Venda de Carros na Noruega

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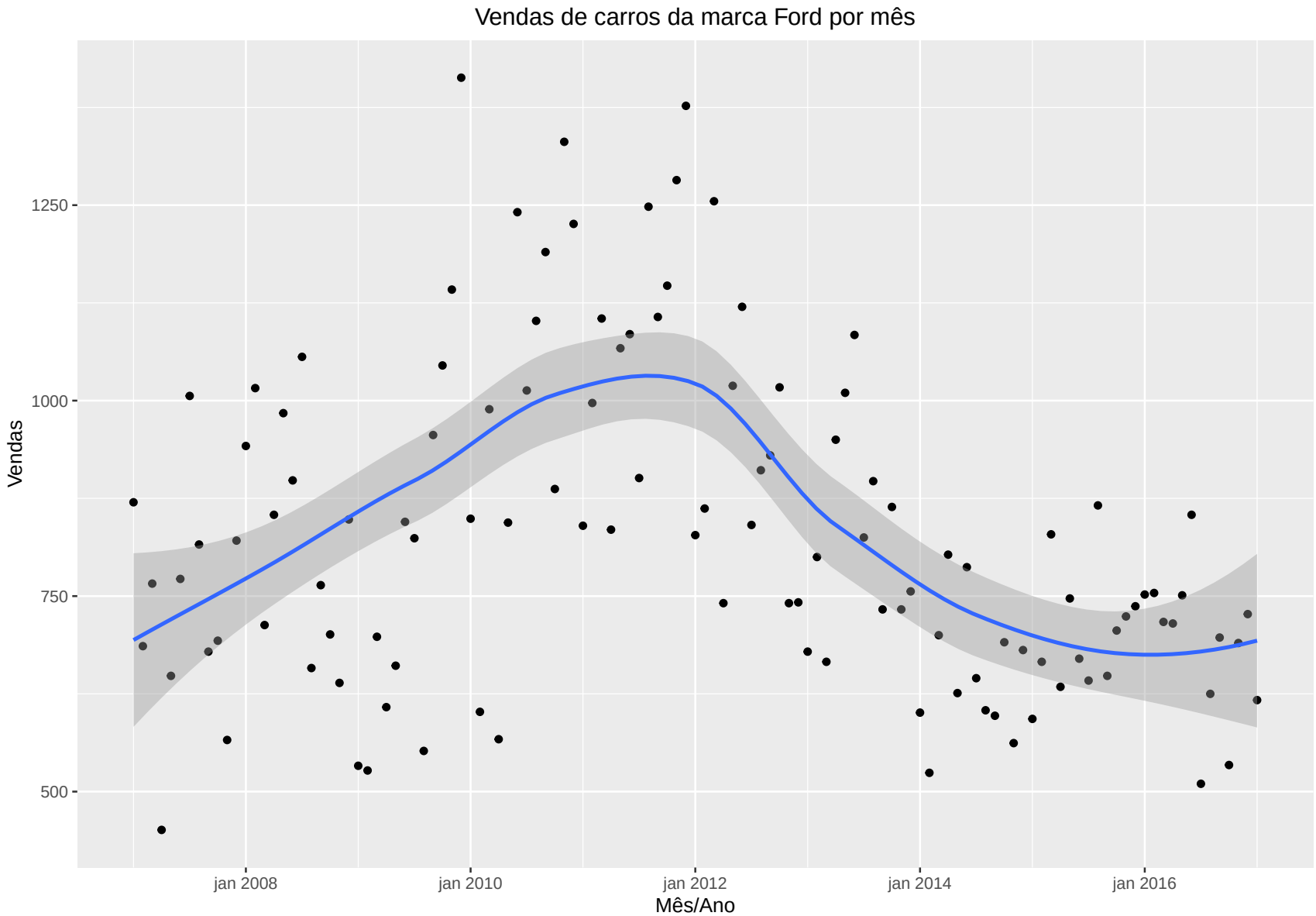
Importando os Dados

Primeiro, baixamos os dados e separamos a marca a ser estudada. Nesse caso, consideramos a marca Ford.

```
cars_df  = read.csv('norway_new_car_sales_by_make.csv')
make = 'Ford'

make_df = subset(cars_df, Make == make)
make_df$Date <- zoo::as.yearmon(paste(make_df$Year, make_df$Month), "%Y %m")
```

