl,p=8,type="burg")

##   
## Coefficients of Original polynomial:   
## 1.0081 -0.0822 0.0885 -0.0332 -0.0533 0.0129 0.1044 -0.0484   
##   
## Factor Roots Abs Recip System Freq   
## 1-0.9970B 1.0030 0.9970 0.0000  
## 1+0.2669B+0.5249B^2 -0.2542+-1.3566i 0.7245 0.2795  
## 1-0.9949B+0.4487B^2 1.1087+-0.9998i 0.6698 0.1168  
## 1+1.1854B+0.4403B^2 -1.3459+-0.6778i 0.6636 0.4258  
## 1-0.4684B 2.1350 0.4684 0.0000  
##   
##

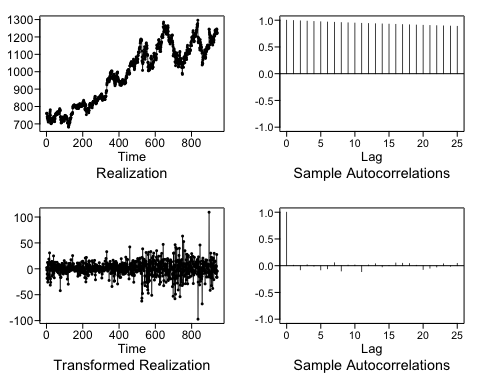
Dickey Fuller also indicates the presence of a unit root.

adf.test(googl)

##   
## Augmented Dickey-Fuller Test  
##   
## data: googl  
## Dickey-Fuller = -2.8866, Lag order = 9, p-value = 0.203  
## alternative hypothesis: stationary

## ARIMA

xd1 = artrans.wge(googl,phi.tr = 1)



aic5.wge(xd1)

## ---------WORKING... PLEASE WAIT...   
##   
##   
## Five Smallest Values of aic

## p q aic  
## 9 2 2 5.388026  
## 17 5 1 5.388246  
## 14 4 1 5.388461  
## 15 4 2 5.388531  
## 12 3 2 5.390017

amodel = est.arma.wge(xd1,p=2,q=2)

##   
## Coefficients of Original polynomial:   
## 0.0834 0.6371   
##   
## Factor Roots Abs Recip System Freq   
## 1-0.8410B 1.1891 0.8410 0.0000  
## 1+0.7576B -1.3200 0.7576 0.5000  
##   
##

#final model  
amodel$phi

## [1] 0.08343329 0.63708949

amodel$theta

## [1] 0.08353262 0.72309028

amodel$avar

## [1] 216.4585

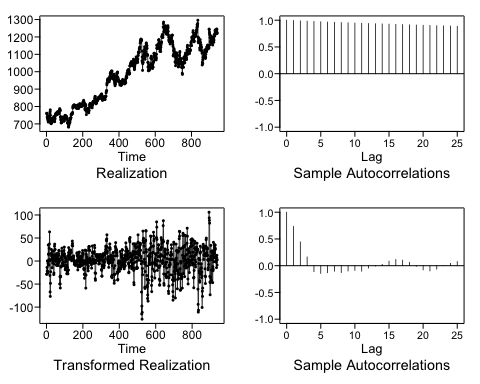
d=1

* phi = 0.0834333, 0.6370895
* theta = 0.0835326, 0.7230903
* avar = 216.4584795
* d = 1

## Seasonal

Stock data is potentially seasonal, so I attempt to difference a quarterly trend

xs4 = artrans.wge(googl,phi.tr = c(0,0,0,1),plottr = TRUE)



aic5.wge(xs4)

## ---------WORKING... PLEASE WAIT...   
##   
##   
## Five Smallest Values of aic

## p q aic  
## 14 4 1 5.644851  
## 17 5 1 5.646045  
## 18 5 2 5.647035  
## 15 4 2 5.676557  
## 16 5 0 5.747056

u = mean(googl)  
u

## [1] 984.5731

smodel = est.arma.wge(xs4,p=4,q=1)

