EDA Capstone

Capstone 2021: Exploratory Time Series Forecasting

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Contents

1 Data Set-up

```
download.file(
  "https://github.com/Kydoimos97/CapstoneMSBA2020/raw/main/Data/CapstoneProjectInfoRevised.rds",
  destfile = "CapstoneProjectInfoRevised.rds")

download.file(
  "https://github.com/Kydoimos97/CapstoneMSBA2020/raw/main/Data/CapstoneProjectProducts.rds",
  destfile= "CapstoneProjectProducts.rds")

df <- readRDS("CapstoneProjectInfoRevised.rds")
products <- readRDS("CapstoneProjectProducts.rds")
```

1.1 Setting Data Types

```
# Factorization
df$Site_ID <- as.factor(df$Site_ID)
df$Location_ID <- as.factor(df$Location_ID)
df$Locale <- as.factor(df$Locale)
df$Fiscal_Period <- as.factor(df$Fiscal_Period)
df$MPDS <- as.factor(df$MPDS)
df$Project <- as.factor(df$Project)

# Numeration
df$Quantity_Sold <- as.numeric(df$Quantity_Sold)
df$SQ_Footage <- as.numeric(df$SQ_Footage)# Shows Factor like tendencies
df$Periodic_GBV <- as.numeric(df$Periodic_GBV)
df$Current_GBV <- as.numeric(df$Current_GBV)

# Re-origin of Dates at 06/22/1998

x <- min(df$Open_Date)
df$Open_Date <- as_date(df$Open_Date, origin = x)
df$DATE <- as_date(df$DATE, origin = x)

rm(x)

# enables DATE to be used in prediction algorithms
```

A Date format in R is based on epoch time and thus easily convert to a number. The origin is reset to the earliest date present in the data set. Setting the origin allows us to work with an origin point that holds value [06/22/1998] instead of the arbitrary origin point of epoch [1/1/1970]

```
candy_vector <- c(products$Item_Desc)

id_vector <- c(products$Item_ID)

df$Item_desc <- df$Item_ID
df$Item_desc <- plyr::mapvalues(df$Item_desc, id_vector, candy_vector)
```

```
df$Item_ID <- as.factor(df$Item_ID)

# Reodering Data
df <- df[, c(1,2,6,17,7,3,12,13,14,10,11,8,9,15,16,4,5)]

#Rename Variables
names(df) <- tolower(make.names(names(df)))

rm(products, candy_vector, id_vector)
```

1.1.1 Removal and Creation of variables

```r
# creation of tempdiff
df$temp_diff <- as.numeric(df$maxtemp-df$mintemp)

# Creation of cgbv_sqf
df$cgbv_sqf <- as.numeric(df$current_gbv/df$sq_footage)

# creation of diff_gbv
df$diff_gbv <- df$current_gbv - df$periodic_gbv

#Days open
x <- min(df$open_date)
df$days_open <- as.numeric(df$date-df$open_date)

rm(x)

df <- df[, c(1,2,3,4,21,6,7,19,20,10,18,12,13,14,15,16,17,8,9,11,5)]

df <- df[,-c(12,18,19,20,21)]
```

2 Time Series Model

2.1 Reshape Data Set

```r
sum_sales <- aggregate(ifelse(df$sales > 150, 150, df$sales)
                       , by=list(df$date, df$site_id), FUN=sum)
names(sum_sales) <- c("date", "site_id", "sum_of_sales")

sum_sales <- dcast(sum_sales, date ~ site_id, value.var ="sum_of_sales")
sum_sales <- sum_sales[-c(2,9,10,11)]

daysdifference <- min(sum_sales$date) - as.Date("2017/01/01", format = "%Y/%m/%d")
maxdate <- max(sum_sales$date)

train <- subset(sum_sales, date <=  maxdate  - 10)[-1]

test <- subset(sum_sales, date >  maxdate  - 10)
datelist <- test$date
test <- test[-1]

mymts = ts(train,
           frequency = 365,
           start = c(2017, daysdifference))
```

3 Dickey Fuller Test

```
apply(mymts, 2, tseries::adf.test)
```

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

```
## Warning in FUN(newX[, i], ...): p-value smaller than printed p-value

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```

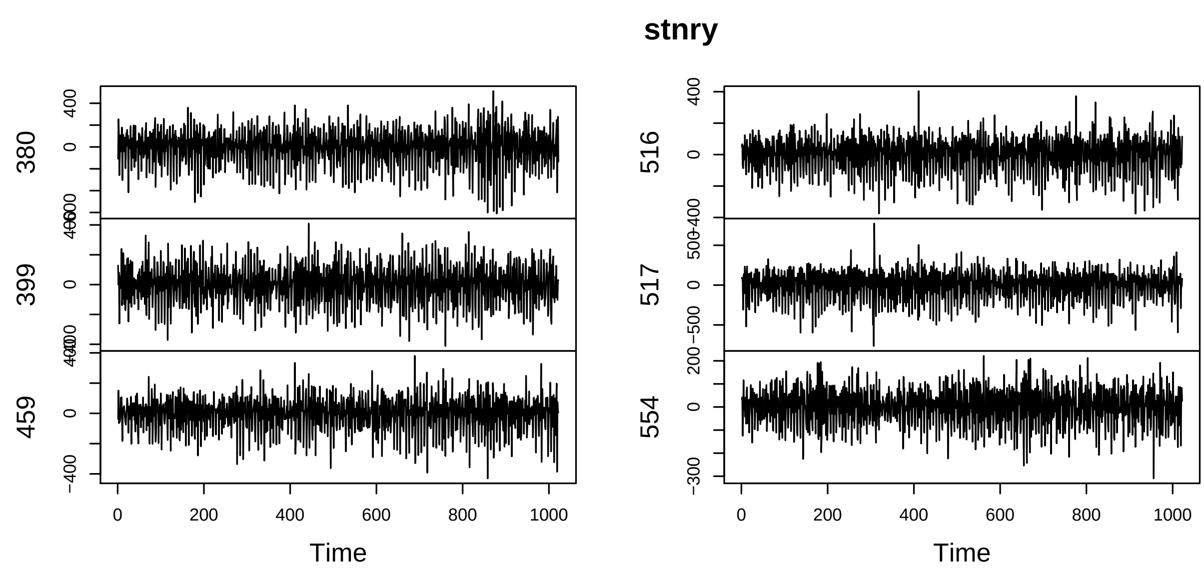
```
## $`380`
##
##  Augmented Dickey-Fuller Test
##
## data:  newX[, i]
## Dickey-Fuller = -4.3177, Lag order = 10, p-value = 0.01
## alternative hypothesis: stationary
##
##
## $`399`
##
##  Augmented Dickey-Fuller Test
##
## data:  newX[, i]
## Dickey-Fuller = -5.3014, Lag order = 10, p-value = 0.01
## alternative hypothesis: stationary
##
##
## $`459`
##
##  Augmented Dickey-Fuller Test
##
## data:  newX[, i]
## Dickey-Fuller = -5.1798, Lag order = 10, p-value = 0.01
## alternative hypothesis: stationary
##
##
## $`516`
##
##  Augmented Dickey-Fuller Test
##
## data:  newX[, i]
```

```
## Dickey-Fuller = -5.2071, Lag order = 10, p-value = 0.01
## alternative hypothesis: stationary
##
##
## $`517`
##
##  Augmented Dickey-Fuller Test
##
## data:  newX[, i]
## Dickey-Fuller = -5.7121, Lag order = 10, p-value = 0.01
## alternative hypothesis: stationary
##
##
## $`554`
##
##  Augmented Dickey-Fuller Test
##
## data:  newX[, i]
## Dickey-Fuller = -5.3323, Lag order = 10, p-value = 0.01
## alternative hypothesis: stationary
```

3.1 Stationary Time Series

