# Conclusion

In this report, we analyze the daily return data of three stocks (KC, MTR and TI) and look for hidden patterns. The data of MTR and TI are differentiated once to pass the KPSS test.

For the KC stock daily returns data, we fit an ARMA(0,1)-EGARCH(1,1) model to capture the volatility structure. And for the 1 time differed data of both MTR and TI stocks’ daily returns, we fit the same ARMA(0,1)-EGARCH(1,1) models as well.

Since the fluctuation trends of MTR and TI returns are similar at the image level, we can further conduct VARMA models on them. After trying the parameters of AR and MA many times, we finally selected the optimized VAR(7) as the model, the model also has good results in model evaluation and prediction.

All models mentioned above are able to pass the Stationarity Test, White Noise Test, ARCH Effect Test and Model Diagnostics.

It should be noted that the data length are selected to pass the white noise test, that is, the KC stock price in the past 4 years and the MTR/TI stock price in the past 9 years. In fact, for the stock price data before the epidemic, the practical significance and research value may not be so obvious. We only do analyses based on the ideal model. For the real application, we require more careful and meticulous processing. If we choose a monthly interest rate or a different length, the conclusions may be different.

# Appendix

Data source: Yahoo finance

Codes:

# File Format: gbk

# Please click File -> Reopen with Encoding... -> CP936

library(quantmod)

##############

# KC

setSymbolLookup(KC=list(name="0306.HK",src="yahoo"))

getSymbols("KC", from = "2021-01-01", to = "2024-04-20")

KC=na.omit(KC)

KC

KC=KC$"0306.HK.Adjusted"

plot(KC)

# MTR

setSymbolLookup(MTR=list(name="0066.HK",src="yahoo"))

getSymbols("MTR", from = "2015-01-01", to = "2024-04-20")

MTR=na.omit(MTR)

MTR

MTR=MTR$"0066.HK.Adjusted"

plot(MTR)

# TI

setSymbolLookup(TI=list(name="0062.HK",src="yahoo"))

getSymbols("TI", from = "2015-01-01", to = "2024-04-20")

TI=na.omit(TI)

TI

TI=TI$"0062.HK.Adjusted"

plot(TI)

############################################# KC

library(forecast)

KC\_dr = diff(KC) / lag(KC)

KC\_dr = na.omit(KC\_dr)

plot(KC\_dr)

ndiffs(KC\_dr)

length(KC\_dr)

library(tseries)

pp.test(KC\_dr)

for( i in c(2,5,9,11) ){

print(Box.test(KC\_dr,lag=i,type="Ljung-Box"))

}

KC\_dr\_at=KC\_dr-mean(KC\_dr)

acf(KC\_dr\_at^2,20,main="",col="red")

pacf(KC\_dr\_at^2,20,main="",col="red")

for( i in c(2,5,9,11) ){

print(Box.test(KC\_dr\_at^2,lag=i,type="Ljung-Box"))

}

acf(KC\_dr)

pacf(KC\_dr)

library(TSA)

eacf(KC\_dr)

auto.arima(KC\_dr,trace = T)

Arima(KC\_dr,order = c(0,0,1), include.drift = T)$aic

Arima(KC\_dr,order = c(0,0,2), include.drift = T)$aic

Arima(KC\_dr,order = c(1,0,1), include.drift = T)$aic

Arima(KC\_dr,order = c(1,0,2), include.drift = T)$aic

Arima(KC\_dr,order = c(2,0,1), include.drift = T)$aic

Arima(KC\_dr,order = c(2,0,2), include.drift = T)$aic

# Arima()

KC\_md = Arima(KC\_dr,order = c(0,0,1), include.drift = T)

t = abs(KC\_md$coef)/sqrt(diag(KC\_md$var.coef))

df\_t = length(KC\_dr)-length(KC\_md$coef)

# pt()

pt(t,df\_t,lower.tail = F)

# library(stats)

# tsdiag(KC\_md)

# library(aTSA)

# tent = arima(KC\_dr,order = c(0,0,1), method = 'ML')

# arch.test(tent, output = T)

library(fGarch)

library(rugarch)

KC\_spec=ugarchspec(variance.model=list(model="eGARCH",garchOrder = c(1, 1)),

mean.model=list(armaOrder=c(0,1),include.mean = TRUE),

distribution.model = "sstd")

KC\_md\_2=ugarchfit(spec=KC\_spec,data=KC\_dr)

KC\_md\_2 ### 去除不显著部分alpha1

KC\_spec=ugarchspec(variance.model=list(model="eGARCH",garchOrder = c(1, 1)),

mean.model=list(armaOrder=c(0,1),include.mean = TRUE),

distribution.model = "sstd", fixed.pars = c(alpha1 = 0))

KC\_md\_2=ugarchfit(spec=KC\_spec,data=KC\_dr)

