

# Traditional\_forecasting

ABDUL KHADER

## PACKAGE

```
library(readxl)
library(urca)
library(lmtest)

## Loading required package: zoo

##
## Attaching package: 'zoo'

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

library(fpp2)

## Registered S3 method overwritten by 'quantmod':
##      method      from
##      as.zoo.data.frame zoo

## — Attaching packages ————— fpp2 2.5 —

## ✓ ggplot2 3.4.2    ✓ fma 2.5
## ✓ forecast 8.21    ✓ expsmooth 2.3

##

library(forecast)
library(TTR)
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(tseries)
library(aTSA)

##
## Attaching package: 'aTSA'

## The following objects are masked from 'package:tseries':
##
##      adf.test, kpss.test, pp.test
```

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

## The following object is masked from 'package:graphics':
##
##      identify
```

## FORECASTING: AAPL

```
library(readxl)
AAPL <- read_excel("AAPL.xlsx")

str(AAPL) # To check the structure of the dataframe

## tibble [264 × 7] (S3: tbl_df/tbl/data.frame)
## $ Date      : POSIXct[1:264], format: "2000-01-01" "2000-02-01" ...
## $ Open      : num [1:264] 0.936 0.929 1.059 1.21 1.115 ...
## $ High      : num [1:264] 1.08 1.07 1.34 1.25 1.13 ...
## $ Low       : num [1:264] 0.772 0.866 1.018 0.936 0.73 ...
## $ Close     : num [1:264] 0.926 1.023 1.213 1.108 0.75 ...
## $ Adj Close: num [1:264] 0.79 0.872 1.034 0.944 0.639 ...
## $ Volume    : num [1:264] 1.26e+10 7.32e+09 8.70e+09 8.66e+09 9.81e+09 ...

class = c(rep("TRAIN", 211), rep("TEST", 53))

str(class)

