

Assignment 04, Question 3&4

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March 26, 2021

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FBE 543 Forecasting and Risk Analysis

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Question 3

a.

$$Y_t = 2.5 + .35Y_{t-1} + \epsilon_t \quad (1)$$

- **ARIMA model:** $ARIMA(1, 0, 0)$.
- **Stationarity:** Stationary as $\sum_{i=1}^n |\alpha_i| = .35 < 1$.
- **Invertibility:** N/A.

b.

$$Y_t = 4.5 - 1.5Y_{t-1} + \epsilon_t - .5\epsilon_{t-1} \quad (2)$$

- **ARIMA model:** $ARIMA(1, 0, 1)$.
- **Stationarity:** Non-Stationary as $\sum_{i=1}^n |\alpha_i| = |1.5| > 1$.
- **Invertibility:** Invertible as $\sum_{i=1}^n |\beta_i| = .5 < 1$.

c.

$$Y_t = 1.2 - .75Y_{t-1} + .3Y_{t-2} + \epsilon_t \quad (3)$$

- **ARIMA model:** $ARIMA(2, 0, 0)$.
- **Stationarity:** Non-Stationary as $\sum_{i=1}^n |\alpha_i| = |- .75| + |.3| = 1.05 > 1$.
- **Invertibility:** N/A.

d.

$$Y_t = 2.5 - .95Y_{t-1} + \epsilon_t - .5\epsilon_{t-1} - .2\epsilon_t - 2 \quad (4)$$

- **ARIMA model:** $ARIMA(1, 0, 2)$.
- **Stationarity:** Stationary as $\sum_{i=1}^n |\alpha_i| = 0.95 < 1$.
- **Invertibility:** Invertible as $\sum_{i=1}^n |\beta_i| = |- .5| + |- .2| = 0.7 < 1$.

e.

$$Y_t = .52 - 1.2Y_{t-1} + \epsilon_t + .2\epsilon_{t-1} \quad (5)$$

- **ARIMA model:** $ARIMA(1, 0, 1)$.
- **Stationarity:** Non-Stationary as $\sum_{i=1}^n |\alpha_i| = 1.2 > 1$.
- **Invertibility:** Invertible as $\sum_{i=1}^n |\beta_i| = |.2| = 0.2 < 1$.

f.

$$DY_t = 1.2DY_{t-1} + \epsilon_t \quad (6)$$

- **ARIMA model:** $ARIMA(1, 1, 0)$.
- **Stationarity:** Non-Stationary as $\sum_{i=1}^n |\alpha_i| = 1.2 > 1$.
- **Invertibility:** N/A.

g.

$$DY_t = .42DY_{t-1} + \epsilon_t - .6\epsilon_{t-1} \quad (7)$$

- **ARIMA model:** $ARIMA(1, 1, 1)$.
- **Stationarity:** Stationary as $\sum_{i=1}^n |\alpha_i| = 0.42 < 1$.
- **Invertibility:** Invertible as $\sum_{i=1}^n |\beta_i| = |- .6| = 0.6 < 1$.

h.

$$DY_t = .62Y_{t-1} + \epsilon_t - .6\epsilon_{t-1} \quad (8)$$

- **ARIMA model:** Incorrect model as LHS and RHS does not have similar order difference term.
- **Stationarity:** N/A.
- **Invertibility:** N/A.

i.

$$Y_t = 2.5 + .95DY_{t-1} + \epsilon_t \quad (9)$$

- **ARIMA model:** Incorrect model as *LHS* and *RHS* does not have similar order difference term.
- **Stationarity:** N/A.
- **Invertibility:** N/A.

j.

$$Y_t = 1.6 + \epsilon_t - .6\epsilon_{t-1} \quad (10)$$

- **ARIMA model:** $ARIMA(0, 0, 1)$.
- **Stationarity:** Stationary as $\sum_{i=1}^n |\beta_i| = |- .6| = 0.6 < 1$.
- **Invertibility:** Invertible as $\sum_{i=1}^n |\beta_i| = |- .6| = 0.6 < 1$.

Question 4

a. Do a three-period ahead forecasting using the given initial values and statistics. Write 95% confidence interval for each forecast.

a)

$$Y_t = 1.6 + .75Y_{t-1} + \epsilon_t$$

given:

$$y_0 = 2$$

$$\sigma^2 = 1.21 \quad (11)$$

```
y_0 <- 2
sigmaSq <- 1.21
alpha_0 <- 1.6
alpha_1 <- .75

f <- function(y_t) {alpha_0 + alpha_1*y_t}
y_1 <- f(y_0)
y_2 <- f(y_1)
y_3 <- f(y_2)
```