##   
## Coefficients of Original polynomial:   
## 0.0177 0.6172 -0.0317 -0.3615   
##   
## Factor Roots Abs Recip System Freq   
## 1-1.3580B+0.6171B^2 1.1002+-0.6402i 0.7856 0.0839  
## 1+1.3403B+0.5857B^2 -1.1441+-0.6311i 0.7653 0.4198  
##   
##

* phi = 0.0176581, 0.6172171, -0.0317355, -0.3614892
* theta = -0.9972141
* avar = 279.2362026
* d = 1

## Sig-Plus Noise

### lm

z <- fortify.zoo(googl, name = "Date")  
x <- z$GOOGL.Close  
t = seq(1,length(x),1)  
df = data.frame(x = x, t= t)  
fit = lm(x~t, data = df)  
summary(fit)

##   
## Call:  
## lm(formula = x ~ t, data = df)  
##   
## Residuals:  
## Min 1Q Median 3Q Max   
## -168.45 -42.79 -10.56 41.65 200.68   
##   
## Coefficients:  
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 7.137e+02 4.152e+00 171.90 <2e-16 \*\*\*  
## t 5.745e-01 7.628e-03 75.31 <2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 63.66 on 940 degrees of freedom  
## Multiple R-squared: 0.8578, Adjusted R-squared: 0.8577   
## F-statistic: 5672 on 1 and 940 DF, p-value: < 2.2e-16

### Chochrane-Orcutt

cfit = cochrane.orcutt(fit)  
summary(cfit)

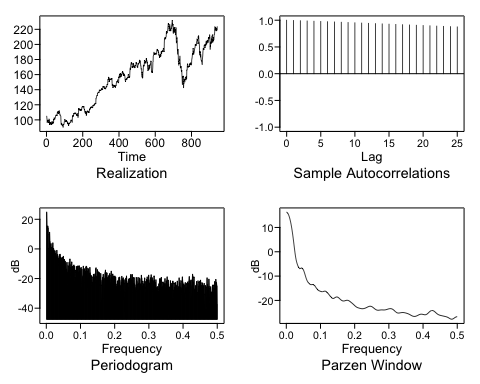
## Call:  
## lm(formula = x ~ t, data = df)  
##   
## Estimate Std. Error t value Pr(>|t|)   
## (Intercept) 709.095757 37.388436 18.966 < 2.2e-16 \*\*\*  
## t 0.577563 0.064928 8.895 < 2.2e-16 \*\*\*  
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Residual standard error: 14.7238 on 939 degrees of freedom  
## Multiple R-squared: 0.0777 , Adjusted R-squared: 0.0767  
## F-statistic: 79.1 on 1 and 939 DF, p-value: < 2.938e-18  
##   
## Durbin-Watson statistic   
## (original): 0.05418 , p-value: 4.63e-197  
## (transformed): 1.95657 , p-value: 2.421e-01

## Apple Stock

getSymbols("AAPL", src = "yahoo", from = start, to = end)

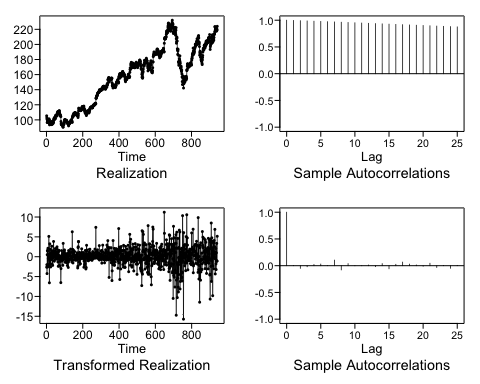
## [1] "AAPL"

aapl = AAPL$AAPL.Close  
plotts.sample.wge(aapl)