```
stnry <- MTS::diffM(mymts)
```

```
plot.ts(stnry)
```




```
apply(stnry, 2, tseries::adf.test)
```

```
## Warning in FUN(newX[, i], ...): p-value smaller than printed p-value
```

```
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## $`380`
##
##  Augmented Dickey-Fuller Test
##
## data:  newX[, i]
## Dickey-Fuller = -11.839, Lag order = 10, p-value = 0.01
## alternative hypothesis: stationary
##
##
## $`399`
##
##  Augmented Dickey-Fuller Test
##
## data:  newX[, i]
## Dickey-Fuller = -12.31, Lag order = 10, p-value = 0.01
## alternative hypothesis: stationary
##
##
## $`459`
##
##  Augmented Dickey-Fuller Test
##
## data:  newX[, i]
## Dickey-Fuller = -13.095, Lag order = 10, p-value = 0.01
## alternative hypothesis: stationary
##
##
## $`516`
##
##  Augmented Dickey-Fuller Test
##
## data:  newX[, i]
## Dickey-Fuller = -12.635, Lag order = 10, p-value = 0.01
## alternative hypothesis: stationary
##
##
## $`517`
##
##  Augmented Dickey-Fuller Test
##
## data:  newX[, i]
## Dickey-Fuller = -11.493, Lag order = 10, p-value = 0.01
## alternative hypothesis: stationary
```

```
##
##
## $`554`
##
##  Augmented Dickey-Fuller Test
##
## data:  newX[, i]
## Dickey-Fuller = -11.738, Lag order = 10, p-value = 0.01
## alternative hypothesis: stationary
```

3.2 Variable Selection

```
vars::VARselect(stnry,
          type = "none", #type of deterministic regressors to include. We use none becasue the time seri
          lag.max = 10) #highest lag order
```

```
## $selection
## AIC(n)  HQ(n)  SC(n) FPE(n)
##      9      7      6      9
##
## $criteria
##                   1            2            3            4            5
## AIC(n) 5.418079e+01 5.343327e+01 5.291415e+01 5.244901e+01 5.187072e+01
## HQ(n)  5.424726e+01 5.356622e+01 5.311358e+01 5.271492e+01 5.220310e+01
## SC(n)  5.435579e+01 5.378329e+01 5.343918e+01 5.314905e+01 5.274576e+01
## FPE(n) 3.391692e+23 1.606117e+23 9.557279e+22 6.002610e+22 3.366753e+22
##                   6            7            8            9           10
## AIC(n) 5.144295e+01 5.132462e+01 5.130901e+01 5.130398e+01 5.131036e+01
## HQ(n)  5.184181e+01 5.178996e+01 5.184083e+01 5.190227e+01 5.197513e+01
## SC(n)  5.249300e+01 5.254968e+01 5.270908e+01 5.287905e+01 5.306044e+01
## FPE(n) 2.195171e+22 1.950400e+22 1.920467e+22 1.911168e+22 1.923838e+22
```

3.3 Time Series Regression

```
# Creating a VAR model with vars
var.a <- vars::VAR(stnry,
                   lag.max = 25, #highest lag order for lag length selection according to the choosen ic
                   ic = "AIC", #information criterion
                   type = "none") #type of deterministic regressors to include
summary(var.a)
```

```
##
## VAR Estimation Results:
## =========================
## Endogenous variables: X380, X399, X459, X516, X517, X554
## Deterministic variables: none
## Sample size: 1009
## Log Likelihood: -33954.634
## Roots of the characteristic polynomial:
```

```
## 0.9924 0.9924 0.9888 0.9888 0.9634 0.9634  0.91  0.91 0.8946 0.8946 0.8926 0.8926 0.8891 0.8891 0.884
## Call:
## vars::VAR(y = stnry, type = "none", lag.max = 25, ic = "AIC")
##
##
## Estimation results for equation X380:
## =====================================
## X380 = X380.l1 + X399.l1 + X459.l1 + X516.l1 + X517.l1 + X554.l1 + X380.l2 + X399.l2 + X459.l2 + X516
##
##           Estimate Std. Error t value Pr(>|t|)
## X380.l1  -0.820314   0.035843 -22.886  < 2e-16 ***
## X399.l1   0.020621   0.043840   0.470 0.638201
## X459.l1   0.083120   0.048072   1.729 0.084129 .
## X516.l1   0.236692   0.050018   4.732 2.57e-06 ***
## X517.l1   0.119967   0.032013   3.747 0.000190 ***
## X554.l1   0.184782   0.064116   2.882 0.004043 **
## X380.l2  -0.814940   0.046932 -17.364  < 2e-16 ***
## X399.l2   0.036705   0.057047   0.643 0.520110
## X459.l2  -0.023213   0.062658  -0.370 0.711115
## X516.l2   0.193050   0.066606   2.898 0.003839 **
## X517.l2   0.092229   0.040818   2.260 0.024083 *
## X554.l2   0.256324   0.084875   3.020 0.002596 **
## X380.l3  -0.788871   0.055636 -14.179  < 2e-16 ***
## X399.l3  -0.027826   0.064784  -0.430 0.667646
## X459.l3  -0.050483   0.074635  -0.676 0.498961
## X516.l3   0.246734   0.078042   3.162 0.001620 **
## X517.l3   0.166867   0.045632   3.657 0.000270 ***
## X554.l3   0.240430   0.098012   2.453 0.014347 *
## X380.l4  -0.676470   0.062457 -10.831  < 2e-16 ***
## X399.l4  -0.109080   0.070287  -1.552 0.121021
## X459.l4  -0.072893   0.082003  -0.889 0.374285
## X516.l4   0.130585   0.086201   1.515 0.130138
## X517.l4   0.181993   0.049161   3.702 0.000227 ***
## X554.l4   0.380074   0.105706   3.596 0.000341 ***
## X380.l5  -0.553224   0.067351  -8.214 7.11e-16 ***
## X399.l5  -0.080972   0.074776  -1.083 0.279149
## X459.l5  -0.086616   0.087259  -0.993 0.321151
## X516.l5   0.033956   0.090193   0.376 0.706641
## X517.l5   0.117044   0.051911   2.255 0.024384 *
## X554.l5   0.423008   0.110940   3.813 0.000146 ***
## X380.l6  -0.484846   0.070187  -6.908 9.10e-12 ***
## X399.l6   0.049733   0.077372   0.643 0.520530
## X459.l6  -0.095784   0.091785  -1.044 0.296957
## X516.l6   0.016053   0.093434   0.172 0.863624
## X517.l6   0.086444   0.053095   1.628 0.103843
## X554.l6   0.258509   0.114389   2.260 0.024057 *
## X380.l7  -0.274257   0.072248  -3.796 0.000157 ***
## X399.l7   0.011893   0.078123   0.152 0.879030
## X459.l7   0.016815   0.093902   0.179 0.857921
## X516.l7   0.158358   0.094451   1.677 0.093954 .
## X517.l7   0.158679   0.053508   2.966 0.003099 **
## X554.l7   0.239117   0.115588   2.069 0.038849 *
## X380.l8  -0.296701   0.070826  -4.189 3.07e-05 ***
## X399.l8  -0.005366   0.077397  -0.069 0.944743
```