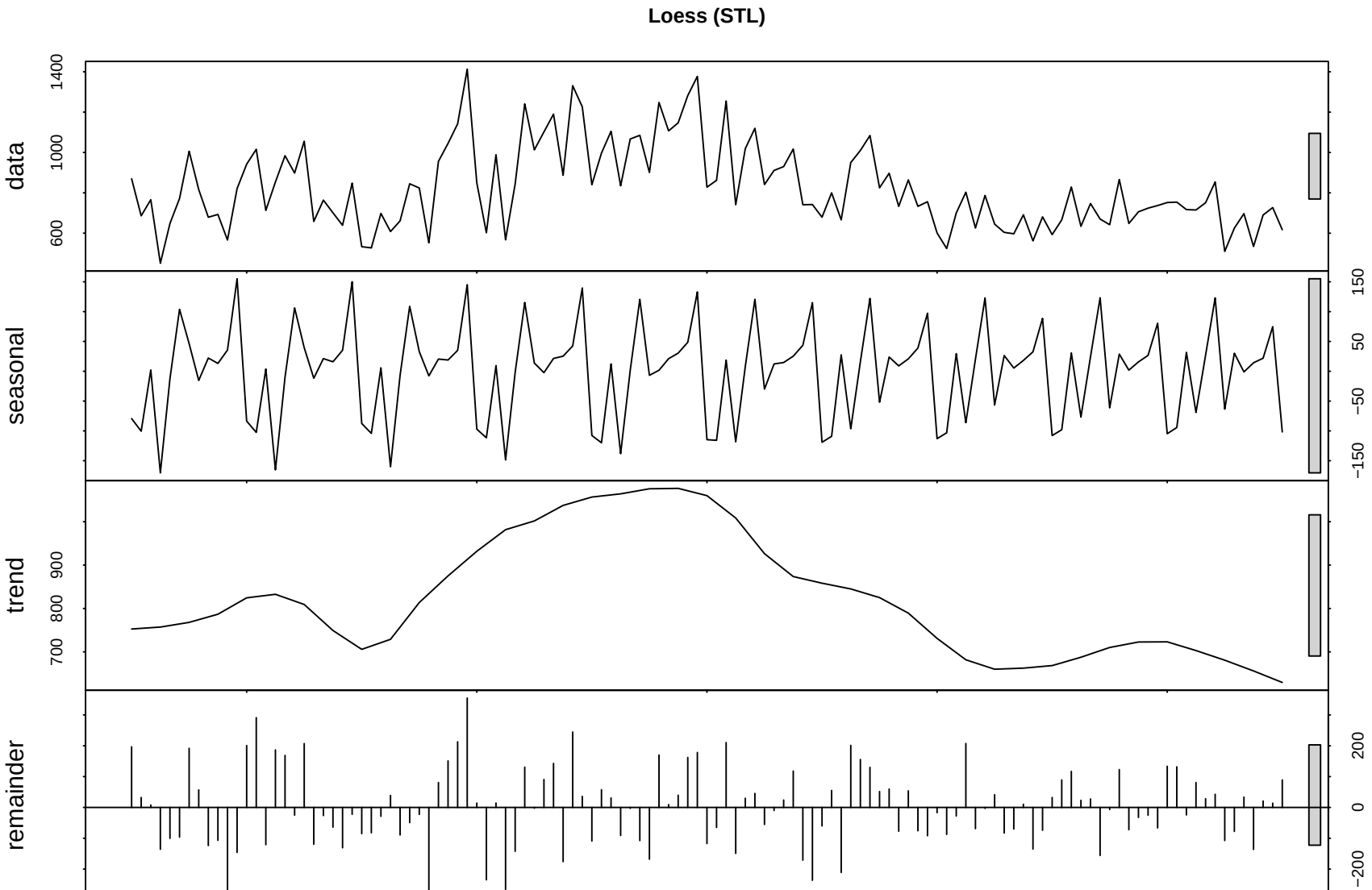
Série Temporal de Vendas

Podemos ver o gráfico da série.