## chr [1:264] "TRAIN" "TRAIN" "TRAIN" "TRAIN" "TRAIN" "TRAIN" "TRAIN" ...

AAPL = cbind(AAPL, class)
AAPL
```

	Date	Open	High	Low	Close	Adj Close
## 1	2000-01-01	0.936384	1.084821	0.772321	0.926339	0.789628
## 2	2000-02-01	0.928571	1.070871	0.866071	1.023438	0.872397
## 3	2000-03-01	1.058594	1.342634	1.017857	1.212612	1.033653
## 4	2000-04-01	1.209821	1.245536	0.936384	1.107701	0.944224
## 5	2000-05-01	1.114955	1.127232	0.729911	0.750000	0.639313
## 6	2000-06-01	0.729911	1.029018	0.717634	0.935268	0.797239
## 7	2000-07-01	0.930804	1.082589	0.837054	0.907366	0.773455
## 8	2000-08-01	0.898438	1.098214	0.790179	1.088170	0.927576
## 9	2000-09-01	1.094866	1.145089	0.453125	0.459821	0.391960
## 10	2000-10-01	0.476563	0.477679	0.312500	0.349330	0.297775
## 11	2000-11-01	0.347098	0.410714	0.287946	0.294643	0.251159
## 12	2000-12-01	0.303571	0.312500	0.243304	0.265625	0.226424
## 13	2001-01-01	0.265625	0.401786	0.257813	0.386161	0.329170
## 14	2001-02-01	0.369420	0.391741	0.321429	0.325893	0.277797
## 15	2001-03-01	0.318080	0.424107	0.306920	0.394107	0.335944
## 16	2001-04-01	0.394464	0.484286	0.334821	0.455179	0.388003
## 17	2001-05-01	0.453750	0.476786	0.344643	0.356250	0.303674
## 18	2001-06-01	0.359464	0.448214	0.345536	0.415179	0.353906
## 19	2001-07-01	0.422143	0.450357	0.318750	0.335536	0.286017
## 20	2001-08-01	0.339464	0.355357	0.308571	0.331250	0.282363
## 21	2001-09-01	0.330357	0.340714	0.262143	0.276964	0.236089
## 22	2001-10-01	0.276607	0.346786	0.264821	0.313571	0.267294

## 23	2001-11-01	0.315179	0.384821	0.308036	0.380357	0.324223
## 24	2001-12-01	0.376071	0.429107	0.358750	0.391071	0.333356
## 25	2002-01-01	0.393750	0.441607	0.361607	0.441429	0.376282
## 26	2002-02-01	0.434643	0.463929	0.373929	0.387500	0.330312
## 27	2002-03-01	0.391607	0.451786	0.389643	0.422679	0.360299
## 28	2002-04-01	0.417500	0.467321	0.410714	0.433393	0.369432
## 29	2002-05-01	0.433750	0.463929	0.395357	0.416071	0.354666
## 30	2002-06-01	0.417679	0.418750	0.285357	0.316429	0.269730
## 31	2002-07-01	0.316250	0.335536	0.246429	0.272500	0.232284
## 32	2002-08-01	0.269821	0.290179	0.249464	0.263393	0.224521
## 33	2002-09-01	0.258750	0.271250	0.250893	0.258929	0.220716
## 34	2002-10-01	0.260536	0.293571	0.238571	0.286964	0.244613
## 35	2002-11-01	0.284643	0.310357	0.268036	0.276786	0.235937
## 36	2002-12-01	0.283929	0.287500	0.246071	0.255893	0.218128
## 37	2003-01-01	0.256429	0.274643	0.242143	0.256429	0.218585
## 38	2003-02-01	0.257321	0.273214	0.246429	0.268036	0.228479
## 39	2003-03-01	0.268036	0.270714	0.250714	0.252500	0.215235
## 40	2003-04-01	0.253571	0.266964	0.227143	0.253929	0.216454
## 41	2003-05-01	0.254464	0.339464	0.250000	0.320536	0.273231
## 42	2003-06-01	0.323214	0.351607	0.296964	0.340357	0.290126
## 43	2003-07-01	0.336964	0.385179	0.330536	0.376429	0.320875
## 44	2003-08-01	0.375000	0.408036	0.346786	0.403750	0.344164
## 45	2003-09-01	0.404643	0.416429	0.359821	0.370000	0.315395
## 46	2003-10-01	0.369821	0.446607	0.360536	0.408750	0.348426
## 47	2003-11-01	0.407679	0.416071	0.354464	0.373393	0.318287
## 48	2003-12-01	0.375714	0.391071	0.343750	0.381607	0.325289
## 49	2004-01-01	0.384821	0.443571	0.378214	0.402857	0.343402
## 50	2004-02-01	0.401071	0.430357	0.387500	0.427143	0.364104
## 51	2004-03-01	0.430357	0.502500	0.421429	0.482857	0.411596
## 52	2004-04-01	0.480179	0.528214	0.455179	0.460357	0.392417
## 53	2004-05-01	0.464286	0.513929	0.455357	0.501071	0.427122
## 54	2004-06-01	0.496250	0.610536	0.493036	0.581071	0.495315
## 55	2004-07-01	0.573214	0.600536	0.513214	0.577500	0.492271
## 56	2004-08-01	0.556786	0.628214	0.530357	0.615893	0.524998
## 57	2004-09-01	0.612500	0.701250	0.610536	0.691964	0.589842
## 58	2004-10-01	0.698571	0.950000	0.672321	0.935714	0.797620
## 59	2004-11-01	0.937500	1.242321	0.929286	1.197321	1.020618
## 60	2004-12-01	1.210536	1.213393	1.100000	1.150000	0.980280
## 61	2005-01-01	1.156786	1.390893	1.117857	1.373214	1.170553
## 62	2005-02-01	1.375893	1.622857	1.367500	1.602143	1.365695
## 63	2005-03-01	1.606786	1.611071	1.386786	1.488214	1.268580
## 64	2005-04-01	1.503214	1.587500	1.214286	1.287857	1.097792
## 65	2005-05-01	1.293214	1.462143	1.182500	1.420000	1.210433
## 66	2005-06-01	1.424643	1.455714	1.268571	1.314643	1.120625
## 67	2005-07-01	1.315357	1.585000	1.296071	1.523214	1.298415
## 68	2005-08-01	1.520357	1.726071	1.500714	1.674643	1.427496
## 69	2005-09-01	1.678571	1.948571	1.646071	1.914643	1.632076
## 70	2005-10-01	1.934286	2.070714	1.709643	2.056786	1.753241
## 71	2005-11-01	2.044286	2.538214	2.031071	2.422143	2.064679
## 72	2005-12-01	2.462500	2.695000	2.457500	2.567500	2.188583
## 73	2006-01-01	2.585000	3.085714	2.531071	2.696786	2.298788
## 74	2006-02-01	2.676786	2.730714	2.246429	2.446071	2.085074
## 75	2006-03-01	2.458571	2.499643	2.059643	2.240000	1.909416
## 76	2006-04-01	2.273929	2.573214	2.180357	2.513929	2.142918
## 77	2006-05-01	2.527500	2.635714	2.096071	2.134643	1.819608

## 78	2006-06-01	2.137500	2.253571	1.978929	2.045357	1.743499
## 79	2006-07-01	2.054286	2.451071	1.791429	2.427143	2.068940
## 80	2006-08-01	2.400714	2.500000	2.235000	2.423214	2.065591
## 81	2006-09-01	2.445714	2.777857	2.422143	2.749286	2.343540
## 82	2006-10-01	2.682143	2.950000	2.592857	2.895714	2.468358
## 83	2006-11-01	2.896429	3.327143	2.778214	3.273571	2.790451
## 84	2006-12-01	3.278571	3.297500	2.741786	3.030000	2.582826
## 85	2007-01-01	3.081786	3.492857	2.925000	3.061786	2.609922
## 86	2007-02-01	3.079643	3.243214	2.959286	3.021786	2.575824
## 87	2007-03-01	3.001071	3.458214	2.991071	3.318214	2.828504
## 88	2007-04-01	3.362143	3.660714	3.200000	3.564286	3.038261
## 89	2007-05-01	3.556786	4.363214	3.519643	4.328214	3.689447
## 90	2007-06-01	4.325000	4.557500	4.121429	4.358571	3.715324
## 91	2007-07-01	4.323214	5.318571	4.260714	4.705714	4.011234
## 92	2007-08-01	4.772857	4.987500	3.986429	4.945714	4.215815
## 93	2007-09-01	4.997857	5.535714	4.642857	5.481071	4.672163
## 94	2007-10-01	5.522500	6.790000	5.461786	6.783929	5.782744
## 95	2007-11-01	6.735714	6.881429	5.379643	6.507857	5.547414
## 96	2007-12-01	6.495000	7.248571	6.321071	7.074286	6.030247
## 97	2008-01-01	7.116786	7.152143	4.505000	4.834286	4.120831
## 98	2008-02-01	4.865714	4.878214	4.122857	4.465000	3.806046
## 99	2008-03-01	4.444286	5.205000	4.214286	5.125000	4.368642
## 100	2008-04-01	5.225000	6.428571	5.128929	6.212500	5.295646
## 101	2008-05-01	6.248571	6.865714	6.142857	6.741071	5.746209
## 102	2008-06-01	6.735714	6.783929	5.862500	5.980000	5.097458
## 103	2008-07-01	5.865357	6.461071	5.233214	5.676786	4.838995
## 104	2008-08-01	5.710714	6.444643	5.461071	6.054643	5.161087
## 105	2008-09-01	6.157143	6.196429	3.592500	4.059286	3.460208
## 106	2008-10-01	3.997143	4.157143	3.035714	3.842500	3.275416
## 107	2008-11-01	3.783214	3.992500	2.826429	3.309643	2.821200
## 108	2008-12-01	3.260714	3.700000	3.019643	3.048214	2.598351
## 109	2009-01-01	3.067143	3.470357	2.792857	3.218929	2.743872
## 110	2009-02-01	3.182143	3.678571	3.089643	3.189643	2.718909
## 111	2009-03-01	3.147143	3.927857	2.940357	3.754286	3.200221
## 112	2009-04-01	3.717500	4.542857	3.710357	4.493929	3.830704
## 113	2009-05-01	4.492857	4.853571	4.263571	4.850357	4.134530
## 114	2009-06-01	4.873929	5.228571	4.745714	5.086786	4.336068
## 115	2009-07-01	5.125000	5.892857	4.800714	5.835357	4.974163
## 116	2009-08-01	5.900357	6.160357	5.693571	6.007500	5.120901
## 117	2009-09-01	5.999643	6.746429	5.861071	6.619643	5.642703
## 118	2009-10-01	6.619643	7.453929	6.453571	6.732143	5.738598
## 119	2009-11-01	6.778571	7.428571	6.627500	7.139643	6.085958
## 120	2009-12-01	7.222857	7.641071	6.738571	7.526071	6.415359
## 121	2010-01-01	7.622500	7.699643	6.794643	6.859286	5.846978
## 122	2010-02-01	6.870357	7.327500	6.816071	7.307857	6.229348
## 123	2010-03-01	7.348214	8.481429	7.337500	8.392857	7.154222
## 124	2010-04-01	8.478929	