```
## X459.l8  -0.114866   0.091441  -1.256 0.209367
## X516.l8  -0.023302   0.093331  -0.250 0.802894
## X517.l8   0.144392   0.053256   2.711 0.006826 **
## X554.l8   0.146708   0.113981   1.287 0.198368
## X380.l9  -0.258018   0.067609  -3.816 0.000144 ***
## X399.l9  -0.013091   0.074977  -0.175 0.861433
## X459.l9  -0.039215   0.087065  -0.450 0.652518
## X516.l9   0.057495   0.090357   0.636 0.524728
## X517.l9   0.079280   0.052102   1.522 0.128443
## X554.l9   0.110622   0.111376   0.993 0.320857
## X380.l10 -0.194026   0.063055  -3.077 0.002152 **
## X399.l10 -0.027636   0.070322  -0.393 0.694410
## X459.l10 -0.002541   0.081581  -0.031 0.975154
## X516.l10  0.113912   0.086277   1.320 0.187056
## X517.l10  0.021603   0.049498   0.436 0.662617
## X554.l10  0.125336   0.106662   1.175 0.240265
## X380.l11 -0.156532   0.056044  -2.793 0.005329 **
## X399.l11 -0.064758   0.064869  -0.998 0.318403
## X459.l11 -0.092814   0.074131  -1.252 0.210875
## X516.l11  0.089479   0.078548   1.139 0.254925
## X517.l11  0.064517   0.046070   1.400 0.161725
## X554.l11  0.136345   0.099665   1.368 0.171634
## X380.l12 -0.110712   0.047462  -2.333 0.019880 *
## X399.l12  0.005470   0.056688   0.096 0.923145
## X459.l12 -0.024618   0.062663  -0.393 0.694510
## X516.l12  0.094042   0.066645   1.411 0.158553
## X517.l12 -0.003106   0.041323  -0.075 0.940092
## X554.l12 -0.037024   0.087610  -0.423 0.672684
## X380.l13 -0.106708   0.035053  -3.044 0.002398 **
## X399.l13  0.005146   0.042758   0.120 0.904237
## X459.l13 -0.065729   0.048583  -1.353 0.176414
## X516.l13 -0.087617   0.050962  -1.719 0.085900 .
## X517.l13 -0.042804   0.032326  -1.324 0.185779
## X554.l13 -0.062817   0.066161  -0.949 0.342635
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 90.73 on 931 degrees of freedom
## Multiple R-Squared: 0.7277,  Adjusted R-squared: 0.7049
## F-statistic:  31.9 on 78 and 931 DF,  p-value: < 2.2e-16
##
##
## Estimation results for equation X399:
## =====================================
## X399 = X380.l1 + X399.l1 + X459.l1 + X516.l1 + X517.l1 + X554.l1 + X380.l2 + X399.l2 + X459.l2 + X51
##
##           Estimate Std. Error t value Pr(>|t|)
## X380.l1   0.041821   0.028599   1.462 0.143993
## X399.l1  -0.844503   0.034980 -24.142  < 2e-16 ***
## X459.l1   0.037969   0.038357   0.990 0.322491
## X516.l1   0.113499   0.039909   2.844 0.004553 **
## X517.l1   0.096169   0.025543   3.765 0.000177 ***
## X554.l1   0.211341   0.051158   4.131 3.93e-05 ***
```

```
## X380.12   0.034520   0.037447   0.922 0.356858
## X399.12  -0.749873   0.045518 -16.474  < 2e-16 ***
## X459.12  -0.036664   0.049995  -0.733 0.463524
## X516.12   0.100330   0.053145   1.888 0.059355 .
## X517.12   0.057463   0.032569   1.764 0.078001 .
## X554.12   0.294162   0.067721   4.344 1.55e-05 ***
## X380.13   0.010974   0.044392   0.247 0.804806
## X399.13  -0.683751   0.051691 -13.228  < 2e-16 ***
## X459.13  -0.089669   0.059552  -1.506 0.132474
## X516.13   0.170178   0.062270   2.733 0.006397 **
## X517.13   0.069921   0.036410   1.920 0.055115 .
## X554.13   0.250576   0.078204   3.204 0.001401 **
## X380.14   0.027425   0.049835   0.550 0.582227
## X399.14  -0.663422   0.056082 -11.829  < 2e-16 ***
## X459.14  -0.057798   0.065430  -0.883 0.377278
## X516.14   0.141625   0.068779   2.059 0.039760 *
## X517.14   0.113773   0.039226   2.900 0.003814 **
## X554.14   0.296864   0.084343   3.520 0.000453 ***
## X380.15   0.032413   0.053739   0.603 0.546554
## X399.15  -0.585207   0.059664  -9.808  < 2e-16 ***
## X459.15  -0.042167   0.069624  -0.606 0.544902
## X516.15   0.031744   0.071965   0.441 0.659235
## X517.15   0.070580   0.041420   1.704 0.088711 .
## X554.15   0.150172   0.088519   1.697 0.090125 .
## X380.16   0.086024   0.056002   1.536 0.124858
## X399.16  -0.459272   0.061735  -7.439 2.30e-13 ***
## X459.16  -0.042983   0.073236  -0.587 0.557406
## X516.16   0.013743   0.074551   0.184 0.853784
## X517.16   0.067934   0.042365   1.604 0.109151
## X554.16   0.011633   0.091271   0.127 0.898610
## X380.17   0.091852   0.057647   1.593 0.111418
## X399.17  -0.357511   0.062334  -5.735 1.31e-08 ***
## X459.17  -0.031142   0.074924  -0.416 0.677762
## X516.17   0.103486   0.075363   1.373 0.170028
## X517.17   0.105590   0.042694   2.473 0.013570 *
## X554.17   0.185800   0.092227   2.015 0.044235 *
## X380.18   0.052200   0.056512   0.924 0.355885
## X399.18  -0.329857   0.061755  -5.341 1.16e-07 ***
## X459.18  -0.062196   0.072961  -0.852 0.394175
## X516.18   0.106614   0.074469   1.432 0.152578
## X517.18   0.061329   0.042493   1.443 0.149283
## X554.18   0.166792   0.090945   1.834 0.066976 .
## X380.19   0.069454   0.053945   1.287 0.198242
## X399.19  -0.288786   0.059824  -4.827 1.62e-06 ***
## X459.19  -0.075186   0.069469  -1.082 0.279403
## X516.19   0.124822   0.072096   1.731 0.083722 .
## X517.19   0.032072   0.041572   0.771 0.440618
## X554.19   0.078657   0.088867   0.885 0.376325
## X380.110  0.033469   0.050312   0.665 0.506069
## X399.110 -0.271502   0.056110  -4.839 1.53e-06 ***
## X459.110 -0.081516   0.065093  -1.252 0.210778
## X516.110  0.110150   0.068840   1.600 0.109920
## X517.110  0.031760   0.039495   0.804 0.421510
## X554.110  0.168347   0.085106   1.978 0.048213 *
```