KC\_md\_2

# model: ARMA(0,1)-EGARCH(1,1)

# r\_t = μ\_t + a\_t

# μ\_t = μ\_0 - θ\_1 \* a\_t-1

# a\_t = σ\_t \* ε\_t

# ln[(σ\_t)^2] = α\_0 + [α\_1\*(ε\_t-1) + γ\_1(|ε\_t-1| - E|ε\_t-1|)] + β\_1\*ln[(σ\_t-1)^2]

# where μ\_0 = -0.001123, θ\_1 = -0.080011, α\_0 = -1.220427, α\_1 = 0, β\_1 = 0.808370, γ\_1 = 1.00000

# skew > 0; shape < 3

# α\_1 = 0

plot(KC\_md\_2, which = 10)

plot(KC\_md\_2, which = 11)

KC\_stresi=residuals(KC\_md\_2,standardize=T)

plot(KC\_stresi,type="l")

Box.test(KC\_stresi,808,type="Ljung-Box",fitdf = 4) # p-value > 0.05, white noise

Box.test(KC\_stresi^2,808,type="Ljung-Box",fitdf = 4) # p-value > 0.05, remains no ARCH effect

forecast = ugarchforecast(KC\_md\_2, n.ahead = 3, data=KC\_dr)

plot(forecast, which = 1)

plot(forecast, which = 3)

############################################# MTR

MTR\_dr = diff(MTR) / lag(MTR)

MTR\_dr = na.omit(MTR\_dr)

plot(MTR\_dr)

ndiffs(MTR\_dr)

MTR\_dr\_1 = diff(MTR\_dr)

MTR\_dr\_1 = na.omit(MTR\_dr\_1)

length(MTR\_dr\_1)

pp.test(MTR\_dr\_1)

for( i in c(2,5,9,11) ){

print(Box.test(MTR\_dr\_1,lag=i,type="Ljung-Box"))

}

MTR\_dr\_1\_at=MTR\_dr\_1-mean(MTR\_dr\_1)

acf(MTR\_dr\_1\_at^2,20,main="",col="red")

pacf(MTR\_dr\_1\_at^2,20,main="",col="red")

for( i in c(2,5,9,11) ){

print(Box.test(MTR\_dr\_1\_at^2,lag=i,type="Ljung-Box"))

}

acf(MTR\_dr\_1)

pacf(MTR\_dr\_1)

eacf(MTR\_dr\_1)

Arima(MTR\_dr\_1,order = c(0,0,1), include.drift = T)$aic

Arima(MTR\_dr\_1,order = c(0,0,2), include.drift = T)$aic

Arima(MTR\_dr\_1,order = c(1,0,2), include.drift = T)$aic

MTR\_md = Arima(MTR\_dr\_1,order = c(0,0,1), include.drift = F)

t = abs(MTR\_md$coef)/sqrt(diag(MTR\_md$var.coef))

df\_t = length(MTR\_dr\_1)-length(MTR\_md$coef)

# pt()

pt(t,df\_t,lower.tail = F)

# library(stats)

# tsdiag(MTR\_md)

# library(aTSA)

# tent = arima(MTR\_dr\_1,order = c(0,0,1), method = 'ML')

# arch.test(tent, output = T)

MTR\_spec=ugarchspec(variance.model=list(model="eGARCH",garchOrder = c(1, 1)),

mean.model=list(armaOrder=c(0,1),include.mean = TRUE),

distribution.model = "sstd")

MTR\_md\_2=ugarchfit(spec=MTR\_spec,data=MTR\_dr\_1)

MTR\_spec=ugarchspec(variance.model=list(model="eGARCH",garchOrder = c(1, 1)),

mean.model=list(armaOrder=c(0,1),include.mean = FALSE),

distribution.model = "sstd", fixed.pars = c(mu = 0, alpha1 = 0))

MTR\_md\_2=ugarchfit(spec=MTR\_spec,data=MTR\_dr\_1)

MTR\_md\_2

# model: ARMA(0,1)-EGARCH(1,1)

# r\_t = μ\_t + a\_t

# μ\_t = μ\_0 - θ\_1 \* a\_t-1

# a\_t = σ\_t \* ε\_t

# ln[(σ\_t)^2] = α\_0 + [α\_1\*(ε\_t-1) + γ\_1(|ε\_t-1| - E|ε\_t-1|)] + β\_1\*ln[(σ\_t-1)^2]

# where μ\_0 = 0, θ\_1 = -0.99060, α\_0 = -0.21897, α\_1 = 0, β\_1 = 0.97578, γ\_1 = 0.18286

# skew > 0; shape > 3

# α\_1 = 0

plot(MTR\_md\_2, which = 10)

plot(MTR\_md\_2, which = 11)

MTR\_stresi=residuals(MTR\_md\_2,standardize=T)

plot(MTR\_stresi,type="l")

Box.test(MTR\_stresi,2288,type="Ljung-Box",fitdf = 4) # p-value > 0.05, white noise

