

ECO374: Forecasting and Time Series Econometrics
Department of Economics, University of Toronto
Problem Set 3
Winter 2024

This Problem Set is based on the software file *Case Study 3*.

1. Load data on the NASDAQ Composite Index (daily close price). The start of the data series should be adjusted to 2010-01-01.
2. Fit an ARMA(1,1)-GARCH(1,1) model to the data. Based on this model:
3. Forecast the Value at Risk (VaR) at $\alpha=1\%$ for a \$50,000 position in the Index for the next 8 days and plot the result in a graph (adjust the title).
4. Forecast the Expected Shortfall at $\alpha=1\%$ for a \$50,000 position in the Index for the next 8 days and plot the result in a graph (adjust the title).

Submission details:

Submit one pdf file with your code, Markdown text, and output. The file should be uploaded to Quercus by the due date and time. There is 10% grade penalty for each new day of late submission.

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Relevant Packages

```
options(repos = c(CRAN="http://cran.rstudio.com"))
if (!require("MASS")) install.packages("MASS")
if (!require("forecast")) install.packages("forecast")
if (!require("rugarch")) install.packages("rugarch")
if (!require("rmgarch")) install.packages("rmgarch")
if (!require("timetk")) install.packages("timetk")
if (!require("quantmod")) install.packages("quantmod")
library(MASS); library(rugarch); library(rmgarch); library(quantmod); library(graphics); library(forecast)
library(xts); library(timetk); library(stats); library(ggplot2); library(ggfortify); library(ggpubr)
```

Question 1: Obtaining NASDAQ Index Data

Data: NASDAQ Composite Index from Yahoo Finance ([Source](#))

```
IXIC <- quantmod::getSymbols("^IXIC", src="yahoo", return.class="xts", from="2010-01-01", auto.assign=F)
NASDAQ <- IXIC$IXIC.Close
colnames(NASDAQ) <- "NASDAQ"
NASDAQ_r <- na.omit(diff(log(NASDAQ)))
```

Question 2: ARMA and GARCH Model Specifications

ARMA of Order (1,1), GARCH of order (1,1).

```
model <- rugarch::ugarchspec(variance.model = list(model="sGARCH", garchOrder=c(1, 1)),
                             mean.model = list(armaOrder=c(1, 1)))
model
```

```
##
## *-----*
## *      GARCH Model Spec      *
## *-----*
##
## Conditional Variance Dynamics
## -----
## GARCH Model      : sGARCH(1,1)
## Variance Targeting : FALSE
```

```
##
## Conditional Mean Dynamics
## -----
## Mean Model      : ARFIMA(1,0,1)
## Include Mean    : TRUE
## GARCH-in-Mean   : FALSE
##
## Conditional Distribution
## -----
## Distribution : norm
## Includes Skew : FALSE
## Includes Shape : FALSE
## Includes Lambda : FALSE
```

Estimate the model

```
model_fit <- rugarch::ugarchfit(spec=model, data=NASDAQ_r)
```

Forecast

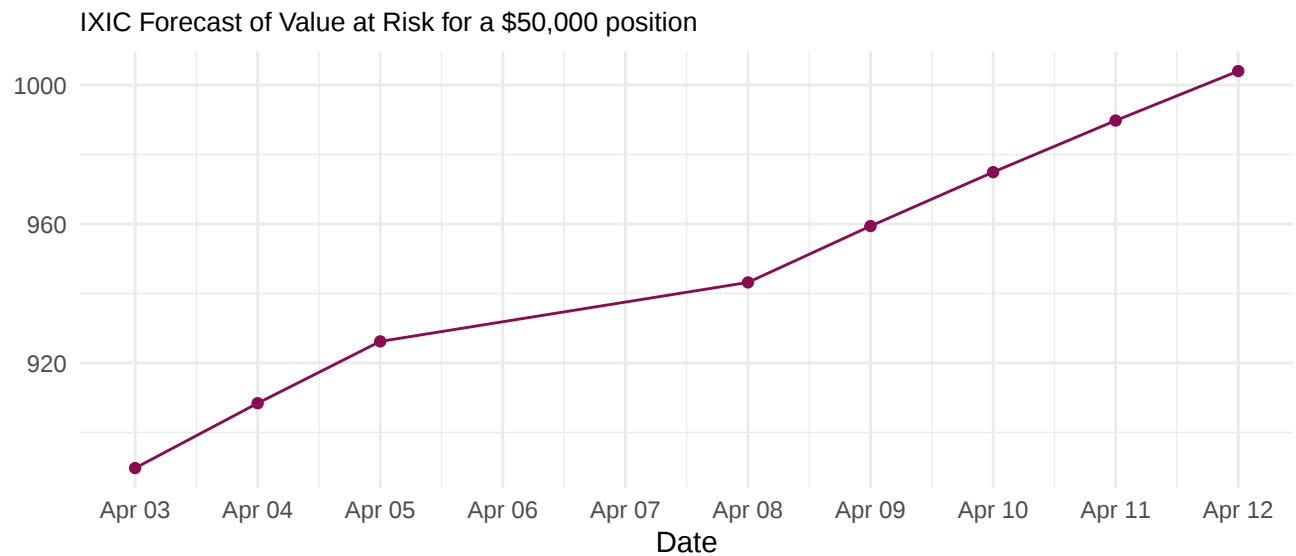
```
n_future <- 8
model_forecast <- rugarch::ugarchforecast(fit=model_fit, n.ahead=n_future)
id <- timetk::tk_index(NASDAQ_r)
id.f <- timetk::tk_make_future_timeseries(id, length_out=n_future, inspect_weekdays=TRUE)
```

Question 3: Value at Risk Forecasting

VaR at $\alpha = 1\%$ for a \$50,000 position in IXIC. Time horizon is 8 days.

```
f_mean <- as.numeric(model_forecast@forecast$seriesFor)
f_std <- as.numeric(model_forecast@forecast$sigmaFor)
VaR_f <- 50000*abs(f_mean-2.33*f_std)
VaR_f <- xts(VaR_f, order.by=id.f)
colnames(VaR_f) <- "VaR"

ggplot(data=VaR_f, aes(x=index(VaR_f), y=VaR)) +
  geom_line(color="deeppink4") +
  geom_point(color="deeppink4") +
  labs(x="Date", y="", title="IXIC Forecast of Value at Risk for a $50,000 position") +
  theme_minimal() + scale_x_date(date_breaks="1 day", date_labels = "%b %d") +
  theme(plot.title = element_text(size=10))
```



Question 4: Expected Shortfall

Expected Shortfall at $\alpha = 1\%$ for a \$50,000 position in IXIC. Time horizon remains 8 days.

```
ES <- 50000*abs(f_mean-2.64*f_std)
ES <- xts(ES, order.by=id.f)
colnames(ES) <- "es"

ggplot(data=ES, aes(x=index(ES), y=es)) +
  geom_line(color="springgreen4") +
  geom_point(color="springgreen4") +
  labs(x="Date", y="", title="IXIC Expected Shortfall for a $50,000 position.") +
  theme_minimal() + scale_x_date(date_breaks="1 day", date_labels = "%b %d") +
  theme(plot.title = element_text(size=10))
```

