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title: "04_Fitting_Models"
author: "Callum Weinberg"
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output: pdf_document
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```{r setup, include=FALSE}
knitr::opts_chunk$set(echo = TRUE)
```

Libraries

```{r}
library(dplyr, warn.conflicts = FALSE) #Using
library(tidyr) #Using
library(knitr) #Using
library(lubridate, warn.conflicts = FALSE) #Using
library(ggplot2) #Using
library(MASS) #Uncertain
library(qpcR) #Using
library(forecast) #Using
library(cowplot) #Using
library(TSA) #Using
```


MODEL WITH ONLY SEASONAL DIFFERENCE (Lag 12)

```{r}
load(file="Data/landings_transformed_season_only.Rdata")
landing_ts_so = landings_transformed_season_only$pounds_transformed
```

Model 40
```{r}
model40 = arima(landing_ts_so, order=c(2,0,2), seasonal = list(order = c(1,1,1), period = 12),
                method = "ML",fixed = c(NA,NA,0,NA,NA,NA))
model40
AICc(model40)


# Phi (corresponsing to AR)
AR = polyroot(c(1,-.1195,-.8804))
AR_df = data.frame(Root = c("AR1","AR2"),
                   real = Re(AR), im = Im(AR))
AR_df =
  AR_df %>%
  mutate(z = sqrt(real^2 + im^2))
paste0("Smallest AR Root on Complex Plane: ",min(AR_df$z))

# Theta (Corresponding to MA)
MA = polyroot(c(1,0,-0.8638))
MA_df = data.frame(Root = c("MA1","MA2"),
                   real = Re(MA), im = Im(MA))
MA_df =
  MA_df %>%
  mutate(z = sqrt(real^2 + im^2))
paste0("Smallest MA Root on Complex Plane: ",min(MA_df$z))

# PHI (corresponsing to SAR)
SAR = polyroot(c(1,0.4485))
SAR_df = data.frame(Root = c("SAR1"),
                   real = Re(SAR), im = Im(SAR))
SAR_df =
  SAR_df %>%
  mutate(z = sqrt(real^2 + im^2))
paste0("Smallest SAR Root on Complex Plane: ",min(SAR_df$z))

# THETA (Corresponding to SMA)
SMA = polyroot(c(1,-e0.9806))
SMA_df = data.frame(Root = c("SMA1"),
                   real = Re(SMA), im = Im(SMA))
SMA_df =
  SMA_df %>%
  mutate(z = sqrt(real^2 + im^2))
paste0("Smallest SMA Root on Complex Plane: ",min(SMA_df$z))

kable(rbind(AR_df,MA_df,SAR_df,SMA_df), caption = "Phi(B) Roots and Theta(B) Roots")
```
```

```

# Model 41

```{r}
model41 = arima(landing_ts_so, order=c(2,0,2), seasonal = list(order = c(1,1,1), period = 12),
                method = "ML",fixed = c(NA,NA,NA,NA,NA,NA))
model41
AICc(model41)


# Phi (corresponsing to AR)
#AR = polyroot(c(1,0.5245,-0.5261,-0.9983)) for 303 x 111
AR = polyroot(c(1,-.1195,-.8804))
AR_df = data.frame(Root = c("AR1","AR2"),
                   real = Re(AR), im = Im(AR))
AR_df =
  AR_df %>%
  mutate(z = sqrt(real^2 + im^2))
paste0("Smallest AR Root on Complex Plane: ",min(AR_df$z))


# MA = polyroot(c(1,-.6319,0.3399,.8839))  for 303 x 111
MA = polyroot(c(1,0,0.8638))
MA_df = data.frame(Root = c("MA1","MA2"),
                   real = Re(MA), im = Im(MA))
MA_df =
  MA_df %>%
  mutate(z = sqrt(real^2 + im^2))
paste0("Smallest MA Root on Complex Plane: ",min(MA_df$z))

kable(rbind(AR_df,MA_df), caption = "Phi(B) Roots and Theta(B) Roots")
```

Model 42
```{r}
model42 = arima(landing_ts_so, order=c(3,0,3), seasonal = list(order = c(1,1,1), period = 12),
                method = "ML",fixed = c(NA,NA,0,NA,NA,NA,NA,NA))
model42
AICc(model42)

# Theta_1 = 1, not invertible
```

Model 43

```{r}
# Model 43
model43 = arima(landing_ts_so, order=c(1,0,1), seasonal = list(order = c(1,1,1), period = 12),
                method = "ML",fixed = c(NA,NA,NA,NA))
model43
AICc(model43)