Forecast Variable	Forecasted Value	95% Confidence Interval Equation	95% Confidence Interval
$Y_1^F = 1.6 + .75Y_0$	3.1	$Y_{t+1}^F \pm 1.96\sqrt{\sigma^2}$	[0.944, 5.256]
$Y_2^F = 1.6 + .75Y_1$	3.925	$Y_{t+2}^F \pm 1.96\sqrt{\sigma^2(1 + \alpha^2)}$	[1.23, 6.62]
$Y_3^F = 1.6 + .75Y_2$	4.54375	$Y_{t+3}^F \pm 1.96\sqrt{\sigma^2(1 + \alpha_1^2 + \alpha_1^4)}$	[1.5884518, 7.4990482]

b)

$$Y_t = 2.5 + .3Y_{t-1} + \epsilon_t$$

given:

$$y_0 = 10$$

$$\sigma^2 = 6.25$$
(12)

```
y_0 <- 10
sigmaSq <- 6.25
alpha_0 <- 2.5
alpha_1 <- .3

f <- function(y_t) {alpha_0 + alpha_1*y_t}
y_1 <- f(y_0)
y_2 <- f(y_1)
y_3 <- f(y_2)
```

Forecast Variable	Forecasted Value	95% Confidence Interval Equation	95% Confidence Interval
$Y_1^F = 2.5 + .3Y_0$	5.5	$Y_{t+1}^F \pm 1.96\sqrt{\sigma^2}$	[0.6, 10.4]
$Y_2^F = 2.5 + .3Y_1$	4.15	$Y_{t+2}^F \pm 1.96\sqrt{\sigma^2(1 + \alpha^2)}$	[-1.975, 9.2657502]
$Y_3^F = 2.5 + .3Y_2$	3.745	$Y_{t+3}^F \pm 1.96\sqrt{\sigma^2(1 + \alpha_1^2 + \alpha_1^4)}$	[-1.3897231, 8.8797231]

c)

$$Y_t = 1.2 - .2Y_{t-1} + \epsilon_t$$

given:

$$y_0 = 1.5$$

$$\sigma^2 = .49$$
(13)

```
y_0 <- 1.5
sigmaSq <- .49
alpha_0 <- 1.2
alpha_1 <- .2

f <- function(y_t) {alpha_0 - alpha_1*y_t}
y_1 <- f(y_0)
y_2 <- f(y_1)
y_3 <- f(y_2)
```

Forecast Variable	Forecasted Value	95% Confidence Interval Equation	95% Confidence Interval
$Y_1^F = 1.2 - .2Y_0$	0.9	$Y_{t+1}^F \pm 1.96\sqrt{\sigma^2}$	[-0.472, 2.272]
$Y_2^F = 1.2 - .2Y_1$	1.02	$Y_{t+2}^F \pm 1.96\sqrt{\sigma^2(1 + \alpha^2)}$	[-0.379171, 2.419171]

Forecast Variable	Forecasted Value	95% Confidence Interval Equation	95% Confidence Interval
$Y_3^F = 1.2 - .2Y_2$	0.996	$Y_{t+3}^F \pm 1.96\sqrt{\sigma^2(1 + \alpha_1^2 + \alpha_1^4)}$	[-0.4042468, 2.3962468]

d)

$$\begin{aligned}
Y_t &= 2.5 - .8Y_{t-1} + \epsilon_t \\
\text{given:} \\
y_0 &= 6 \\
\sigma^2 &= 3.69
\end{aligned} \tag{14}$$

```

y_0 <- 6
sigmaSq <- 3.69
alpha_0 <- 2.5
alpha_1 <- .8

f <- function(y_t) {alpha_0 - alpha_1*y_t}
y_1 <- f(y_0)
y_2 <- f(y_1)
y_3 <- f(y_2)

```

Forecast Variable	Forecasted Value	95% Confidence Interval Equation	95% Confidence Interval
$Y_1^F = 2.5 - .8Y_0$	-2.3	$Y_{t+1}^F \pm 1.96\sqrt{\sigma^2}$	[-6.0650371, 1.4650371]
$Y_2^F = 2.5 - .8Y_1$	4.34	$Y_{t+2}^F \pm 1.96\sqrt{\sigma^2(1 + \alpha^2)}$	[-0.4816, 9.1616]
$Y_3^F = 2.5 - .8Y_2$	-0.972	$Y_{t+3}^F \pm 1.96\sqrt{\sigma^2(1 + \alpha_1^2 + \alpha_1^4)}$	[-6.3621867, 4.4181867]

e)

$$\begin{aligned}
Y_t &= - .5Y_{t-1} + \epsilon_t \\
\text{given:} \\
y_0 &= - 1.6 \\
\sigma^2 &= 1.44
\end{aligned} \tag{15}$$

```

y_0 <- -1.6
sigmaSq <- 1.44
alpha_0 <- 0
alpha_1 <- -.5

f <- function(y_t) {alpha_0 + alpha_1*y_t}
y_1 <- f(y_0)
y_2 <- f(y_1)
y_3 <- f(y_2)

```

Forecast Variable	Forecasted Value	95% Confidence Interval Equation	95% Confidence Interval
$Y_1^F = -0.5Y_0$	0.8	$Y_{t+1}^F \pm 1.96\sqrt{\sigma^2}$	[-1.552, 3.152]
$Y_2^F = -0.5Y_1$	-0.4	$Y_{t+2}^F \pm 1.96\sqrt{\sigma^2(1 + \alpha^2)}$	[-3.0296159, 2.2296159]
$Y_3^F = -0.5Y_2$	0.2	$Y_{t+3}^F \pm 1.96\sqrt{\sigma^2(1 + \alpha_1^2 + \alpha_1^4)}$	[-2.4945545, 2.8945545]