## $autplt  
## [1] 1.0000000 0.9953077 0.9907363 0.9862489 0.9816292 0.9770797 0.9723944  
## [8] 0.9677858 0.9624673 0.9574719 0.9523100 0.9471629 0.9420670 0.9366830  
## [15] 0.9315268 0.9264457 0.9217443 0.9167251 0.9114262 0.9062992 0.9012345  
## [22] 0.8959871 0.8905852 0.8854894 0.8803310 0.8752992  
##   
## $freq  
## [1] 0.001061571 0.002123142 0.003184713 0.004246285 0.005307856  
## [6] 0.006369427 0.007430998 0.008492569 0.009554140 0.010615711  
## [11] 0.011677282 0.012738854 0.013800425 0.014861996 0.015923567  
## [16] 0.016985138 0.018046709 0.019108280 0.020169851 0.021231423  
## [21] 0.022292994 0.023354565 0.024416136 0.025477707 0.026539278  
## [26] 0.027600849 0.028662420 0.029723992 0.030785563 0.031847134  
## [31] 0.032908705 0.033970276 0.035031847 0.036093418 0.037154989  
## [36] 0.038216561 0.039278132 0.040339703 0.041401274 0.042462845  
## [41] 0.043524416 0.044585987 0.045647558 0.046709130 0.047770701  
## [46] 0.048832272 0.049893843 0.050955414 0.052016985 0.053078556  
## [51] 0.054140127 0.055201699 0.056263270 0.057324841 0.058386412  
## [56] 0.059447983 0.060509554 0.061571125 0.062632696 0.063694268  
## [61] 0.064755839 0.065817410 0.066878981 0.067940552 0.069002123  
## [66] 0.070063694 0.071125265 0.072186837 0.073248408 0.074309979  
## [71] 0.075371550 0.076433121 0.077494692 0.078556263 0.079617834  
## [76] 0.080679406 0.081740977 0.082802548 0.083864119 0.084925690  
## [81] 0.085987261 0.087048832 0.088110403 0.089171975 0.090233546  
## [86] 0.091295117 0.092356688 0.093418259 0.094479830 0.095541401  
## [91] 0.096602972 0.097664544 0.098726115 0.099787686 0.100849257  
## [96] 0.101910828 0.102972399 0.104033970 0.105095541 0.106157113  
## [101] 0.107218684 0.108280255 0.109341826 0.110403397 0.111464968  
## [106] 0.112526539 0.113588110 0.114649682 0.115711253 0.116772824  
## [111] 0.117834395 0.118895966 0.119957537 0.121019108 0.122080679  
## [116] 0.123142251 0.124203822 0.125265393 0.126326964 0.127388535  
## [121] 0.128450106 0.129511677 0.130573248 0.131634820 0.132696391  
## [126] 0.133757962 0.134819533 0.135881104 0.136942675 0.138004246  
## [131] 0.139065817 0.140127389 0.141188960 0.142250531 0.143312102  
## [136] 0.144373673 0.145435244 0.146496815 0.147558386 0.148619958  
## [141] 0.149681529 0.150743100 0.151804671 0.152866242 0.153927813  
## [146] 0.154989384 0.156050955 0.157112527 0.158174098 0.159235669  
## [151] 0.160297240 0.161358811 0.162420382 0.163481953 0.164543524  
## [156] 0.165605096 0.166666667 0.167728238 0.168789809 0.169851380  
## [161] 0.170912951 0.171974522 0.173036093 0.174097665 0.175159236  
## [166] 0.176220807 0.177282378 0.178343949 0.179405520 0.180467091  
## [171] 0.181528662 0.182590234 0.183651805 0.184713376 0.185774947  
## [176] 0.186836518 0.187898089 0.188959660 0.190021231 0.191082803  
## [181] 0.192144374 0.193205945 0.194267516 0.195329087 0.196390658  
## [186] 0.197452229 0.198513800 0.199575372 0.200636943 0.201698514  
## [191] 0.202760085 0.203821656 0.204883227 0.205944798 0.207006369  
## [196] 0.208067941 0.209129512 0.210191083 0.211252654 0.212314225  
## [201] 0.213375796 0.214437367 0.215498938 0.216560510 0.217622081  
## [206] 0.218683652 0.219745223 0.220806794 0.221868365 0.222929936  
## [211] 0.223991507 