```
## X380.l11  0.088967   0.044717   1.990 0.046932 *
## X399.l11 -0.250157   0.051759  -4.833 1.57e-06 ***
## X459.l11 -0.081887   0.059149  -1.384 0.166562
## X516.l11  0.019220   0.062673   0.307 0.759166
## X517.l11  0.009232   0.036759   0.251 0.801753
## X554.l11  0.249865   0.079523   3.142 0.001731 **
## X380.l12  0.051314   0.037870   1.355 0.175748
## X399.l12 -0.169446   0.045231  -3.746 0.000191 ***
## X459.l12 -0.100981   0.049999  -2.020 0.043702 *
## X516.l12  0.026100   0.053176   0.491 0.623670
## X517.l12 -0.022252   0.032972  -0.675 0.499916
## X554.l12  0.107091   0.069904   1.532 0.125871
## X380.l13 -0.001548   0.027969  -0.055 0.955873
## X399.l13 -0.049624   0.034117  -1.455 0.146131
## X459.l13 -0.019209   0.038765  -0.496 0.620348
## X516.l13  0.018700   0.040663   0.460 0.645712
## X517.l13 -0.058679   0.025793  -2.275 0.023131 *
## X554.l13  0.002317   0.052790   0.044 0.964995
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 72.39 on 931 degrees of freedom
## Multiple R-Squared: 0.7026,  Adjusted R-squared: 0.6777
## F-statistic: 28.19 on 78 and 931 DF,  p-value: < 2.2e-16
##
##
## Estimation results for equation X459:
## =====================================
## X459 = X380.l1 + X399.l1 + X459.l1 + X516.l1 + X517.l1 + X554.l1 + X380.l2 + X399.l2 + X459.l2 + X51
##
##           Estimate Std. Error t value Pr(>|t|)
## X380.l1   0.032595   0.026592   1.226 0.220616
## X399.l1   0.014562   0.032525   0.448 0.654468
## X459.l1  -0.829628   0.035665 -23.261  < 2e-16 ***
## X516.l1   0.042363   0.037109   1.142 0.253919
## X517.l1   0.037517   0.023751   1.580 0.114532
## X554.l1   0.118925   0.047568   2.500 0.012587 *
## X380.l2   0.043028   0.034819   1.236 0.216866
## X399.l2  -0.014007   0.042324  -0.331 0.740763
## X459.l2  -0.833370   0.046487 -17.927  < 2e-16 ***
## X516.l2   0.030354   0.049416   0.614 0.539198
## X517.l2   0.077048   0.030284   2.544 0.011113 *
## X554.l2   0.233121   0.062969   3.702 0.000226 ***
## X380.l3   0.058278   0.041277   1.412 0.158318
## X399.l3  -0.068004   0.048064  -1.415 0.157441
## X459.l3  -0.751488   0.055373 -13.571  < 2e-16 ***
## X516.l3   0.037060   0.057901   0.640 0.522293
## X517.l3   0.126807   0.033855   3.746 0.000191 ***
## X554.l3   0.258550   0.072717   3.556 0.000396 ***
## X380.l4   0.108651   0.046338   2.345 0.019249 *
## X399.l4  -0.040370   0.052147  -0.774 0.439033
## X459.l4  -0.705707   0.060839 -11.600  < 2e-16 ***
## X516.l4  -0.001641   0.063953  -0.026 0.979537
```

```
## X517.l4   0.119543   0.036473   3.278 0.001086 **
## X554.l4   0.241533   0.078424   3.080 0.002132 **
## X380.l5   0.120380   0.049968   2.409 0.016184 *
## X399.l5  -0.033599   0.055477  -0.606 0.544902
## X459.l5  -0.706675   0.064739 -10.916  < 2e-16 ***
## X516.l5  -0.066458   0.066915  -0.993 0.320883
## X517.l5   0.094146   0.038513   2.445 0.014690 *
## X554.l5   0.236584   0.082307   2.874 0.004140 **
## X380.l6   0.122805   0.052072   2.358 0.018562 *
## X399.l6  -0.005184   0.057403  -0.090 0.928066
## X459.l6  -0.637528   0.068097  -9.362  < 2e-16 ***
## X516.l6  -0.022232   0.069319  -0.321 0.748501
## X517.l6   0.094603   0.039392   2.402 0.016520 *
## X554.l6   0.146200   0.084866   1.723 0.085274 .
## X380.l7   0.132482   0.053602   2.472 0.013629 *
## X399.l7   0.028441   0.057960   0.491 0.623759
## X459.l7  -0.416120   0.069667  -5.973 3.31e-09 ***
## X516.l7   0.122317   0.070075   1.746 0.081224 .
## X517.l7   0.121558   0.039698   3.062 0.002261 **
## X554.l7   0.148685   0.085756   1.734 0.083280 .
## X380.l8   0.039607   0.052547   0.754 0.451185
## X399.l8  -0.005007   0.057422  -0.087 0.930535
## X459.l8  -0.402643   0.067841  -5.935 4.14e-09 ***
## X516.l8   0.066550   0.069244   0.961 0.336750
## X517.l8   0.101561   0.039511   2.570 0.010312 *
## X554.l8   0.145673   0.084564   1.723 0.085284 .
## X380.l9   0.020591   0.050160   0.411 0.681527
## X399.l9  -0.014628   0.055626  -0.263 0.792625
## X459.l9  -0.344925   0.064594  -5.340 1.17e-07 ***
## X516.l9   0.066307   0.067037   0.989 0.322866
## X517.l9   0.089480   0.038655   2.315 0.020839 *
## X554.l9   0.074712   0.082631   0.904 0.366141
## X380.l10  0.004917   0.046781   0.105 0.916312
## X399.l10 -0.064330   0.052173  -1.233 0.217880
## X459.l10 -0.329924   0.060526  -5.451 6.42e-08 ***
## X516.l10  0.071700   0.064010   1.120 0.262940
## X517.l10  0.061070   0.036723   1.663 0.096657 .
## X554.l10  0.210168   0.079134   2.656 0.008046 **
## X380.l11  0.031906   0.041579   0.767 0.443072
## X399.l11 -0.088924   0.048127  -1.848 0.064966 .
## X459.l11 -0.197304   0.054999  -3.587 0.000351 ***
## X516.l11  0.030586   0.058275   0.525 0.599808
## X517.l11  0.066310   0.034180   1.940 0.052680 .
## X554.l11  0.122320   0.073943   1.654 0.098415 .
## X380.l12  0.051465   0.035213   1.462 0.144202
## X399.l12 -0.042845   0.042057  -1.019 0.308595
## X459.l12 -0.179789   0.046490  -3.867 0.000118 ***
## X516.l12  0.027364   0.049445   0.553 0.580109
## X517.l12  0.035477   0.030658   1.157 0.247503
## X554.l12  0.019529   0.064999   0.300 0.763905
## X380.l13 -0.035524   0.026006  -1.366 0.172270
## X399.l13 -0.027230   0.031723  -0.858 0.390899
## X459.l13 -0.079591   0.036045  -2.208 0.027478 *
## X516.l13 -0.032321   0.037810  -0.855 0.392865
```