9.730714	8.312500	9.324643	7.948493
## 125	2010-05-01	9.422857	9.567143	7.116071	9.174286	7.820324
## 126	2010-06-01	9.274643	9.964643	8.650000	8.983214	7.657452
## 127	2010-07-01	9.082143	9.499643	8.557143	9.187500	7.831588
## 128	2010-08-01	9.301429	9.438571	8.412857	8.682143	7.400814
## 129	2010-09-01	8.838214	10.526071	8.795714	10.133929	8.638339
## 130	2010-10-01	10.219643	11.392857	9.920357	10.749286	9.162885
## 131	2010-11-01	10.793571	11.475000	10.634286	11.112500	9.472491
## 132	2010-12-01	11.259643	11.666429	11.246071	11.520000	9.819860

##	133	2011-01-01	11.630000	12.450000	11.601429	12.118571	10.330086
##	134	2011-02-01	12.189286	13.032143	12.061429	12.614643	10.752951
##	135	2011-03-01	12.695357	12.916786	11.652143	12.446786	10.609865
##	136	2011-04-01	12.539643	12.683214	11.434286	12.504643	10.659183
##	137	2011-05-01	12.490714	12.565357	11.765000	12.422500	10.589158
##	138	2011-06-01	12.459643	12.576071	11.089286	11.988214	10.218966
##	139	2011-07-01	11.998214	14.446429	11.935714	13.945714	11.887578
##	140	2011-08-01	14.206429	14.267857	12.607857	13.743929	11.715570
##	141	2011-09-01	13.779286	15.102143	13.088571	13.618571	11.608711
##	142	2011-10-01	13.584643	15.239286	12.651429	14.456429	12.322919
##	143	2011-11-01	14.193214	14.571429	12.975714	13.650000	11.635505
##	144	2011-12-01	13.662143	14.610357	13.488571	14.464286	12.329618
##	145	2012-01-01	14.621429	16.365713	14.607143	16.302856	13.896846
##	146	2012-02-01	16.371786	19.557501	16.213572	19.372856	16.513767
##	147	2012-03-01	19.577499	22.194643	18.436428	21.412500	18.252398
##	148	2012-04-01	21.493929	23.000000	19.821428	20.856428	17.778395
##	149	2012-05-01	20.889286	21.312857	18.649286	20.633215	17.588121
##	150	2012-06-01	20.327143	21.071428	19.589287	20.857143	17.779001
##	151	2012-07-01	20.883215	22.138214	20.357143	21.812857	18.593672
##	152	2012-08-01	21.996786	24.316786	21.437500	23.758572	20.252230
##	153	2012-09-01	23.777143	25.181070	23.428572	23.825001	20.396053
##	154	2012-10-01	23.969999	24.169643	20.989286	21.261429	18.201439
##	155	2012-11-01	21.365000	21.535713	18.062500	20.902857	17.894472
##	156	2012-12-01	21.201786	21.235357	17.901072	19.006071	16.344995
##	157	2013-01-01	19.779285	19.821428	15.535714	16.267500	13.989851
##	158	2013-02-01	16.396786	17.319286	15.630714	15.764286	13.557092
##	159	2013-03-01	15.642857	16.783930	14.964286	15.809286	13.675029
##	160	2013-04-01	15.782143	15.901786	13.753571	15.813571	13.678739
##	161	2013-05-01	15.873571	16.633928	14.960714	16.061787	13.893443
##	162	2013-06-01	16.097500	16.229643	13.888214	14.161786	12.331028
##	163	2013-07-01	14.381786	16.333570	14.329286	16.161785	14.072474
##	164	2013-08-01	16.276787	18.347857	16.187857	17.400715	15.151244
##	165	2013-09-01	17.610714	18.139999	15.972143	17.026787	14.923545
##	166	2013-10-01	17.087500	19.258928	17.081429	18.667856	16.361904
##	167	2013-11-01	18.715000	19.940357	18.299286	19.859644	17.406473
##	168	2013-12-01	19.928572	20.540714	19.242857	20.036428	17.663952
##	169	2014-01-01	19.845715	20.007143	17.626785	17.878571	15.761600
##	170	2014-02-01	17.950357	19.685356	17.832144	18.794287	16.568890
##	171	2014-03-01	18.693571	19.607143	18.671785	19.169287	17.000645
##	172	2014-04-01	19.205713	21.408215	18.261786	21.074642	18.690445
##	173	2014-05-01	21.142857	23.006071	20.726070	22.607143	20.049570
##	174	2014-06-01	22.641430	23.762501	22.232143	23.232500	20.719263
##	175	2014-07-01	23.379999	24.860001	23.142500	23.900000	21.314552
##	176	2014-08-01	23.725000	25.725000	23.320000	25.625000	22.852949
##	177	2014-09-01	25.764999	25.934999	24.035000	25.187500	22.574507
##	178	2014-10-01	25.147499	27.010000	23.795000	27.000000	24.198980
##	179	2014-11-01	27.055000	29.937500	26.930000	29.732500	26.648006
##	180	2014-12-01	29.702499	29.812500	26.565001	27.594999	24.839497
##	181	2015-01-01	27.847500	30.000000	26.157499	29.290001	26.365236
##	182	2015-02-01	29.512501	33.400002	29.020000	32.115002	28.908152
##	183	2015-03-01	32.312500	32.570000	30.407499	31.107500	28.111761
##	184	2015-04-01	31.205000	33.634998	30.775000	31.287500	28.274426
##	185	2015-05-01	31.525000	33.242500	30.840000	32.570000	29.433420
##	186	2015-06-01	32.570000	32.847500	31.120001	31.357500	28.456059
##	187	2015-07-01	31.725000	33.242500	29.805000	30.325001	27.519087

## 188	2015-08-01	30.375000	30.642500	23.000000	28.190001	25.581642
## 189	2015-09-01	27.537500	29.222500	26.840000	27.575001	25.136810
## 190	2015-10-01	27.267500	30.305000	26.827499	29.875000	27.233442
## 191	2015-11-01	30.200001	30.955000	27.750000	29.575001	26.959967
## 192	2015-12-01	29.687500	29.965000	26.205000	26.315001	24.090900
## 193	2016-01-01	25.652500	26.462500	23.097500	24.334999	22.278248
## 194	2016-02-01	24.117500	24.722500	23.147499	24.172501	22.129480
## 195	2016-03-01	24.412500	27.605000	24.355000	27.247499	25.079941
## 196	2016-04-01	27.195000	28.097500	23.127501	23.434999	21.570734
## 197	2016-05-01	23.492500	25.182501	22.367500	24.965000	22.979013
## 198	2016-06-01	24.754999	25.472500	22.875000	23.900000	22.132671
## 199	2016-07-01	23.872499	26.137501	23.592501	26.052500	24.126005
## 200	2016-08-01	26.102501	27.557501	26.000000	26.525000	24.563560
## 201	2016-09-01	26.535000	29.045000	25.632500	28.262501	26.314367
## 202	2016-10-01	28.177500	29.672501	28.070000	28.385000	26.428423
## 203	2016-11-01	28.365000	28.442499	26.020000	27.629999	25.725466
## 204	2016-12-01	27.592501	29.504999	27.062500	28.955000	27.097549
## 205	2017-01-01	28.950001	30.610001	28.690001	30.337500	28.391357
## 206	2017-02-01	31.757500	34.369999	31.752501	34.247501	32.050541
## 207	2017-03-01	34.472500	36.125000	34.262501	35.915001	33.756790
## 208	2017-04-01	35.927502	36.365002	35.014999	35.912498	33.754433
## 209	2017-05-01	36.275002	39.162498	36.067501	38.189999	35.895081
## 210	2017-06-01	38.292500	38.994999	35.549999	36.005001	33.981060
## 211	2017-07-01	36.220001	38.497501	35.602501	37.182499	35.092373
## 212	2017-08-01	37.275002	41.130001	37.102501	41.000000	38.695293
## 213	2017-09-01	41.200001	41.235001	37.290001	38.529999	36.506927
## 214	2017-10-01	38.564999	42.412498	38.115002	42.259998	40.041077
## 215	2017-11-01	42.467499	44.060001	41.320000	42.962502	40.706692
## 216	2017-12-01	42.487499	44.299999	41.615002	42.307499	40.230194
## 217	2018-01-01	42.540001	45.025002	41.174999	41.857498	39.802280
## 218	2018-02-01	41.792500	45.154999	37.560001	44.529999	42.343575
## 219	2018-03-01	44.634998	45.875000	41.235001	41.945000	40.048103
## 220	2018-04-01	41.660000	44.735001	40.157501	41.314999	39.446594
## 221	2018-05-01	41.602501	47.592499	41.317501	46.717499	44.604774
## 222	2018-06-01	46.997501	48.549999	45.182499	46.277500	44.355061
## 223	2018-07-01	45.955002	48.990002	45.855000	47.572498	45.596252
## 224	2018-08-01	49.782501	57.217499	49.327499	56.907501	54.543476
## 225	2018-09-01	57.102501	57.417500	53.825001	56.435001	54.280304
## 226	2018-10-01	56.987499	58.367500	51.522499	54.715000	52.625969
## 227	2018-11-01	54.762501	55.590000	42.564999	44.645000	42.940449
## 228	2018-12-01	46.115002	46.235001	36.647499	39.435001	38.061703
## 229	2019-01-01	38.722500	42.250000	35.500000	41.610001	40.160961
## 230	2019-02-01	41.740002	43.967499	41.482498	43.287498	41.780041
## 231	2019-03-01	43.570000	49.422501	42.375000	47.487499	46.030361
## 232	2019-04-01	47.910000	52.119999	47.095001	50.167500	48.628120
## 233	2019-05-01	52.470001	53.827499	43.747501	43.767502	42.424500
## 234	2019-06-01	43.900002	50.392502	42.567501	49.480000	48.146412
## 235	2019-07-01	50.792500	55.342499	49.602501	53.259998	51.824539
## 236	2019-08-01	53.474998	54.507500	48.145000	52.185001	50.778515
## 237	2019-09-01	51.607498	56.605000	51.055000	55.992500	54.690395
## 238	2019-10-01	56.267502	62.437500	53.782501	62.189999	60.743778
## 239	2019-11-01	62.384998	67.000000	62.290001	66.812500	