0.225053079 0.226114650 0.227176221 0.228237792  
## [216] 0.229299363 0.230360934 0.231422505 0.232484076 0.233545648  
## [221] 0.234607219 0.235668790 0.236730361 0.237791932 0.238853503  
## [226] 0.239915074 0.240976645 0.242038217 0.243099788 0.244161359  
## [231] 0.245222930 0.246284501 0.247346072 0.248407643 0.249469214  
## [236] 0.250530786 0.251592357 0.252653928 0.253715499 0.254777070  
## [241] 0.255838641 0.256900212 0.257961783 0.259023355 0.260084926  
## [246] 0.261146497 0.262208068 0.263269639 0.264331210 0.265392781  
## [251] 0.266454352 0.267515924 0.268577495 0.269639066 0.270700637  
## [256] 0.271762208 0.272823779 0.273885350 0.274946921 0.276008493  
## [261] 0.277070064 0.278131635 0.279193206 0.280254777 0.281316348  
## [266] 0.282377919 0.283439490 0.284501062 0.285562633 0.286624204  
## [271] 0.287685775 0.288747346 0.289808917 0.290870488 0.291932059  
## [276] 0.292993631 0.294055202 0.295116773 0.296178344 0.297239915  
## [281] 0.298301486 0.299363057 0.300424628 0.301486200 0.302547771  
## [286] 0.303609342 0.304670913 0.305732484 0.306794055 0.307855626  
## [291] 0.308917197 0.309978769 0.311040340 0.312101911 0.313163482  
## [296] 0.314225053 0.315286624 0.316348195 0.317409766 0.318471338  
## [301] 0.319532909 0.320594480 0.321656051 0.322717622 0.323779193  
## [306] 0.324840764 0.325902335 0.326963907 0.328025478 0.329087049  
## [311] 0.330148620 0.331210191 0.332271762 0.333333333 0.334394904  
## [316] 0.335456476 0.336518047 0.337579618 0.338641189 0.339702760  
## [321] 0.340764331 0.341825902 0.342887473 0.343949045 0.345010616  
## [326] 0.346072187 0.347133758 0.348195329 0.349256900 0.350318471  
## [331] 0.351380042 0.352441614 0.353503185 0.354564756 0.355626327  
## [336] 0.356687898 0.357749469 0.358811040 0.359872611 0.360934183  
## [341] 0.361995754 0.363057325 0.364118896 0.365180467 0.366242038  
## [346] 0.367303609 0.368365180 0.369426752 0.370488323 0.371549894  
## [351] 0.372611465 0.373673036 0.374734607 0.375796178 0.376857749  
## [356] 0.377919321 0.378980892 0.380042463 0.381104034 0.382165605  
## [361] 0.383227176 0.384288747 0.385350318 0.386411890 0.387473461  
## [366] 0.388535032 0.389596603 0.390658174 0.391719745 0.392781316  
## [371] 0.393842887 0.394904459 0.395966030 0.397027601 0.398089172  
## [376] 0.399150743 0.400212314 0.401273885 0.402335456 0.403397028  
## [381] 0.404458599 0.405520170 0.406581741 0.407643312 0.408704883  
## [386] 0.409766454 0.410828025 0.411889597 0.412951168 0.414012739  
## [391] 0.415074310 0.416135881 0.417197452 0.418259023 0.419320594  
## [396] 0.420382166 0.421443737 0.422505308 0.423566879 0.424628450  
## [401] 0.425690021 0.426751592 0.427813163 0.428874735 0.429936306  
## [406] 0.430997877 0.432059448 0.433121019 0.434182590 0.435244161  
## [411] 0.436305732 0.437367304 0.438428875 0.439490446 0.440552017  
## [416] 0.441613588 0.442675159 0.443736730 0.444798301 0.445859873  
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ad1 = artrans.wge(aapl,phi.tr = 1)



aic5.wge(ad1)

## ---------WORKING... PLEASE WAIT...   
##   
##   
## Five Smallest Values of aic

## p q aic  
## 1 0 0 1.891236  
## 7 2 0 1.892964  
## 3 0 2 1.893080  
## 2 0 1 1.893345  
## 4 1 0 1.893347

Final model is simply the variance of the signal data