```
## X517.l13 -0.001147   0.023983  -0.048 0.961849
## X554.l13 -0.069929   0.049086  -1.425 0.154596
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 67.31 on 931 degrees of freedom
## Multiple R-Squared: 0.6645,  Adjusted R-squared: 0.6364
## F-statistic: 23.64 on 78 and 931 DF,  p-value: < 2.2e-16
##
##
## Estimation results for equation X516:
## =====================================
## X516 = X380.l1 + X399.l1 + X459.l1 + X516.l1 + X517.l1 + X554.l1 + X380.l2 + X399.l2 + X459.l2 + X516
##
##           Estimate Std. Error t value Pr(>|t|)
## X380.l1   0.043553   0.026287   1.657 0.097889 .
## X399.l1   0.008178   0.032152   0.254 0.799280
## X459.l1   0.055703   0.035256   1.580 0.114451
## X516.l1  -0.812567   0.036682 -22.151  < 2e-16 ***
## X517.l1   0.036546   0.023478   1.557 0.119908
## X554.l1   0.117222   0.047022   2.493 0.012843 *
## X380.l2   0.036171   0.034419   1.051 0.293587
## X399.l2   0.001867   0.041837   0.045 0.964407
## X459.l2   0.138399   0.045953   3.012 0.002668 **
## X516.l2  -0.798701   0.048848 -16.351  < 2e-16 ***
## X517.l2   0.054797   0.029936   1.830 0.067495 .
## X554.l2   0.145597   0.062246   2.339 0.019543 *
## X380.l3   0.022149   0.040802   0.543 0.587370
## X399.l3  -0.067083   0.047512  -1.412 0.158305
## X459.l3   0.110662   0.054737   2.022 0.043490 *
## X516.l3  -0.713904   0.057235 -12.473  < 2e-16 ***
## X517.l3   0.078461   0.033466   2.344 0.019263 *
## X554.l3   0.028829   0.071881   0.401 0.688462
## X380.l4   0.072435   0.045805   1.581 0.114134
## X399.l4  -0.059207   0.051548  -1.149 0.251024
## X459.l4   0.049555   0.060140   0.824 0.410157
## X516.l4  -0.600924   0.063218  -9.506  < 2e-16 ***
## X517.l4   0.085415   0.036054   2.369 0.018036 *
## X554.l4   0.032564   0.077523   0.420 0.674541
## X380.l5   0.096407   0.049394   1.952 0.051263 .
## X399.l5  -0.059698   0.054840  -1.089 0.276611
## X459.l5   0.054264   0.063995   0.848 0.396689
## X516.l5  -0.647086   0.066146  -9.783  < 2e-16 ***
## X517.l5   0.040668   0.038071   1.068 0.285693
## X554.l5   0.097614   0.081362   1.200 0.230539
## X380.l6   0.121296   0.051474   2.356 0.018656 *
## X399.l6  -0.028713   0.056744  -0.506 0.612972
## X459.l6   0.019654   0.067314   0.292 0.770369
## X516.l6  -0.503584   0.068523  -7.349 4.36e-13 ***
## X517.l6   0.042977   0.038939   1.104 0.270010
## X554.l6   0.094910   0.083891   1.131 0.258204
## X380.l7   0.161444   0.052986   3.047 0.002377 **
## X399.l7   0.025023   0.057294   0.437 0.662396
```

```
## X459.l7   0.088278   0.068867   1.282 0.200207
## X516.l7  -0.320652   0.069270  -4.629 4.19e-06 ***
## X517.l7   0.108012   0.039242   2.752 0.006030 **
## X554.l7   0.084427   0.084771   0.996 0.319537
## X380.l8   0.099182   0.051943   1.909 0.056513 .
## X399.l8  -0.009653   0.056762  -0.170 0.865003
## X459.l8  -0.047617   0.067061  -0.710 0.477854
## X516.l8  -0.377612   0.068448  -5.517 4.48e-08 ***
## X517.l8   0.071097   0.039057   1.820 0.069030 .
## X554.l8   0.047522   0.083592   0.569 0.569830
## X380.l9   0.090333   0.049584   1.822 0.068801 .
## X399.l9  -0.039811   0.054987  -0.724 0.469246
## X459.l9  -0.054043   0.063852  -0.846 0.397558
## X516.l9  -0.278090   0.066266  -4.197 2.97e-05 ***
## X517.l9   0.043150   0.038211   1.129 0.259079
## X554.l9  -0.019008   0.081682  -0.233 0.816040
## X380.l10  0.078677   0.046244   1.701 0.089212 .
## X399.l10 -0.089081   0.051573  -1.727 0.084451 .
## X459.l10 -0.032776   0.059830  -0.548 0.583952
## X516.l10 -0.214435   0.063274  -3.389 0.000731 ***
## X517.l10  0.045344   0.036302   1.249 0.211943
## X554.l10 -0.021262   0.078225  -0.272 0.785832
## X380.l11  0.080284   0.041102   1.953 0.051084 .
## X399.l11 -0.076476   0.047574  -1.608 0.108282
## X459.l11 -0.050843   0.054367  -0.935 0.349936
## X516.l11 -0.222168   0.057606  -3.857 0.000123 ***
## X517.l11  0.061417   0.033787   1.818 0.069423 .
## X554.l11 -0.015802   0.073093  -0.216 0.828890
## X380.l12  0.084503   0.034808   2.428 0.015385 *
## X399.l12 -0.060479   0.041574  -1.455 0.146081
## X459.l12 -0.037289   0.045956  -0.811 0.417343
## X516.l12 -0.152781   0.048877  -3.126 0.001828 **
## X517.l12 -0.023780   0.030306  -0.785 0.432861
## X554.l12 -0.074043   0.064252  -1.152 0.249463
## X380.l13  0.008079   0.025707   0.314 0.753377
## X399.l13 -0.004206   0.031358  -0.134 0.893332
## X459.l13 -0.012907   0.035630  -0.362 0.717255
## X516.l13 -0.159402   0.037375  -4.265 2.20e-05 ***
## X517.l13 -0.029373   0.023707  -1.239 0.215668
## X554.l13 -0.102994   0.048522  -2.123 0.034049 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 66.54 on 931 degrees of freedom
## Multiple R-Squared: 0.6732,  Adjusted R-squared: 0.6458
## F-statistic: 24.59 on 78 and 931 DF,  p-value: < 2.2e-16
##
##
## Estimation results for equation X517:
## ====================================
## X517 = X380.l1 + X399.l1 + X459.l1 + X516.l1 + X517.l1 + X554.l1 + X380.l2 + X399.l2 + X459.l2 + X51
##
##           Estimate Std. Error t value Pr(>|t|)
```

```
## X380.l1   0.066703   0.040753   1.637 0.102017
## X399.l1  -0.037210   0.049845  -0.747 0.455544
## X459.l1  -0.040035   0.054658  -0.732 0.464068
## X516.l1   0.084205   0.056869   1.481 0.139030
## X517.l1  -0.728942   0.036398 -20.027  < 2e-16 ***
## X554.l1   0.205193   0.072899   2.815 0.004984 **
## X380.l2   0.096142   0.053361   1.802 0.071912 .
## X399.l2  -0.090354   0.064861  -1.393 0.163943
## X459.l2  -0.073774   0.071241  -1.036 0.300678
## X516.l2  -0.050766   0.075730  -0.670 0.502800
## X517.l2  -0.586164   0.046410 -12.630  < 2e-16 ***
## X554.l2   0.316491   0.096501   3.280 0.001078 **
## X380.l3   0.020053   0.063257   0.317 0.751303
## X399.l3  -0.051439   0.073658  -0.698 0.485135
## X459.l3  -0.022717   0.084859  -0.268 0.788989
## X516.l3  -0.092779   0.088733  -1.046 0.296021
## X517.l3  -0.488026   0.051883  -9.406  < 2e-16 ***
## X554.l3   0.249163   0.111439   2.236 0.025596 *
## X380.l4   0.075476   0.071013   1.063 0.288127
## X399.l4  -0.065359   0.079916  -0.818 0.413653
## X459.l4  -0.098462   0.093236  -1.056 0.291219
## X516.l4  -0.080180   0.098009  -0.818 0.413515
## X517.l4  -0.452377   0.055896  -8.093 1.81e-15 ***
## X554.l4   0.337503   0.120186   2.808 0.005087 **
## X380.l5   0.147181   0.076577   1.922 0.054910 .
## X399.l5   0.009597   0.085019   0.113 0.910147
## X459.l5  -0.118185   0.099213  -1.191 0.233867
## X516.l5  -0.136730   0.102548  -1.333 0.182749
## X517.l5  -0.415601   0.059022  -7.041 3.69e-12 ***
## X554.l5   0.283324   0.126137   2.246 0.024927 *
## X380.l6   0.210882   0.079801   2.643 0.008365 **
## X399.l6   0.024368   0.087971   0.277 0.781838
## X459.l6  -0.132963   0.104359  -1.274 0.202949
## X516.l6  -0.119444   0.106233  -1.124 0.261150
## X517.l6  -0.298869   0.060369  -4.951 8.77e-07 ***
## X554.l6   0.154304   0.130059   1.186 0.235760
## X380.l7   0.201864   0.082145   2.457 0.014175 *
## X399.l7   0.102192   0.088825   1.150 0.250237
## X459.l7  -0.057930   0.106765  -0.543 0.587541
## X516.l7   0.069003   0.107390   0.643 0.520677
## X517.l7  -0.161687   0.060838  -2.658 0.008003 **
## X554.l7   0.250610   0.131421   1.907 0.056839 .
## X380.l8   0.148232   0.080528   1.841 0.065976 .
## X399.l8   0.072486   0.087999   0.824 0.410311
## X459.l8  -0.155726   0.103967  -1.498 0.134513
## X516.l8  -0.036021   0.106117  -0.339 0.734346
## X517.l8  -0.244961   0.060551  -4.046 5.65e-05 ***
## X554.l8   0.340992   0.129594   2.631 0.008648 **
## X380.l9   0.057995   0.076870   0.754 0.450772
## X399.l9  -0.039778   0.085248  -0.467 0.640880
## X459.l9  -0.188434   0.098991  -1.904 0.057277 .
## X516.l9   0.039696   0.102734   0.386 0.699289
## X517.l9  -0.273166   0.059239  -4.611 4.56e-06 ***
## X554.l9   0.203980   0.126633   1.611 0.107562
```