65.258781
## 240	2019-12-01	66.817497	73.492500	64.072502	73.412498	71.920563
## 241	2020-01-01	74.059998	81.962502	73.187500	77.377502	75.805000
## 242	2020-02-01	76.074997	81.805000	64.092499	68.339996	66.951157

##	243	2020-03-01	70.570000	76.000000	53.152500	63.572498	62.428360
##	244	2020-04-01	61.625000	73.632500	59.224998	73.449997	72.128098
##	245	2020-05-01	71.562500	81.059998	71.462502	79.485001	78.054474
##	246	2020-06-01	79.437500	93.095001	79.302498	91.199997	89.801064
##	247	2020-07-01	91.279999	106.415001	89.144997	106.260002	104.630066
##	248	2020-08-01	108.199997	131.000000	107.892502	129.039993	127.060631
##	249	2020-09-01	132.759995	137.979996	103.099998	115.809998	114.239166
##	250	2020-10-01	117.639999	125.389999	107.720001	108.860001	107.383438
##	251	2020-11-01	109.110001	121.989998	107.320000	119.050003	117.435234
##	252	2020-12-01	121.010002	138.789993	120.010002	132.690002	131.116043
##	253	2021-01-01	133.520004	145.089996	126.379997	131.960007	130.394684
##	254	2021-02-01	133.750000	137.880005	118.389999	121.260002	119.821609
##	255	2021-03-01	123.750000	128.720001	116.209999	122.150002	120.881416
##	256	2021-04-01	123.660004	137.070007	122.489998	131.460007	130.094742
##	257	2021-05-01	132.039993	134.070007	122.250000	124.610001	123.315872
##	258	2021-06-01	125.080002	137.410004	123.129997	136.960007	135.767853
##	259	2021-07-01	136.600006	150.000000	135.759995	145.860001	144.590378
##	260	2021-08-01	146.360001	153.490005	144.500000	151.830002	150.508423
##	261	2021-09-01	152.830002	157.259995	141.270004	141.500000	140.478500
##	262	2021-10-01	141.899994	153.169998	138.270004	149.800003	148.718536
##	263	2021-11-01	148.990005	165.699997	147.479996	165.300003	164.106674
##	264	2021-12-01	167.479996	182.130005	157.800003	177.570007	176.545380

## Volume class

##	1	12555177600	TRAIN
##	2	7319782400	TRAIN
##	3	8698356800	TRAIN
##	4	8662404800	TRAIN
##	5	9807750400	TRAIN
##	6	8105204800	TRAIN
##	7	5746770400	TRAIN
##	8	5636086400	TRAIN
##	9	14516930400	TRAIN
##	10	21905788800	TRAIN
##	11	8488373600	TRAIN
##	12	8858970400	TRAIN
##	13	13709460800	TRAIN
##	14	7023766400	TRAIN
##	15	10799062400	TRAIN
##	16	11158991200	TRAIN
##	17	7468434400	TRAIN
##	18	7638265600	TRAIN
##	19	8655102400	TRAIN
##	20	5129359200	TRAIN
##	21	5531523200	TRAIN
##	22	7544247200	TRAIN
##	23	5369744800	TRAIN
##	24	4629839200	TRAIN
##	25	8515376800	TRAIN
##	26	7837424000	TRAIN
##	27	5318583200	TRAIN
##	28	6422836000	TRAIN
##	29	5976157600	TRAIN
##	30	8708016800	TRAIN
##	31	8118415200	TRAIN
##	32	5151686400	TRAIN

##	33	5291837600	TRAIN
##	34	6611432800	TRAIN
##	35	4531721600	TRAIN
##	36	4530439200	TRAIN
##	37	6045832800	TRAIN
##	38	4114303200	TRAIN
##	39	4028404800	TRAIN
##	40	7775342400	TRAIN
##	41	10811544800	TRAIN
##	42	6113335200	TRAIN
##	43	5218270400	TRAIN
##	44	4307564800	TRAIN
##	45	5347484800	TRAIN
##	46	7040191200	TRAIN
##	47	4974104800	TRAIN
##	48	5453873600	TRAIN
##	49	7927802400	TRAIN
##	50	4922030400	TRAIN
##	51	11626115200	TRAIN
##	52	8930174400	TRAIN
##	53	5304275200	TRAIN
##	54	8227234400	TRAIN
##	55	9696579200	TRAIN
##	56	8011365600	TRAIN
##	57	7673506400	TRAIN
##	58	16094366400	TRAIN
##	59	17439604000	TRAIN
##	60	15948615200	TRAIN
##	61	25708244800	TRAIN
##	62	21448946400	TRAIN
##	63	14675920000	TRAIN
##	64	19375518400	TRAIN
##	65	12858294400	TRAIN
##	66	11327195600	TRAIN
##	67	10094246400	TRAIN
##	68	9400806800	TRAIN
##	69	12347770400	TRAIN
##	70	18643447200	TRAIN
##	71	13456427600	TRAIN
##	72	13064164400	TRAIN
##	73	21878371200	TRAIN
##	74	18760697200	TRAIN
##	75	23192632400	TRAIN
##	76	20119282400	TRAIN
##	77	15608779200	TRAIN
##	78	17936623600	TRAIN
##	79	17479742000	TRAIN
##	80	17887646000	TRAIN
##	81	17721558400	TRAIN
##	82	14387956800	TRAIN
##	83	13834884000	TRAIN
##	84	16890792800	TRAIN
##	85	27209781200	TRAIN
##	86	13722354800	TRAIN
##	87	15918644000	TRAIN



##	88	13459740000	TRAIN
##	89	17365068000	TRAIN
##	90	23279541600	TRAIN
##	91	24018573600	TRAIN
##	92	24360798000	TRAIN
##	93	20931223600	TRAIN
##	94	23277791600	TRAIN
##	95	26199790400	TRAIN
##	96	17252678800	TRAIN
##	97	35173888400	TRAIN
##	98	24865954400	TRAIN
##	99	22927273600	TRAIN
##	100	22786982400	TRAIN
##	101	18588214400	TRAIN
##	102	19475794800	TRAIN
##	103	19749760800	TRAIN
##	104	13085755200	TRAIN
##	105	24067562400	TRAIN
##	106	41426711200	TRAIN
##	107	23619461600	TRAIN
##	108	20213846800	TRAIN
##	109	18105740800	TRAIN
##	110	13867450800	TRAIN
##	111	15424598000	TRAIN
##	112	11821681200	TRAIN
##	113	9457142800	TRAIN
##	114	12675572000	TRAIN
##	115	10942136800	TRAIN
##	116	8165124800	TRAIN
##	117	9989319200	TRAIN
##	118	12956176800	TRAIN
##	119	8454784800	TRAIN
##	120	11393958800	TRAIN
##	121	15168994400	TRAIN
##	122	10776080000	TRAIN
##	123	12154172800	TRAIN
##	124	12367129600	TRAIN
##	125	18082654800	TRAIN
##	126	16651252800	TRAIN
##	127	15669704400	TRAIN
##	128	9589120800	TRAIN
##	129	11849919200	TRAIN
##	130	12234577600	TRAIN
##	131	9508086000	TRAIN
##	132	6973234800	TRAIN
##	133	10841535600	TRAIN
##	134	9295949600	TRAIN
##	135	11306458800	TRAIN
##	136	9253829200	TRAIN
##	137	6912060400	TRAIN
##	138	9263850400	TRAIN
##	139	10653946800	TRAIN
##	140	16142599200	TRAIN
##	141	11977448000	TRAIN
##	142	13141427600	TRAIN

##	143	8963701600	TRAIN
##	144	6306532400	TRAIN
##	145	6859854400	TRAIN
##	146	11368554400	TRAIN
##	147	15584338000	TRAIN
##	148	15598990400	TRAIN
##	149	11106345600	TRAIN
##	150	7855825600	TRAIN
##	151	8909650400	TRAIN
##	152	8276206400	TRAIN
##	153	9199005200	TRAIN
##	154	12142830000	TRAIN
##	155	12929851200	TRAIN
##	156	12132752800	TRAIN
##	157	13123423600	TRAIN
##	158	9344034000	TRAIN
##	159	9176876800	TRAIN
##	160	10963489600	TRAIN
##	161	9447530400	TRAIN
##	162	7018536000	TRAIN
##	163	6538114800	TRAIN
##	164	8058338400	TRAIN
##	165	8630941200	TRAIN
##	166	7837732000	TRAIN
##	167	5225155600	TRAIN
##	168	7057397200	TRAIN
##	169	8765954400	TRAIN
##	170	5880366800	TRAIN
##	171	5001698800	TRAIN
##	172	6435060800	TRAIN
##	173	5735668400	TRAIN
##	174	4827739200	TRAIN
##	175	4140344000	TRAIN
##	176	3748308000	TRAIN
##	177	6105680000	TRAIN
##	178	5441120800	TRAIN
##	179	3281632800	TRAIN
##	180	4294378400	TRAIN
##	181	5221053600	TRAIN
##	182	4546140800	TRAIN
##	183	4554568400	TRAIN
##	184	3984542000	TRAIN
##	185	3816608400	TRAIN
##	186	3514426800	TRAIN
##	187	4233122400	TRAIN
##	188	6427276400	TRAIN
##	189	4826189200	TRAIN
##	190	4450048400	TRAIN
##	191	3002562400	TRAIN
##	192	3687660800	TRAIN
##	193	5087392000	TRAIN
##	194	3243450400	TRAIN
##	195	2984198400	TRAIN
##	196	3489534800	TRAIN
##	197	3602686000	TRAIN

##	198	3117990800	TRAIN
##	199	2743118400	TRAIN
##	200	2520514000	TRAIN
##	201	3872062400	TRAIN
##	202	2747657200	TRAIN
##	203	2886220000	TRAIN
##	204	2435086800	TRAIN
##	205	2252488000	TRAIN
##	206	2299874400	TRAIN
##	207	2246513600	TRAIN
##	208	1493216400	TRAIN
##	209	2615927200	TRAIN
##	210	2736712400	TRAIN
##	211	1688047600	TRAIN
##	212	2644276000	TEST
##	213	2721496400	TEST
##	214	2017165200	TEST
##	215	2402653600	TEST
##	216	2124735200	TEST
##	217	2638717600	TEST
##	218	3711577200	TEST
##	219	2854910800	TEST
##	220	2664617200	TEST
##	221	2483905200	TEST
##	222	2110498000	TEST
##	223	1574765600	TEST
##	224	2801275600	TEST
##	225	2715888000	TEST
##	226	3158994000	TEST
##	227	3845305600	TEST
##	228	3595690000	TEST
##	229	3312349600	TEST
##	230	1890162400	TEST
##	231	2603925600	TEST
##	232	2024470800	TEST
##	233	2957826400	TEST
##	234	2060874800	TEST
##	235	1895406800	TEST
##	236	2724326400	TEST
##	237	2170268400	TEST
##	238	2433210800	TEST
##	239	1793326000	TEST
##	240	2388794800	TEST
##	241	2934370400	TEST
##	242	3019279200	TEST
##	243	6280072400	TEST
##	244	3265299200	TEST
##	245	2805936000	TEST
##	246	3243375600	TEST
##	247	3020283200	TEST
##	248	4070061100	TEST
##	249	3885245100	TEST
##	250	2894666500	TEST
##	251	2123077300	TEST
##	252	2322189600	TEST