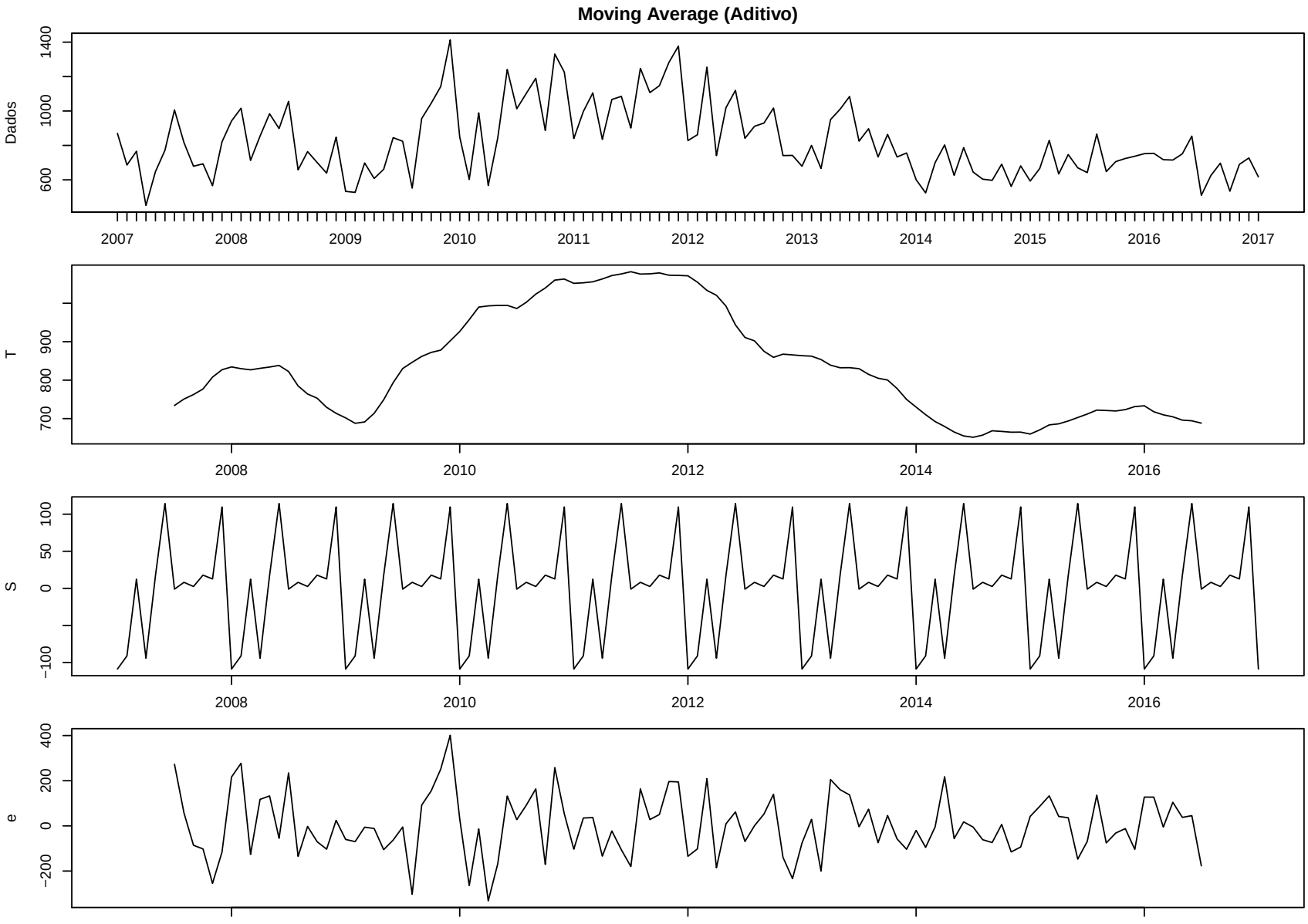
Decomposição STL (Loess)

Podemos fazer uma decomposição, considerando a janela de 12 meses para verificar tendência e sazonalidade. É um bom chute inicial para entender a série.