# Phi (corresponsing to AR)
AR = polyroot(c(1,-0.9999))
AR_df = data.frame(Root = c("AR1"),
                   real = Re(AR), im = Im(AR))
AR_df =
  AR_df %>%
  mutate(z = sqrt(real^2 + im^2))
paste0("Smallest AR Root on Complex Plane: ",min(AR_df$z))


# Theta (corresponding to MA)
MA = polyroot(c(1,-0.8988))
MA_df = data.frame(Root = c("MA1"),
                   real = Re(MA), im = Im(MA))
MA_df =
  MA_df %>%
  mutate(z = sqrt(real^2 + im^2))
paste0("Smallest MA Root on Complex Plane: ",min(MA_df$z))

# PHI (corresponsing to SAR)
SAR = polyroot(c(1,0.4546))
SAR_df = data.frame(Root = c("SAR1"),
                   real = Re(SAR), im = Im(SAR))
SAR_df =
  SAR_df %>%
```
```

```
  mutate(z = sqrt(real^2 + im^2))
paste0("Smallest SAR Root on Complex Plane: ",min(SAR_df$z))

# THETA (Corresponding to SMA)
SMA = polyroot(c(1,-0.9822))
SMA_df = data.frame(Root = c("SMA1"),
                    real = Re(SMA), im = Im(SMA))
SMA_df =
  SMA_df %>%
  mutate(z = sqrt(real^2 + im^2))
paste0("Smallest SMA Root on Complex Plane: ",min(SMA_df$z))

kable(rbind(AR_df,MA_df,SAR_df,SMA_df), caption = "Phi(B) Roots and Theta(B) Roots")

# Stationary and Invertible, although the ar1 term is only just stationary
```


Model 44

```{r}
model44 = arima(landing_ts_so, order=c(2,0,3), seasonal = list(order = c(1,1,1), period = 12),
                method = "ML",fixed = c(0,NA,0,0,NA,NA,NA))
model44
AICc(model44)

# Phi (corresponsing to AR)
AR = polyroot(c(1,0,-0.2517))
AR_df = data.frame(Root = c("AR1","AR2"),
                    real = Re(AR), im = Im(AR))
AR_df =
  AR_df %>%
  mutate(z = sqrt(real^2 + im^2))
paste0("Smallest AR Root on Complex Plane: ",min(AR_df$z))

# Theta (corresponding to MA)
MA = polyroot(c(1,0,0,0.2789))
MA_df = data.frame(Root = c("MA1","MA2","MA3"),
                    real = Re(MA), im = Im(MA))
MA_df =
  MA_df %>%
  mutate(z = sqrt(real^2 + im^2))
paste0("Smallest MA Root on Complex Plane: ",min(MA_df$z))

# PHI (corresponsing to SAR)
SAR = polyroot(c(1,0.4122))
SAR_df = data.frame(Root = c("SAR1"),
                    real = Re(SAR), im = Im(SAR))
SAR_df =
  SAR_df %>%
  mutate(z = sqrt(real^2 + im^2))
paste0("Smallest SAR Root on Complex Plane: ",min(SAR_df$z))

# THETA (Corresponding to SMA)
SMA = polyroot(c(1,-0.9016))
SMA_df = data.frame(Root = c("SMA1"),
                    real = Re(SMA), im = Im(SMA))
SMA_df =
  SMA_df %>%
  mutate(z = sqrt(real^2 + im^2))
paste0("Smallest SMA Root on Complex Plane: ",min(SMA_df$z))

kable(rbind(AR_df,MA_df,SAR_df,SMA_df), caption = "Phi(B) Roots and Theta(B) Roots")

```

MODELS WITH SEASONAL DIFFERENCE AND TREND DIFFERENCE

NOT USED IN THE REPORT

```{r}
load(file="Data/landings_transformed.Rdata")
landing_ts = landings_transformed$pounds_transformed
```

0 Model

SARIMA (1,1,0)x(1,1,0) 12

This is viable: seems not great based on the PACF, but not sure
```{r}
model0 = arima(landing_ts, order=c(1,1,0), seasonal = list(order = c(1,1,0), period = 12), method = "ML")
model0
AICc(model0)


# Phi (corresponsing to AR)
AR = polyroot(c(1,-0.7046))
roots_AR = c("Root 1")
root_model0 = data.frame(Root = roots_AR, Value = AR)
kable(root_model0, caption = "Phi(B) Roots")
```

Model 1

Double Check Stationarity
```{r}
model1 = arima(landing_ts, order=c(2,1,0), seasonal = list(order = c(1,1,0), period = 12), method = "ML")
model1
AICc(model1)


# Phi (corresponsing to AR)
AR = polyroot(c(1,1.1017,.5427))
roots_AR = c("Root 1", "Root 2")
root_model1 = data.frame(Root = roots_AR, Value = AR)
kable(root_model1, caption = "Phi(B) Roots")
```