```
## 253 2240262000 TEST
## 254 1833855600 TEST
## 255 2650418200 TEST
## 256 1889857500 TEST
## 257 1711934900 TEST
## 258 1606590000 TEST
## 259 1919035100 TEST
## 260 1461542800 TEST
## 261 1797835100 TEST
## 262 1565079200 TEST
## 263 1691029000 TEST
## 264 2444766700 TEST
```

```
train_data = subset(AAPL, class == 'TRAIN')
```

```
test_data = subset(AAPL, class == 'TEST')
```

```
nrow(train_data); nrow(test_data)
```

```
## [1] 211
```

```
## [1] 53
```

```
dat_ts <- ts(train_data[,5], start = c(2000,1), end = c(2017,07), frequency = 12)
dat_ts
```

```
##           Jan           Feb           Mar           Apr           May           Jun           Jul
## 2000  0.926339  1.023438  1.212612  1.107701  0.750000  0.935268  0.907366
## 2001  0.386161  0.325893  0.394107  0.455179  0.356250  0.415179  0.335536
## 2002  0.441429  0.387500  0.422679  0.433393  0.416071  0.316429  0.272500
## 2003  0.256429  0.268036  0.252500  0.253929  0.320536  0.340357  0.376429
## 2004  0.402857  0.427143  0.482857  0.460357  0.501071  0.581071  0.577500
## 2005  1.373214  1.602143  1.488214  1.287857  1.420000  1.314643  1.523214
## 2006  2.696786  2.446071  2.240000  2.513929  2.134643  2.045357  2.427143
## 2007  3.061786  3.021786  3.318214  3.564286  4.328214  4.358571  4.705714
## 2008  4.834286  4.465000  5.125000  6.212500  6.741071  5.980000  5.676786
## 2009  3.218929  3.189643  3.754286  4.493929  4.850357  5.086786  5.835357
## 2010  6.859286  7.307857  8.392857  9.324643  9.174286  8.983214  9.187500
## 2011 12.118571 12.614643 12.446786 12.504643 12.422500 11.988214 13.945714
## 2012 16.302856 19.372856 21.412500 20.856428 20.633215 20.857143 21.812857
## 2013 16.267500 15.764286 15.809286 15.813571 16.061787 14.161786 16.161785
## 2014 17.878571 18.794287 19.169287 21.074642 22.607143 23.232500 23.900000
## 2015 29.290001 32.115002 31.107500 31.287500 32.570000 31.357500 30.325001
## 2016 24.334999 24.172501 27.247499 23.434999 24.965000 23.900000 26.052500
## 2017 30.337500 34.247501 35.915001 35.912498 38.189999 36.005001 37.182499
##           Aug           Sep           Oct           Nov           Dec
## 2000  1.088170  0.459821  0.349330  0.294643  0.265625
## 2001  0.331250  0.276964  0.313571  0.380357  0.391071
## 2002  0.263393  0.258929  0.286964  0.276786  0.255893
## 2003  0.403750  0.370000  0.408750  0.373393  0.381607
## 2004  0.615893  0.691964  0.935714  1.197321  1.150000
## 2005  1.674643  1.914643  2.056786  2.422143  2.567500
## 2006  2.423214  2.749286  2.895714  3.273571  3.030000
## 2007  4.945714  5.481071  6.783929  6.507857  7.074286
## 2008  6.054643  4.059286  3.842500  3.309643  3.048214
## 2009  6.007500  6.619643  6.732143  7.139643  7.526071
```

```
## 2010 8.682143 10.133929 10.749286 11.112500 11.520000
## 2011 13.743929 13.618571 14.456429 13.650000 14.464286
## 2012 23.758572 23.825001 21.261429 20.902857 19.006071
## 2013 17.400715 17.026787 18.667856 19.859644 20.036428
## 2014 25.625000 25.187500 27.000000 29.732500 27.594999
## 2015 28.190001 27.575001 29.875000 29.575001 26.315001
## 2016 26.525000 28.262501 28.385000 27.629999 28.955000
## 2017
```

```
mae <- function(actual,pred){
  mae <- mean(abs(actual - pred))
  return (mae)
}
```

```
RMSE <- function(actual,pred){
  RMSE <- sqrt(mean((actual - pred)^2))
  return (RMSE)
}
```

### Naive Forecasting Method