```
## X380.l10  0.092786   0.071693   1.294 0.195914
## X399.l10 -0.023919   0.079955  -0.299 0.764890
## X459.l10 -0.152917   0.092756  -1.649 0.099569 .
## X516.l10  0.027667   0.098095   0.282 0.777977
## X517.l10 -0.202632   0.056279  -3.600 0.000334 ***
## X554.l10  0.337603   0.121273   2.784 0.005481 **
## X380.l11  0.115228   0.063721   1.808 0.070879 .
## X399.l11 -0.078142   0.073756  -1.059 0.289662
## X459.l11 -0.160631   0.084286  -1.906 0.056986 .
## X516.l11 -0.060184   0.089308  -0.674 0.500545
## X517.l11 -0.121120   0.052381  -2.312 0.020979 *
## X554.l11  0.286557   0.113318   2.529 0.011610 *
## X380.l12  0.076107   0.053964   1.410 0.158777
## X399.l12 -0.085975   0.064453  -1.334 0.182557
## X459.l12 -0.063447   0.071247  -0.891 0.373414
## X516.l12 -0.050751   0.075775  -0.670 0.503173
## X517.l12 -0.178250   0.046984  -3.794 0.000158 ***
## X554.l12  0.146847   0.099612   1.474 0.140766
## X380.l13 -0.022428   0.039854  -0.563 0.573737
## X399.l13 -0.025733   0.048615  -0.529 0.596710
## X459.l13 -0.047781   0.055239  -0.865 0.387269
## X516.l13 -0.068476   0.057943  -1.182 0.237600
## X517.l13 -0.146703   0.036754  -3.992 7.08e-05 ***
## X554.l13 -0.081045   0.075224  -1.077 0.281588
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 103.2 on 931 degrees of freedom
## Multiple R-Squared: 0.694,   Adjusted R-squared: 0.6684
## F-statistic: 27.07 on 78 and 931 DF,  p-value: < 2.2e-16
##
##
## Estimation results for equation X554:
## =====================================
## X554 = X380.l1 + X399.l1 + X459.l1 + X516.l1 + X517.l1 + X554.l1 + X380.l2 + X399.l2 + X459.l2 + X51
##
##            Estimate Std. Error t value Pr(>|t|)
## X380.l1  -0.0124982  0.0191951  -0.651 0.515133
## X399.l1   0.0041615  0.0234777   0.177 0.859350
## X459.l1  -0.0154257  0.0257442  -0.599 0.549190
## X516.l1   0.0494785  0.0267860   1.847 0.065038 .
## X517.l1   0.0292346  0.0171440   1.705 0.088483 .
## X554.l1  -0.8130048  0.0343361 -23.678  < 2e-16 ***
## X380.l2   0.0160017  0.0251336   0.637 0.524499
## X399.l2  -0.0656194  0.0305503  -2.148 0.031978 *
## X459.l2  -0.0385315  0.0335553  -1.148 0.251140
## X516.l2   0.0368231  0.0356695   1.032 0.302180
## X517.l2   0.0342247  0.0218596   1.566 0.117768
## X554.l2  -0.6866280  0.0454529 -15.106  < 2e-16 ***
## X380.l3   0.0443260  0.0297946   1.488 0.137163
## X399.l3  -0.0802001  0.0346937  -2.312 0.021014 *
## X459.l3  -0.0613738  0.0399695  -1.536 0.124997
## X516.l3   0.0006299  0.0417941   0.015 0.987979
```

```
## X517.13   0.0498296  0.0244374   2.039 0.041725 *  
## X554.13  -0.5757179  0.0524887 -10.968  < 2e-16 ***
## X380.14   0.1085757  0.0334478   3.246 0.001212 ** 
## X399.14  -0.0329737  0.0376410  -0.876 0.381254    
## X459.14  -0.0399136  0.0439153  -0.909 0.363649    
## X516.14  -0.0356659  0.0461631  -0.773 0.439952    
## X517.14   0.0352586  0.0263274   1.339 0.180821    
## X554.14  -0.4450752  0.0566087  -7.862 1.04e-14 ***
## X380.15   0.0912954  0.0360684   2.531 0.011532 *  
## X399.15  -0.0247662  0.0400447  -0.618 0.536421    
## X459.15   0.0012593  0.0467301   0.027 0.978507    
## X516.15  -0.0610361  0.0483010  -1.264 0.206668    
## X517.15  -0.0031863  0.0277999  -0.115 0.908776    
## X554.15  -0.4056550  0.0594116  -6.828 1.55e-11 ***
## X380.16   0.0971862  0.0375871   2.586 0.009871 ** 
## X399.16  -0.0029961  0.0414351  -0.072 0.942371    
## X459.16   0.0268542  0.0491540   0.546 0.584972    
## X516.16  -0.0095582  0.0500366  -0.191 0.848548    
## X517.16   0.0016908  0.0284342   0.059 0.952596    
## X554.16  -0.3226461  0.0612588  -5.267 1.72e-07 ***
## X380.17   0.0771029  0.0386910   1.993 0.046576 *  
## X399.17  -0.0071996  0.0418372  -0.172 0.863408    
## X459.17   0.0290357  0.0502873   0.577 0.563812    
## X516.17   0.0452319  0.0505816   0.894 0.371427    
## X517.17   0.0339096  0.0286552   1.183 0.236966    
## X554.17  -0.1812289  0.0619007  -2.928 0.003498 ** 
## X380.18   0.0283523  0.0379295   0.748 0.454950    
## X399.18  -0.0068859  0.0414484  -0.166 0.868090    
## X459.18   0.0237947  0.0489693   0.486 0.627145    
## X516.18  -0.0119435  0.0499819  -0.239 0.811192    
## X517.18  -0.0231936  0.0285202  -0.813 0.416292    
## X554.18  -0.2056310  0.0610402  -3.369 0.000786 ***
## X380.19   0.0177549  0.0362067   0.490 0.623983    
## X399.19  -0.0473986  0.0401524  -1.180 0.238116    
## X459.19   0.0276102  0.0466258   0.592 0.553883    
## X516.19   0.0228944  0.0483888   0.473 0.636228    
## X517.19  -0.0270011  0.0279023  -0.968 0.333445    
## X554.19  -0.2111451  0.0596452  -3.540 0.000420 ***
## X380.110 -0.0149370  0.0337680  -0.442 0.658344    
## X399.110 -0.0538358  0.0376595  -1.430 0.153184    
## X459.110  0.0267151  0.0436890   0.611 0.541029    
## X516.110  0.0392456  0.0462038   0.849 0.395876    
## X517.110 -0.0133468  0.0265080  -0.504 0.614730    
## X554.110 -0.1744859  0.0571209  -3.055 0.002317 ** 
## X380.111 -0.0148233  0.0300131  -0.494 0.621497    
## X399.111 -0.0355650  0.0347396  -1.024 0.306215    
## X459.111  0.0084500  0.0396995   0.213 0.831491    
## X516.111 -0.0025897  0.0420648  -0.062 0.950923    
## X517.111 -0.0194530  0.0246720  -0.788 0.430624    
## X554.111 -0.1669117  0.0533739  -3.127 0.001820 ** 
## X380.112  0.0151653  0.0254175   0.597 0.550887    
## X399.112 -0.0339409  0.0303580  -1.118 0.263845    
## X459.112  0.0006901  0.0335578   0.021 0.983599    
## X516.112  0.0149678  0.0356907   0.419 0.675039    
```