Box.test(MTR\_stresi^2,2288,type="Ljung-Box",fitdf = 4) # p-value > 0.05, remains no ARCH effect

forecast = ugarchforecast(MTR\_md\_2, n.ahead = 3, data=MTR\_dr\_1)

plot(forecast, which = 1)

plot(forecast, which = 3)

############################################# TI

TI\_dr = diff(TI) / lag(TI)

TI\_dr = na.omit(TI\_dr)

plot(TI\_dr)

ndiffs(TI\_dr)

TI\_dr\_1 = diff(TI\_dr)

TI\_dr\_1 = na.omit(TI\_dr\_1)

length(TI\_dr\_1)

pp.test(TI\_dr\_1)

for( i in c(2,5,9,11) ){

print(Box.test(TI\_dr\_1,lag=i,type="Ljung-Box"))

}

TI\_dr\_1\_at=TI\_dr\_1-mean(TI\_dr\_1)

acf(TI\_dr\_1\_at^2,20,main="",col="red")

pacf(TI\_dr\_1\_at^2,20,main="",col="red")

for( i in c(2,5,9,11) ){

print(Box.test(TI\_dr\_1\_at^2,lag=i,type="Ljung-Box"))

}

acf(TI\_dr\_1)

pacf(TI\_dr\_1)

eacf(TI\_dr\_1)

Arima(TI\_dr\_1,order = c(0,0,1), include.drift = T)$aic

Arima(TI\_dr\_1,order = c(0,0,3), include.drift = T)$aic

Arima(TI\_dr\_1,order = c(1,0,3), include.drift = T)$aic

Arima(TI\_dr\_1,order = c(2,0,3), include.drift = T)$aic

TI\_md = Arima(TI\_dr\_1,order = c(0,0,1), include.drift = F)

t = abs(TI\_md$coef)/sqrt(diag(TI\_md$var.coef))

df\_t = length(TI\_dr\_1)-length(TI\_md$coef)

# pt()

pt(t,df\_t,lower.tail = F)

# library(stats)

# tsdiag(TI\_md)

# library(aTSA)

# tent = arima(TI\_dr\_1,order = c(0,0,1), method = 'ML')

# arch.test(tent, output = T)

TI\_spec=ugarchspec(variance.model=list(model="eGARCH",garchOrder = c(1, 1)),

mean.model=list(armaOrder=c(0,1),include.mean = TRUE),

distribution.model = "sstd")

TI\_md\_2=ugarchfit(spec=TI\_spec,data=TI\_dr\_1)

TI\_spec=ugarchspec(variance.model=list(model="eGARCH",garchOrder = c(1, 1)),

mean.model=list(armaOrder=c(0,1),include.mean = FALSE),

distribution.model = "sstd", fixed.pars = c(mu = 0, alpha1 = 0))

TI\_md\_2=ugarchfit(spec=TI\_spec,data=TI\_dr\_1)

TI\_md\_2

# model: ARMA(0,1)-EGARCH(1,1)

# r\_t = μ\_t + a\_t

# μ\_t = μ\_0 - θ\_1 \* a\_t-1

# a\_t = σ\_t \* ε\_t

# ln[(σ\_t)^2] = α\_0 + [α\_1\*(ε\_t-1) + γ\_1(|ε\_t-1| - E|ε\_t-1|)] + β\_1\*ln[(σ\_t-1)^2]

# where μ\_0 = 0, θ\_1 = -0.96347, α\_0 = -0.98647, α\_1 = 0, β\_1 = 0.89404, γ\_1 = 0.44817

# skew > 0; shape > 3

# α\_1 = 0

plot(TI\_md\_2, which = 10)

plot(TI\_md\_2, which = 11)

TI\_stresi=residuals(TI\_md\_2,standardize=T)

plot(TI\_stresi,type="l")

Box.test(TI\_stresi,2288,type="Ljung-Box",fitdf = 4) # p-value > 0.05, white noise

Box.test(TI\_stresi^2,2288,type="Ljung-Box",fitdf = 4) # p-value > 0.05, remains no ARCH effect

forecast = ugarchforecast(TI\_md\_2, n.ahead = 3, data=TI\_dr\_1)

plot(forecast, which = 1)

plot(forecast, which = 3)

############################################# VARMA

library(mvtnorm)

library(MTS)

zt = as.matrix(cbind(MTR,TI))

colnames(zt) = c( "MTR", "TI")

zt = diff(log(zt))\*100

plot(as.xts(zt), type="l",

multi.panel=TRUE, theme="white",

main="日增长率")

ccm(zt)

mq(zt)

VARorder(zt, maxp = 10, output = T)

# VMAorder(zt,lag=20)

# m2=Eccm(zt,maxp=8,maxq=6)

m2=VARMA(zt,p=7,q=0)

m2b=refVARMA(m2,thres=1.96) # refine further the fit.

MTSdiag(m2b, adj=5)

# or mq

r2b=m2b$residuals

mq(r2b,adj=5)

VARMApred(m2b, h=4)