Model 2

SARIMA (3,1,0)x(1,1,0) 12

NON-STATIONARY: Non complex roots less than 1
```{r}
model2 = arima(landing_ts, order=c(3,1,0), seasonal = list(order = c(1,1,0), period = 12), method = "ML")
model2
AICc(model2)

# Phi (corresponsing to AR)
AR = polyroot(c(1,1.3384,1.0118,.4160))
roots_AR = c("Root 1", "Root 2","Root 3")
root_model2 = data.frame(Root = roots_AR, Value = AR)
kable(root_model2, caption = "Phi(B) Roots")
```


Model 3

SARIMA (14,1,0)x(0,1,0) 12

NON-STATIONARY: Need to include this in the code to show that the I tried it
```{r}
model3 = arima(landing_ts, order=c(14,1,0), seasonal = list(order = c(0,1,0), period = 12), method = "ML", fixed =
c(NA,NA,NA,NA,NA,NA,NA,0,0,0,0,0,0,NA))
model3
AICc(model3)

# Phi (corresponsing to AR)
AR = polyroot(c(1,-1.5022,-1.7596,-1.5529,-1.3036,-1.0724,-0.7035,-0.3185,0,0,0,0,0,0,-0.2220))
roots_AR = c("Root 1", "Root 2","Root 3","Root 4", "Root 5","Root 6","Root 7", "Root 8","Root 9","Root 10", "Root
11","Root 12","Root 13", "Root 14")
root_model3 = data.frame(Root = roots_AR, Value = AR)
```

```
kable(root_model3, caption = "Phi(B) Roots")
```

Model 4

SARIMA (27,1,0)x(0,1,0) 12

```{r}
model4 = arima(landing_ts, order=c(27,1,0), seasonal = list(order = c(0,1,0), period = 12), method = "ML")
model4
AICc(model4)
```

MODELS WITH ONLY TREND DIFFERENCE

NOT USED IN THE REPORT

```{r}
load(file="Data/landings_transformed_no_season.Rdata")
landing_ts_ns = landings_transformed_no_season$pounds_transformed
```

MODEL 21
```{r}
# THIS WORKS, BUT PROBABLY NOT A GREAT MODEL
model21 = arima(landing_ts_ns, order=c(2,1,1), method = "ML")
model21
AICc(model21)

# Phi (corresponsing to AR)
AR = polyroot(c(1,-0.6605))
roots_AR = c("Root 1")
root_model21 = data.frame(Root = roots_AR, Value = AR)
kable(root_model21, caption = "Phi(B) Roots")
```
MODEL 22
```{r}
# Revised Model based on Residual PACF
model22 = arima(landing_ts_ns, order=c(15,1,0), method = "ML")
model22
AICc(model22)

# Phi (corresponsing to AR)
AR =
polyroot(c(1,1.7032,2.0569,2.1340,2.1507,2.2627,2.4141,2.5125,2.4864,2.3683,2.1207,1.7952,1.3713,0.9685,0.6628,0.2976))
AR_df = data.frame(Root = seq(1,15,by=1),
                   real = Re(AR), im = Im(AR))
AR_df =
  AR_df %>%
  mutate(z = sqrt(real^2 + im^2))
paste0("Smallest Root on Complex Plane: ",min(AR_df$z))
kable(AR_df, caption = "Phi(B) Roots")
```

MODEL 23
```{r}
model23 = auto.arima(
  landing_ts_ns,
  d = 1,
  max.p = 20,
  max.q = 20,
  max.P = 2,
  max.Q = 2,
  max.order = 50,
  max.D = 1,
  start.p = 0,
  start.q = 0,
  start.P = 0,
  start.Q = 0,
  stationary = FALSE)

model23
```

```

MODEL 24
```{r}
# NOT STATIONARY
model24 = arima(landing_ts_ns, order=c(3,1,0), method = "ML")
model24
AICc(model24)


# Phi (corresponsing to AR)
AR = polyroot(c(1,1.2063,0.8988,0.3598))
roots_AR = c("Root 1", "Root 2","Root 3")
root_model8 = data.frame(Root = roots_AR, Value = AR)
kable(root_model8, caption = "Theta(B) Roots")

acf(residuals(model24))
pacf(residuals(model24))
```


```{r}
# Non Stationary
model9 = arima(landing_ts, order=c(2,1,0), method = "ML")
model9
AICc(model9)

# Phi (corresponsing to AR)
AR = polyroot(c(1,-1.0559,-0.5322))
roots_AR = c("Root 1","Root2")
root_model9 = data.frame(Root = roots_AR, Value = AR)
kable(root_model9, caption = "Phi(B) Roots")
```
```