```
## X517.l12 -0.0600134  0.0221299  -2.712 0.006814 **
## X554.l12 -0.1568133  0.0469181  -3.342 0.000864 ***
## X380.l13  0.0002788  0.0187718   0.015 0.988153
## X399.l13  0.0071444  0.0228982   0.312 0.755104
## X459.l13 -0.0166942  0.0260179  -0.642 0.521262
## X516.l13 -0.0579600  0.0272919  -2.124 0.033958 *
## X517.l13 -0.0388769  0.0173113  -2.246 0.024954 *
## X554.l13 -0.1545114  0.0354313  -4.361 1.44e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
##
## Residual standard error: 48.59 on 931 degrees of freedom
## Multiple R-Squared: 0.6647,  Adjusted R-squared: 0.6366
## F-statistic: 23.66 on 78 and 931 DF,  p-value: < 2.2e-16
##
##
##
## Covariance matrix of residuals:
##        X380   X399   X459   X516  X517   X554
## X380 8230.6 1651.4 1804.7 1855.0  2515  750.6
## X399 1651.4 5240.4  912.5 1163.8  1889  742.5
## X459 1804.7  912.5 4530.0 1318.9  1954  544.4
## X516 1855.0 1163.8 1318.9 4425.7  2296  813.8
## X517 2514.9 1889.2 1953.5 2295.6 10637 1278.4
## X554  750.6  742.5  544.4  813.8  1278 2360.6
##
## Correlation matrix of residuals:
##        X380   X399   X459   X516   X517   X554
## X380 1.0000 0.2515 0.2956 0.3074 0.2688 0.1703
## X399 0.2515 1.0000 0.1873 0.2416 0.2530 0.2111
## X459 0.2956 0.1873 1.0000 0.2946 0.2814 0.1665
## X516 0.3074 0.2416 0.2946 1.0000 0.3346 0.2518
## X517 0.2688 0.2530 0.2814 0.3346 1.0000 0.2551
## X554 0.1703 0.2111 0.1665 0.2518 0.2551 1.0000
```

3.4 Serial Test

```
vars::serial.test(var.a)
```

```
##
##  Portmanteau Test (asymptotic)
##
## data:  Residuals of VAR object var.a
## Chi-squared = 258.87, df = 108, p-value = 2.087e-14
```

3.5 Creating and preparing Predictions

```
# selecting the variables
# Granger test for causality
```

```r
vars::causality(var.a, #VAR model
          cause = c("X380"))
```

```
## $Granger
##
##  Granger causality H0: X380 do not Granger-cause X399 X459 X516 X517
##  X554
##
## data:  VAR object var.a
## F-Test = 1.5941, df1 = 65, df2 = 5586, p-value = 0.001783
##
##
## $Instant
##
##  H0: No instantaneous causality between: X380 and X399 X459 X516 X517
##  X554
##
## data:  VAR object var.a
## Chi-squared = 152.99, df = 5, p-value < 2.2e-16
```

```r
fcast = predict(var.a, n.ahead = 10)
par(mar = c(2.5,2.5,2.5,2.5))

X380 = fcast$fcst[1]; X380
```

```
## $X380
##             fcst      lower     upper       CI
##  [1,]   87.66732  -90.15249 265.48712 177.8198
##  [2,]   50.78343 -172.12985 273.69671 222.9133
##  [3,]  204.46582  -24.88820 433.81984 229.3540
##  [4,] -264.70409 -494.95216 -34.45601 230.2481
##  [5,]  -46.40174 -277.85129 185.04782 231.4496
##  [6,]   11.91893 -220.85695 244.69481 232.7759
##  [7,]  -24.70974 -258.86780 209.44832 234.1581
##  [8,]   43.29329 -200.08338 286.66996 243.3767
##  [9,]   96.14749 -151.60976 343.90474 247.7572
## [10,]  144.93731 -104.24321 394.11783 249.1805
```

```r
x = X380$X380[,1]; x
```

```
##  [1]   87.66732   50.78343  204.46582 -264.70409  -46.40174   11.91893
##  [7]  -24.70974   43.29329   96.14749  144.93731
```

```r
tail(mymts)
```

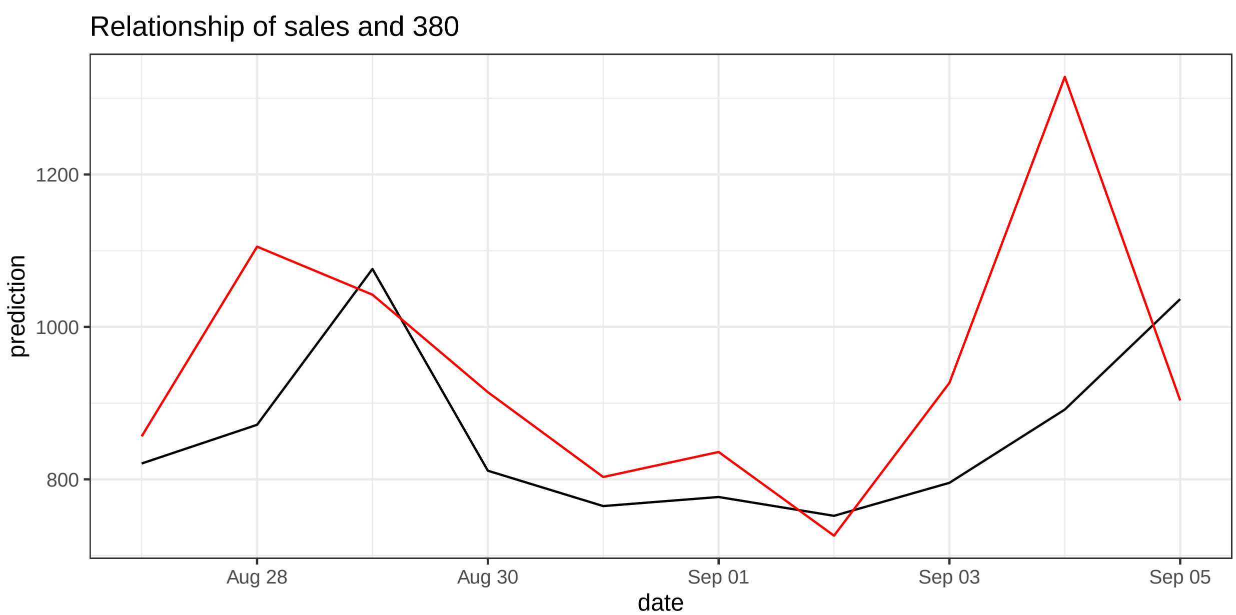
```
##             380    399    459    516     517    554
## [1018,]  867.51 735.65 642.56 740.37 1120.12 312.84
## [1019,] 1114.71 647.80 839.44 685.29 1264.26 399.08
## [1020,]  697.20 603.41 453.36 603.04  973.41 231.36
## [1021,]  591.55 500.77 527.22 607.77 1014.68 265.72
## [1022,]  867.43 532.05 542.22 547.76  994.33 348.15
## [1023,]  733.10 560.13 548.26 662.33 1075.28 374.84
```