Do a long-run (unconditional) forecasting and write 95% confidence interval.

a)

$$\begin{aligned}
 Y_t &= 1.6 + .75Y_{t-1} + \epsilon_t \\
 \text{given:} \\
 y_0 &= 2 \\
 \sigma^2 &= 1.21
 \end{aligned}
 \tag{16}$$

```

alpha_0 <- 1.6
alpha_1 <- .75
y_0 <- 2
sigmaSq <- 1.21

yLR <- alpha_0 / (1 - alpha_1)
sigmaSq_yLR <- sigmaSq / (1 - alpha_1^2)
y_1 <- f(y_0)
y_2 <- f(y_1)
y_3 <- f(y_2)

```

Forecast Long Run	Forecasted Value	95% Confidence Interval Equation	95% Confidence Interval
$Y_{LR} = \frac{1.6}{0.75}$	6.4	$Y_{LR} \pm 1.96\sqrt{\frac{\sigma^2}{1 - \alpha_1^2}}$	[3.1404344, 9.6595656]

b)

$$\begin{aligned}
 Y_t &= 2.5 + .3Y_{t-1} + \epsilon_t \\
 \text{given:} \\
 y_0 &= 10 \\
 \sigma^2 &= 6.25
 \end{aligned}
 \tag{17}$$

```

alpha_0 <- 2.5
alpha_1 <- .3
y_0 <- 10
sigmaSq <- 6.25

yLR <- alpha_0 / (1 - alpha_1)
sigmaSq_yLR <- sigmaSq / (1 - alpha_1^2)

```

```

y_1 <- f(y_0)
y_2 <- f(y_1)
y_3 <- f(y_2)

```

Forecast Long Run	Forecasted Value	95% Confidence Interval Equation	95% Confidence Interval
$Y_{LR} = \frac{2.5}{0.3}$	3.5714286	$Y_{LR} \pm 1.96\sqrt{\frac{\sigma^2}{1-\alpha_1^2}}$	[-1.5651671, 8.7080243]

c)

$$\begin{aligned}
Y_t &= 1.2 - .2Y_{t-1} + \epsilon_t \\
\text{given:} \\
y_0 &= 1.5 \\
\sigma^2 &= .49
\end{aligned}
\tag{18}$$

```

alpha_0 <- 1.2
alpha_1 <- -.2
y_0 <- 1.5
sigmaSq <- .49

yLR <- alpha_0 / (1 - alpha_1)
sigmaSq_yLR <- sigmaSq / (1 - alpha_1^2)
y_1 <- f(y_0)
y_2 <- f(y_1)
y_3 <- f(y_2)

```

Forecast Long Run	Forecasted Value	95% Confidence Interval Equation	95% Confidence Interval
$Y_{LR} = \frac{1.2}{-.2}$	1	$Y_{LR} \pm 1.96\sqrt{\frac{\sigma^2}{1-\alpha_1^2}}$	[-0.4002916, 2.4002916]

d)

$$\begin{aligned}
Y_t &= 2.5 - .8Y_{t-1} + \epsilon_t \\
\text{given:} \\
y_0 &= 6 \\
\sigma^2 &= 3.69
\end{aligned}
\tag{19}$$

```

alpha_0 <- 2.5
alpha_1 <- -.8
y_0 <- 6
sigmaSq <- 3.69

yLR <- alpha_0 / (1 - alpha_1)
sigmaSq_yLR <- sigmaSq / (1 - alpha_1^2)
y_1 <- f(y_0)

```

```
y_2 <- f(y_1)
y_3 <- f(y_2)
```

Forecast Long Run	Forecasted Value	95% Confidence Interval Equation	95% Confidence Interval
$Y_{LR} = \frac{2.5}{-0.8}$	1.3888889	$Y_{LR} \pm 1.96\sqrt{\frac{\sigma^2}{1-\alpha_1^2}}$	[-4.8861729, 7.6639506]

e)

$$\begin{aligned}
 Y_t &= -.5Y_{t-1} + \epsilon_t \\
 \text{given:} \\
 y_0 &= -1.6 \\
 \sigma^2 &= 1.44
 \end{aligned}
 \tag{20}$$

```
alpha_0 <- 0
alpha_1 <- -.5
y_0 <- -1.6
sigmaSq <- 1.44

yLR <- alpha_0 / (1 - alpha_1)
sigmaSq_yLR <- sigmaSq / (1 - alpha_1^2)
y_1 <- f(y_0)
y_2 <- f(y_1)
y_3 <- f(y_2)
```

Forecast Long Run	Forecasted Value	95% Confidence Interval Equation	95% Confidence Interval
$Y_{LR} = \frac{0}{-0.5}$	0	$Y_{LR} \pm 1.96\sqrt{\frac{\sigma^2}{1-\alpha_1^2}}$	[-2.7158557, 2.7158557]