```
nav = naive(dat_ts, h = 53)
```

```
summary(nav)
```

```
##
## Forecast method: Naive method
##
## Model Information:
## Call: naive(y = dat_ts, h = 53)
##
## Residual sd: 1.0402
##
## Error measures:
##           ME      RMSE      MAE      MPE      MAPE      MASE
## Training set 0.1726484 1.040216 0.6426393 0.8545403 9.384122 0.2033476
##           ACF1
## Training set 0.05096841
##
## Forecasts:
##           Point Forecast      Lo 80      Hi 80      Lo 95      Hi 95
## Aug 2017           37.1825 35.84941 38.51559 35.14371 39.22128
## Sep 2017           37.1825 35.29723 39.06777 34.29922 40.06578
## Oct 2017           37.1825 34.87352 39.49148 33.65122 40.71378
## Nov 2017           37.1825 34.51632 39.84868 33.10493 41.26007
## Dec 2017           37.1825 34.20162 40.16338 32.62364 41.74136
## Jan 2018           37.1825 33.91711 40.44789 32.18852 42.17648
## Feb 2018           37.1825 33.65547 40.70952 31.78838 42.57662
## Mar 2018           37.1825 33.41195 40.95305 31.41594 42.94905
## Apr 2018           37.1825 33.18323 41.18177 31.06614 43.29885
## May 2018           37.1825 32.96690 41.39810 30.73529 43.62970
## Jun 2018           37.1825 32.76114 41.60386 30.42061 43.94438
```

## Jul 2018	37.1825	32.56454	41.80046	30.11994	44.24506
## Aug 2018	37.1825	32.37597	41.98902	29.83155	44.53344
## Sep 2018	37.1825	32.19453	42.17046	29.55406	44.81093
## Oct 2018	37.1825	32.01946	42.34553	29.28632	45.07868
## Nov 2018	37.1825	31.85014	42.51486	29.02736	45.33764
## Dec 2018	37.1825	31.68603	42.67897	28.77637	45.58863
## Jan 2019	37.1825	31.52668	42.83832	28.53267	45.83233
## Feb 2019	37.1825	31.37169	42.99330	28.29564	46.06936
## Mar 2019	37.1825	31.22074	43.14426	28.06477	46.30022
## Apr 2019	37.1825	31.07351	43.29148	27.83961	46.52539
## May 2019	37.1825	30.92975	43.43524	27.61975	46.74525
## Jun 2019	37.1825	30.78922	43.57577	27.40483	46.96017
## Jul 2019	37.1825	30.65172	43.71328	27.19453	47.17047
## Aug 2019	37.1825	30.51705	43.84795	26.98857	47.37642
## Sep 2019	37.1825	30.38505	43.97995	26.78669	47.57830
## Oct 2019	37.1825	30.25556	44.10944	26.58866	47.77634
## Nov 2019	37.1825	30.12845	44.23655	26.39426	47.97074
## Dec 2019	37.1825	30.00359	44.36141	26.20331	48.16169
## Jan 2020	37.1825	29.88086	44.48413	26.01561	48.34938
## Feb 2020	37.1825	29.76017	44.60483	25.83102	48.53397
## Mar 2020	37.1825	29.64140	44.72359	25.64939	48.71561
## Apr 2020	37.1825	29.52448	44.84052	25.47057	48.89443
## May 2020	37.1825	29.40932	44.95568	25.29444	49.07056
## Jun 2020	37.1825	29.29583	45.06917	25.12088	49.24411
## Jul 2020	37.1825	29.18396	45.18104	24.94979	49.41521
## Aug 2020	37.1825	29.07363	45.29137	24.78105	49.58394
## Sep 2020	37.1825	28.96478	45.40022	24.61458	49.75041
## Oct 2020	37.1825	28.85736	45.50764	24.45029	49.91471
## Nov 2020	37.1825	28.75130	45.61370	24.28809	50.07691
## Dec 2020	37.1825	28.64656	45.71844	24.12790	50.23709
## Jan 2021	37.1825	28.54309	45.82191	23.96966	50.39534
## Feb 2021	37.1825	28.44084	45.92415	23.81329	50.55171
## Mar 2021	37.1825	28.33978	46.02522	23.65873	50.70627
## Apr 2021	37.1825	28.23986	46.12514	23.50591	50.85909
## May 2021	37.1825	28.14104	46.22395	23.35479	51.01021
## Jun 2021	37.1825	28.04329	46.32170	23.20529	51.15971
## Jul 2021	37.1825	27.94658	46.41842	23.05738	51.30762
## Aug 2021	37.1825	27.85087	46.51413	22.91100	51.45399
## Sep 2021	37.1825	27.75613	46.60887	22.76611	51.59889
## Oct 2021	37.1825	27.66233	46.70267	22.62266	51.74234
## Nov 2021	37.1825	27.56945	46.79555	22.48061	51.88439
## Dec 2021	37.1825	27.47746	46.88754	22.33992	52.02508

####

```
df_nav = as.data.frame(nav)
```

```
mae(test_data$Close, df_nav$`Point Forecast`)
```

```
## [1] 43.46769
```

```
RMSE(test_data$Close, df_nav$`Point Forecast`)
```

```
## [1] 59.85306
```

## Simple Exponential Smoothing

```
se_model <- ses(dat_ts, h = 53)
```

```
summary(se_model)
```

```
##
## Forecast method: Simple exponential smoothing
##
## Model Information:
## Simple exponential smoothing
##
## Call:
## ses(y = dat_ts, h = 53)
##
## Smoothing parameters:
##   alpha = 0.9999
##
## Initial states:
##   l = 0.5385
##
##   sigma: 1.0431
##
##      AIC      AICc      BIC
## 1151.021 1151.137 1161.077
##
## Error measures:
##               ME      RMSE      MAE      MPE      MAPE      MASE      ACF1
## Training set 0.1736849 1.038099 0.6414408 1.04898 9.538236 0.2029684 0.05099227
##
## Forecasts:
##      Point Forecast      Lo 80      Hi 80      Lo 95      Hi 95
## Aug 2017      37.18238 35.84565 38.51911 35.13803 39.22673
## Sep 2017      37.18238 35.29206 39.07270 34.29138 40.07338
## Oct 2017      37.18238 34.86726 39.49751 33.64170 40.72306
## Nov 2017      37.18238 34.50913 39.85564 33.09399 41.27077
## Dec 2017      37.18238 34.19361 40.17116 32.61145 41.75332
## Jan 2018      37.18238 33.90835 40.45641 32.17519 42.18957
## Feb 2018      37.18238 33.64604 40.71873 31.77401 42.59075
## Mar 2018      37.18238 33.40188 40.96289 31.40060 42.96416
## Apr 2018      37.18238 33.17256 41.19221 31.04988 43.31488
## May 2018      37.18238 32.95566 41.40910 30.71817 43.64660
## Jun 2018      37.18238 32.74936 41.61540 30.40266 43.96210
## Jul 2018      37.18238 32.55225 41.81252 30.10120 44.26356
## Aug 2018      37.18238 32.36319 42.00157 29.81206 44.55270
## Sep 2018      37.18238 32.18127 42.18349 29.53384 44.83092
## Oct 2018      37.18238 32.00574 42.35902 29.26539 45.09937
## Nov 2018      37.18238 31.83597 42.52879 29.00576 45.35901
## Dec 2018      37.18238 31.67143 42.69333 28.75411 45.61065
## Jan 2019      37.18238 31.51166 42.85310 28.50977 45.85500
## Feb 2019      37.18238 31.35627 43.00849 28.27212 46.09264
## Mar 2019      37.18238 31.20492 43.15984 28.04065 46.32411
## Apr 2019      37.18238 31.05731 43.30745 27.81489 46.54987
## May 2019      37.18238 30.91317 43.45159 27.59445 46.77031
## Jun 2019      37.18238 30.77228 43.59249 27.37897 46.98579
## Jul 2019      37.18238 30.63441 43.73035 27.16812 47.19664
```

```
## Aug 2019      37.18238 30.49939 43.86538 26.96162 47.40314
## Sep 2019      37.18238 30.36704 43.99772 26.75921 47.60555
## Oct 2019      37.18238 30.23721 44.12755 26.56066 47.80410
## Nov 2019      37.18238 30.10977 44.25499 26.36575 47.99901
## Dec 2019      37.18238 29.98458 44.38018 26.17429 48.19047
## Jan 2020      37.18238 29.86153 44.50323 25.98611 48.37865
## Feb 2020      37.18238 29.74052 44.62424 25.80103 48.56373
## Mar 2020      37.18238 29.62144 44.74332 25.61892 48.74584
## Apr 2020      37.18238 29.50421 44.86055 25.43963 48.92513
## May 2020      37.18238 29.38874 44.97602 25.26304 49.10172
## Jun 2020      37.18238 29.27496 45.08980 25.08903 49.27573
## Jul 2020      37.18238 29.16280 45.20197 24.91749 49.44728
## Aug 2020      37.18238 29.05218 45.31258 24.74831 49.61645
## Sep 2020      37.18238 28.94304 45.42172 24.58140 49.78336
## Oct 2020      37.18238 28.83533 45.52943 24.41668 49.94809
## Nov 2020      37.18238 28.72900 45.63576 24.25405 50.11071
## Dec 2020      37.18238 28.62398 45.74078 24.09344 50.27132
## Jan 2021      37.18238 28.52024 45.84452 23.93479 50.42998
## Feb 2021      37.18238 28.41773 45.94703 23.77800 50.58676
## Mar 2021      37.18238 28.31640 46.04836 23.62304 50.74173
## Apr 2021      37.18238 28.21622 46.14854 23.46982 50.89494
## May 2021      37.18238 28.11714 46.24762 23.31829 51.04647
## Jun 2021      37.18238 28.01914 46.34562 23.16841 51.19635
## Jul 2021      37.18238 27.92217 46.44259 23.02011 51.34465
## Aug 2021      37.18238 27.82621 46.53856 22.87335 51.49142
## Sep 2021      37.18238 27.73122 46.63354 22.72807 51.63669
## Oct 2021      37.18238 27.63717 46.72759 22.58425 51.78051
## Nov 2021      37.18238 27.54405 46.82071 22.44182 51.92294
## Dec 2021      37.18238 27.45181 46.91295 22.30076 52.06400
```

###