```
x = cumsum(x) + 733.10
par(mar = c(2.5,2.5,1,2.5)) #bottom, left, top, and right

test380 <- test$`380`
diff = test380-x

result <- data.frame(test = c(test380),
                     difference = c(diff),
                     prediction =  c(x),
                     date = datelist)


result %>% ggplot(aes(x = date, y = prediction)) +
  geom_line() + geom_line(aes(y=test), color="red") + theme_bw() +
  ggtitle(paste0("Relationship of sales and ", "380", sep= " ")) +
  theme(legend.position="right",legend.direction = "vertical", legend.text = element_text(size=7))
```




```
test[,1]
```

```
##  [1]  856.45 1105.29 1042.28  914.40  803.06  835.91  726.08  926.60 1328.08
## [10]  903.53
```

3.6 Calculate Mean Difference

```
listsites <- c(380,399, 459, 516, 517, 554)
counter = 0
plot_list <- list(1)
g <- NULL
result <- NULL
```

```
for (i in listsites) {
  g <- NULL
  result <- NULL
  counter = counter+1
  x = fcast$fcst[counter]
  x = as.data.frame(x)
  x = unlist(x[1])
  p = as.numeric(tail(mymts,2)[2,counter])
  x =  cumsum(x) + p
  par(mar = c(2.5,2.5,1,2.5))

  g <- test[,counter]
  diff = g-x

  result <- data.frame(test = g,
                       difference = diff,
                       prediction =  x,
                       date = datelist)

  o = ggplot(data=result, aes_string(x = "date", y="prediction")) +
      geom_line() + geom_line(aes_string(y="test"), color="red") + geom_line(aes_string(y="diff"), colo
      theme_fivethirtyeight() + ggtitle(paste0("Site = ", as.character(i), sep= " ")) + theme(plot.titl

  assign(paste0("plt", i), o)
  plot_list <- rlist::list.append(plot_list, o)

  print(paste0("mean error for ",i, " = ", mean(diff)))

}
```

```
## [1] "mean error for 380 = 84.4700618869718"
## [1] "mean error for 399 = 14.7058416069735"
## [1] "mean error for 459 = 0.169449221575502"
## [1] "mean error for 516 = 91.68113802353"
## [1] "mean error for 517 = 27.259284097961"
## [1] "mean error for 554 = 33.2970098272065"
```

3.7 Plot Results

```
plot_list <- plot_list[-1]

nCol <- floor(sqrt(length(plot_list)))

grid.arrange(grobs=plot_list, widths = c(1,1), ncol=2, layout_matrix =  rbind(c(1,2),
                                                                              c(3,4),
                                                                              c(5,6)),
             top = "Predicted time series")
```

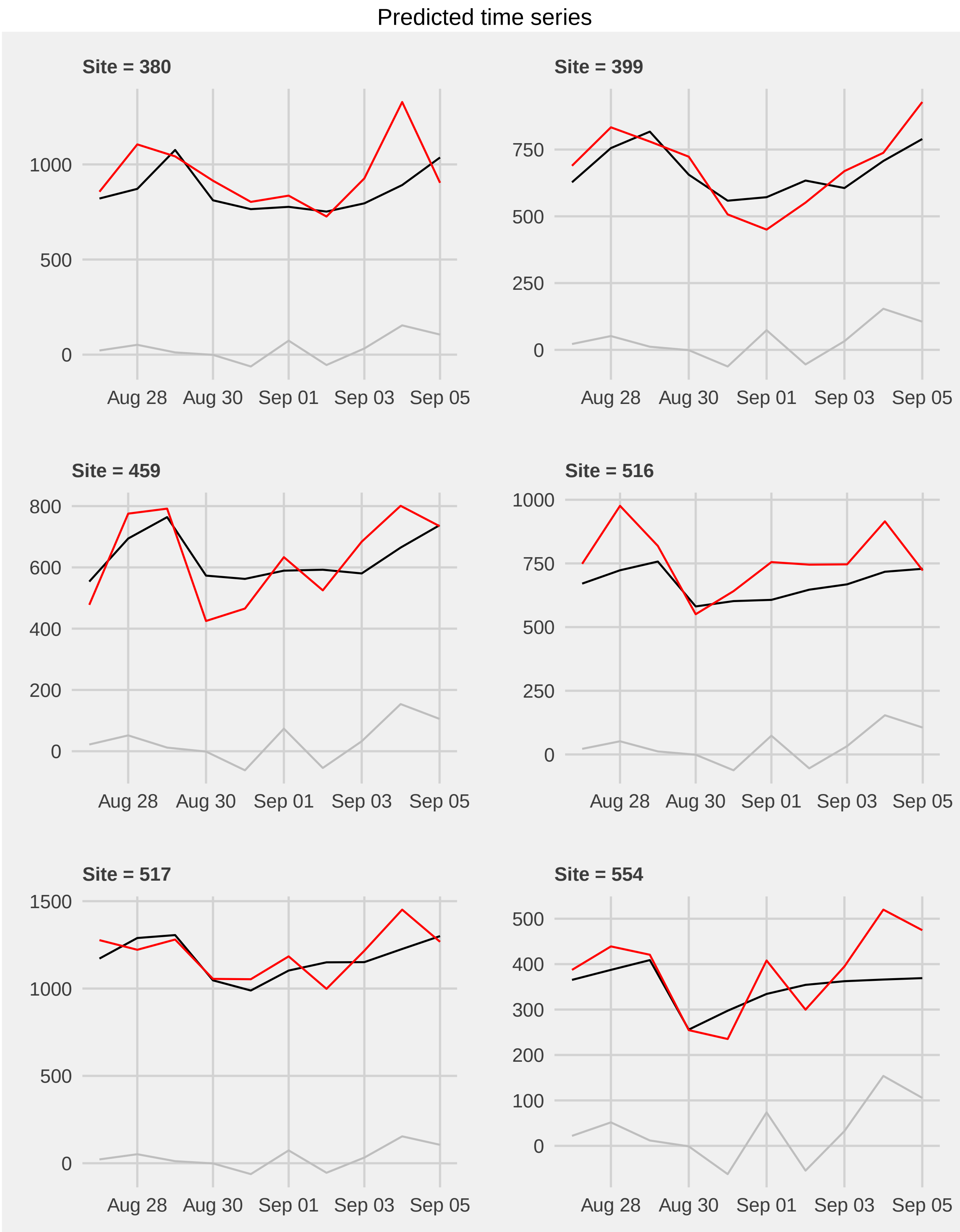


Figure 1: Predictions of Time Series