```
df_s = as.data.frame(se_model)
```

```
mae(test_data$Close, df_s$`Point Forecast`)
```

```
## [1] 43.46781
```

```
RMSE(test_data$Close, df_s$`Point Forecast`)
```

```
## [1] 59.85314
```

## Holt's Trend Method

```
holt_model <- holt(dat_ts, h = 53)
```

```
summary(holt_model)
```

```
##
```

```
## Forecast method: Holt's method
```

```
##
```

```
## Model Information:
```

```
## Holt's method
```

```
##
```

```
## Call:
```

```
## holt(y = dat_ts, h = 53)
```

```
##
```



```

## Smoothing parameters:
##   alpha = 0.9998
##   beta  = 1e-04
##
## Initial states:
##   l = 0.6421
##   b = 0.1725
##
## sigma: 1.0333
##
##      AIC      AICc      BIC
## 1149.021 1149.314 1165.780
##
## Error measures:
##                ME      RMSE      MAE      MPE      MAPE      MASE
## Training set 0.001571517 1.023444 0.6473782 -13.16705 17.83205 0.2048471
##                ACF1
## Training set 0.05112363
##
## Forecasts:
##      Point Forecast      Lo 80      Hi 80      Lo 95      Hi 95
## Aug 2017      37.35480 36.03059 38.67901 35.32960 39.38000
## Sep 2017      37.52728 35.65465 39.39991 34.66334 40.39123
## Oct 2017      37.69977 35.40623 39.99331 34.19210 41.20743
## Nov 2017      37.87225 35.22381 40.52070 33.82181 41.92270
## Dec 2017      38.04474 35.08357 41.00591 33.51602 42.57346
## Jan 2018      38.21723 34.97328 41.46117 33.25605 43.17840
## Feb 2018      38.38971 34.88569 41.89373 33.03078 43.74864
## Mar 2018      38.56220 34.81607 42.30832 32.83299 44.29140
## Apr 2018      38.73468 34.76113 42.70824 32.65765 44.81171
## May 2018      38.90717 34.71847 43.09586 32.50111 45.31322
## Jun 2018      39.07965 34.68630 43.47301 32.36060 45.79871
## Jul 2018      39.25214 34.66321 43.84107 32.23398 46.27030
## Aug 2018      39.42462 34.64808 44.20117 32.11953 46.72972
## Sep 2018      39.59711 34.64001 44.55421 32.01589 47.17833
## Oct 2018      39.76960 34.63826 44.90093 31.92190 47.61729
## Nov 2018      39.94208 34.64220 45.24196 31.83662 48.04755
## Dec 2018      40.11457 34.65131 45.57783 31.75923 48.46990
## Jan 2019      40.28705 34.66513 45.90898 31.68906 48.88505
## Feb 2019      40.45954 34.68327 46.23580 31.62550 49.29357
## Mar 2019      40.63202 34.70541 46.55864 31.56805 49.69600
## Apr 2019      40.80451 34.73123 46.87778 31.51624 50.09278
## May 2019      40.97699 34.76049 47.19350 31.46967 50.48432
## Jun 2019      41.14948 34.79295 47.50601 31.42800 50.87096
## Jul 2019      41.32197 34.82839 47.81554 31.39091 51.25303
## Aug 2019      41.49445 34.86665 48.12225 31.35810 51.63080
## Sep 2019      41.66694 34.90754 48.42633 31.32934 52.00454
## Oct 2019      41.83942 34.95092 48.72792 31.30437 52.37447
## Nov 2019      42.01191 34.99666 49.02716 31.28301 52.74081
## Dec 2019      42.18439 35.04461 49.32417 31.26504 53.10375
## Jan 2020      42.35688 35.09468 49.61908 31.25030 53.46345
## Feb 2020      42.52937 35.14675 49.91198 31.23864 53.82009
## Mar 2020      42.70185 35.20074 50.20296 31.22989 54.17381
## Apr 2020      42.87434 35.25654 50.49213 31.22392 54.52475
## May 2020      43.04682 35.31408 50.77956 31.22062 54.87303

```

```
## Jun 2020      43.21931 35.37328 51.06533 31.21985 55.21877
## Jul 2020      43.39179 35.43408 51.34951 31.22152 55.56207
## Aug 2020      43.56428 35.49639 51.63216 31.22551 55.90304
## Sep 2020      43.73676 35.56017 51.91336 31.23175 56.24178
## Oct 2020      43.90925 35.62536 52.19314 31.24013 56.57837
## Nov 2020      44.08174 35.69189 52.47158 31.25058 56.91289
## Dec 2020      44.25422 35.75973 52.74871 31.26302 57.24542
## Jan 2021      44.42671 35.82882 53.02459 31.27737 57.57604
## Feb 2021      44.59919 35.89912 53.29927 31.29358 57.90481
## Mar 2021      44.77168 35.97058 53.57277 31.31156 58.23179
## Apr 2021      44.94416 36.04317 53.84515 31.33127 58.55705
## May 2021      45.11665 36.11685 54.11644 31.35265 58.88065
## Jun 2021      45.28913 36.19159 54.38668 31.37564 59.20263
## Jul 2021      45.46162 36.26734 54.65590 31.40019 59.52305
## Aug 2021      45.63411 36.34409 54.92413 31.42625 59.84197
## Sep 2021      45.80659 36.42179 55.19140 31.45377 60.15941
## Oct 2021      45.97908 36.50042 55.45774 31.48271 60.47544
## Nov 2021      46.15156 36.57995 55.72318 31.51304 60.79009
## Dec 2021      46.32405 36.66035 55.98774 31.54470 61.10339
```

```
####
```

```
df_h = as.data.frame(holt_model)
```

```
mae(test_data$Close, df_h$`Point Forecast`)
```

```
## [1] 38.83641
```

```
RMSE(test_data$Close, df_h$`Point Forecast`)
```

```
## [1] 54.82537
```

## ARIMA

```
arima_model_AIC <- auto.arima(dat_ts, stationary = FALSE, seasonal = FALSE, ic = "aic",
stepwise = TRUE, trace = TRUE)
```

```
##
```

```
## Fitting models using approximations to speed things up...
```

```
##
```

```
## ARIMA(2,1,2)           with drift           : 609.9307
## ARIMA(0,1,0)           with drift           : 610.569
## ARIMA(1,1,0)           with drift           : 613.0171
## ARIMA(0,1,1)           with drift           : 612.0578
## ARIMA(0,1,0)           : 614.4351
## ARIMA(1,1,2)           with drift           : 615.3623
## ARIMA(2,1,1)           with drift           : 616.4622
## ARIMA(3,1,2)           with drift           : 612.8939
## ARIMA(2,1,3)           with drift           : 611.3846
## ARIMA(1,1,1)           with drift           : 613.5694
## ARIMA(1,1,3)           with drift           : 616.341
## ARIMA(3,1,1)           with drift           : 618.7093
## ARIMA(3,1,3)           with drift           : 614.0363
## ARIMA(2,1,2)           : Inf
```

```
##
```

```
## Now re-fitting the best model(s) without approximations...
```

```
##
```

```
## ARIMA(2,1,2)           with drift           : 608.0525
```

```
##
## Best model: ARIMA(2,1,2)          with drift
summary(arima_model_AIC)

## Series: dat_ts
## ARIMA(2,1,2) with drift
##
## Coefficients:
##          ar1      ar2      ma1      ma2      drift
##          1.6729 -0.8454 -1.7053  0.9250  0.1706
## s.e.    0.0839  0.0830  0.0601  0.0563  0.0876
##
## sigma^2 = 1.022: log likelihood = -298.03
## AIC=608.05  AICc=608.47  BIC=628.14
##
## Training set error measures:
##              ME      RMSE      MAE      MPE      MAPE      MASE
## Training set -0.0001339843 0.9963789 0.6287314 -10.30182 15.29538 0.1989468
##              ACF1
## Training set 0.0354659

###
fore_arima = forecast::forecast(arima_model_AIC, h=53)
```

```
df_arima = as.data.frame(fore_arima)
df_arima
```

##	Point Forecast	Lo 80	Hi 80	Lo 95	Hi 95
## Aug 2017	37.61879	36.32333	38.91425	35.63755	39.60003
## Sep 2017	37.88248	36.07984	39.68512	35.12558	40.63938
## Oct 2017	37.98419	35.76959	40.19879	34.59726	41.37113
## Nov 2017	37.96084	35.35305	40.56863	33.97257	41.94911
## Dec 2017	37.86521	34.85647	40.87396	33.26374	42.46669
## Jan 2018	37.75439	34.33202	41.17676	32.52033	42.98845
## Feb 2018	37.67926	33.83796	41.52057	31.80449	43.55403
## Mar 2018	37.67669	33.42429	41.92909	31.17321	44.18017
## Apr 2018	37.76532	33.12337	42.40727	30.66607	44.86457
## May 2018	37.94519	32.94576	42.94462	30.29923	45.59116
## Jun 2018	38.20060	32.88131	43.51989	30.06544	46.33576
## Jul 2018	38.50523	32.90409	44.10638	29.93903	47.07144
## Aug 2018	38.82837	32.97964	44.67710	29.88351	47.77322
## Sep 2018	39.14082	33.07239	45.20926	29.85995	48.42170
## Oct 2018	39.41979	33.15200	45.68757	29.83404	49.00554
## Nov 2018	39.65174	33.19752	46.10596	29.78086	49.52262
## Dec 2018	39.83336	33.19905	46.46768	29.68705	49.97968
## Jan 2019	39.97054	33.15731	46.78376	29.55061	50.39046
## Feb 2019	40.07589	33.08153	47.07024	29.37895	50.77283
## Mar 2019	40.16559	32.98631	47.34487	29.18582	51.14536
## Apr 2019	40.25601	32.88820	47.62383	28.98791	51.52411
## May 2019	40.36087	32.80252	47.91921	28.80138	51.92036
## Jun 2019	40.48926	32.74083	48.23769	28.63906	52.33947
## Jul 2019	40.64483	32.70941	48.58026	28.50865	52.78102
## Aug 2019	40.82597	32.70893	48.94301	28.41202	53.23992
## Sep 2019	41.02690	32.73512	49.31868	28.34571	53.70809
## Oct 2019	41.23933	32.78028	49.69837	28.30233	54.17632

```
## Nov 2019      41.45426 32.83515 50.07336 28.27248 54.63604
## Dec 2019      41.66366 32.89077 50.43654 28.24669 55.08062
## Jan 2020      41.86168 32.93998 50.78339 28.21711 55.50626
## Feb 2020      42.04536 32.97834 51.11239 28.17854 55.91218
## Mar 2020      42.21465 33.00448 51.42482 28.12891 56.30039
## Apr 2020      42.37200 33.01980 51.72420 28.06904 56.67495
## May 2020      42.52153 33.02775 52.01532 28.00204 57.04102
## Jun 2020      42.66809 33.03291 52.30328 27.93235 57.40383
## Jul 2020      42.81628 33.04000 52.59256 27.86474 57.76781
## Aug 2020      42.96971 33.05301 52.88640 27.80342 58.13599
## Sep 2020      43.13052 33.07463 53.18641 27.75136 58.50968
## Oct 2020      43.29927 33.10595 53.49258 27.70993 58.88860
## Nov 2020      43.47503 33.14651 53.80355 27.67893 59.27114
## Dec 2020      43.65584 33.19463 54.11706 27.65679 59.65489
## Jan 2021      43.83915 33.24782 54.43047 27.64111 60.03718
## Feb 2021      44.02237 33.30342 54.74133 27.62915 60.41560
## Mar 2021      44.20335 33.35899 55.04770 27.61834 60.78836
## Apr 2021      44.38063 33.41277 55.34849 27.60673 61.15452
## May 2021      44.55363 33.46380 55.64346 27.59320 61.51406
## Jun 2021      44.72259 33.51201 55.93318 27.57748 61.86770
## Jul 2021      44.88843 33.55805 56.21880 27.56011 62.21674
## Aug 2021      45.05243 33.60308 56.50178 27.54216 62.56270
## Sep 2021      45.21602 33.64846 56.78358 27.52496 62.90708
## Oct 2021      45.38047 33.69549 57.06545 27.50984 63.25110
## Nov 2021      45.54670 33.74520 57.34821 27.49786 63.59555
## Dec 2021      45.71519 33.79816 57.63222 27.48967 63.94072
```

```
mae(test_data$Close, df_arima$`Point Forecast`)
```

```
## [1] 39.33623
```

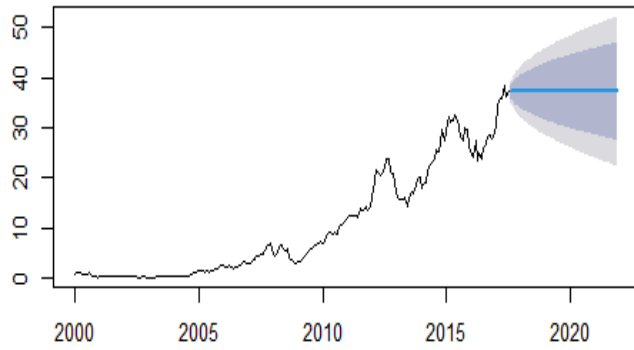
```
RMSE(test_data$Close, df_arima$`Point Forecast`)
```

```
## [1] 55.23373
```

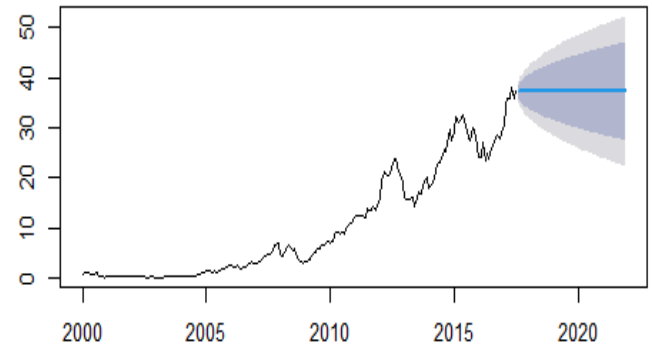
## Plot

```
par(mfrow=c(2,2))
plot(nav)
plot(se_model)
plot(holt_model)
plot(fore_arima)
```

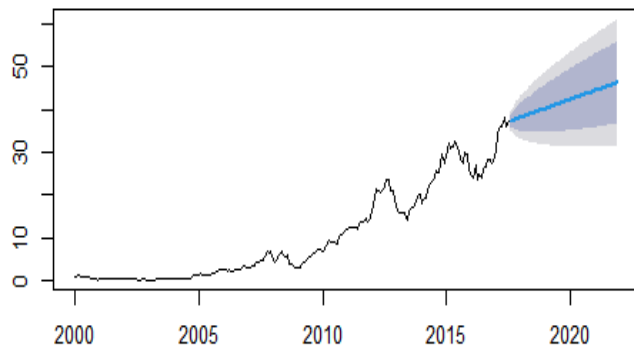
**Forecasts from Naive method**



**Forecasts from Simple exponential smoothing**



**Forecasts from Holt's method**



**Forecasts from ARIMA(2,1,2) with drift**