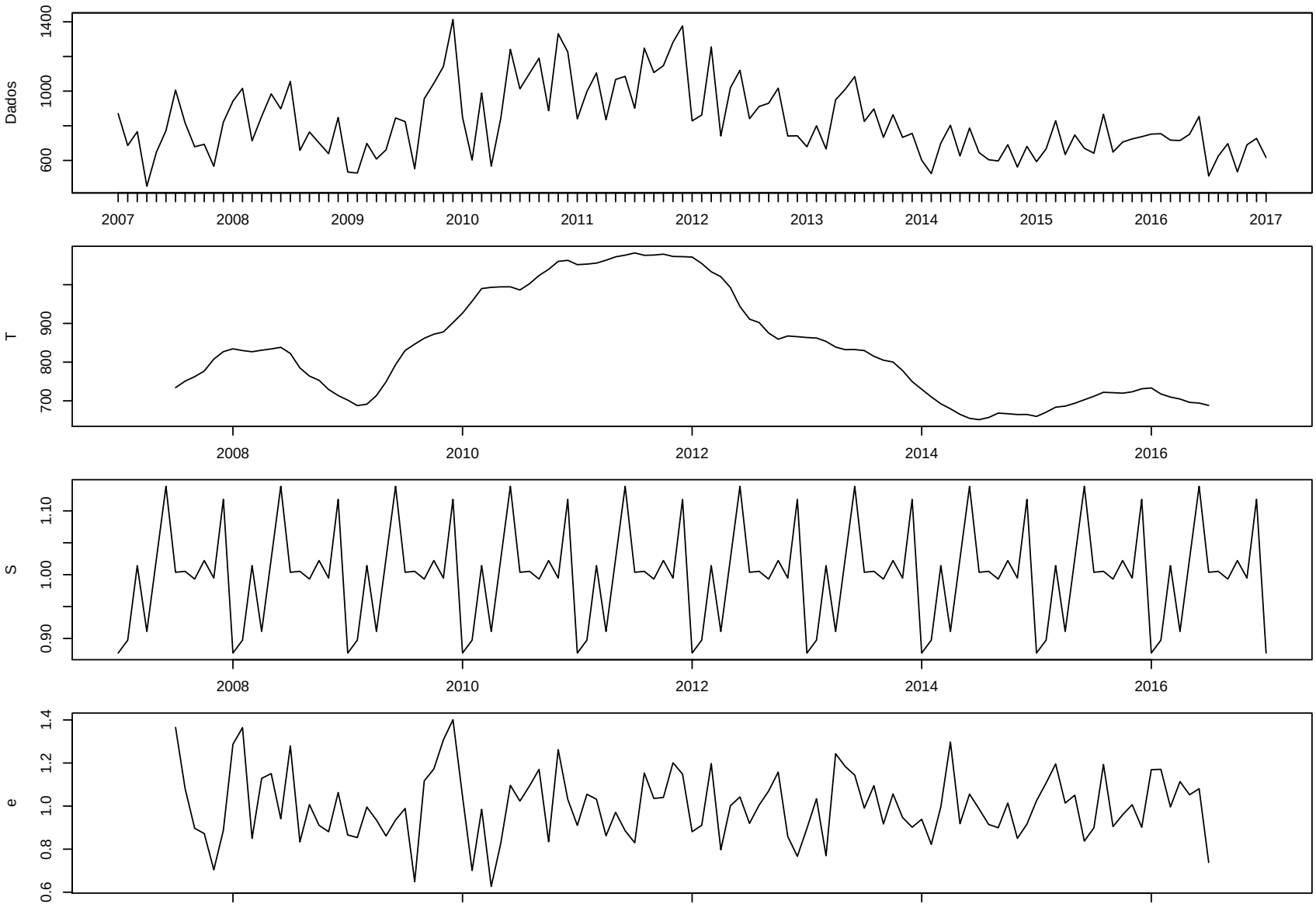


Decompose Aditivo (Moving Average)

Agora, vamos considerar a decomposição com moving average.



Decompose Multiplicativo (Moving Average)



Modelo de Regressão (Polinomial + Sazonal (12))

Utilizarei polinômios de ordem 1 até 5 para avaliar. Modelos lineares e polinomias são os mais básicos para serem testados.

```
D <- factor(cycle(make_df$Date))
t <- seq(1:length(make_df$Date))

make_df_model <- data.frame(Q = make_df$Quantity, t = t, D = D)

pm = function(z, degree){
  j <- nrow(z)-1
  model <- lm(formula = Q ~ poly(t, degree) + D, data = as.data.frame(z)[1:j,])
  y <- as.data.frame(z)[nrow(z),]
  yhat <- predict(model, y)
  return(yhat)
}

width = 25

mape_poly <- rep(0, 5)
yhat <- matrix(nrow = nrow(make_df_model)-width+1, ncol = 5)
for(degree in seq(1,5)){
  for(i in seq(1, nrow(make_df_model)-width+1)){
    j <- width + i - 1
    y <- make_df_model[i:j,]
    yhat[i,degree] <- pm(y, degree)
    y <- make_df_model[j,1]
    mape_poly[degree] <- mape_poly[degree] + abs((y - yhat[i,degree])/y)
  }
  mape_poly[degree] <- mape_poly[degree]/(nrow(make_df_model)-width+1)
}
mape_poly <- data.frame(degree = seq(1,5), MAPE = mape_poly)
```

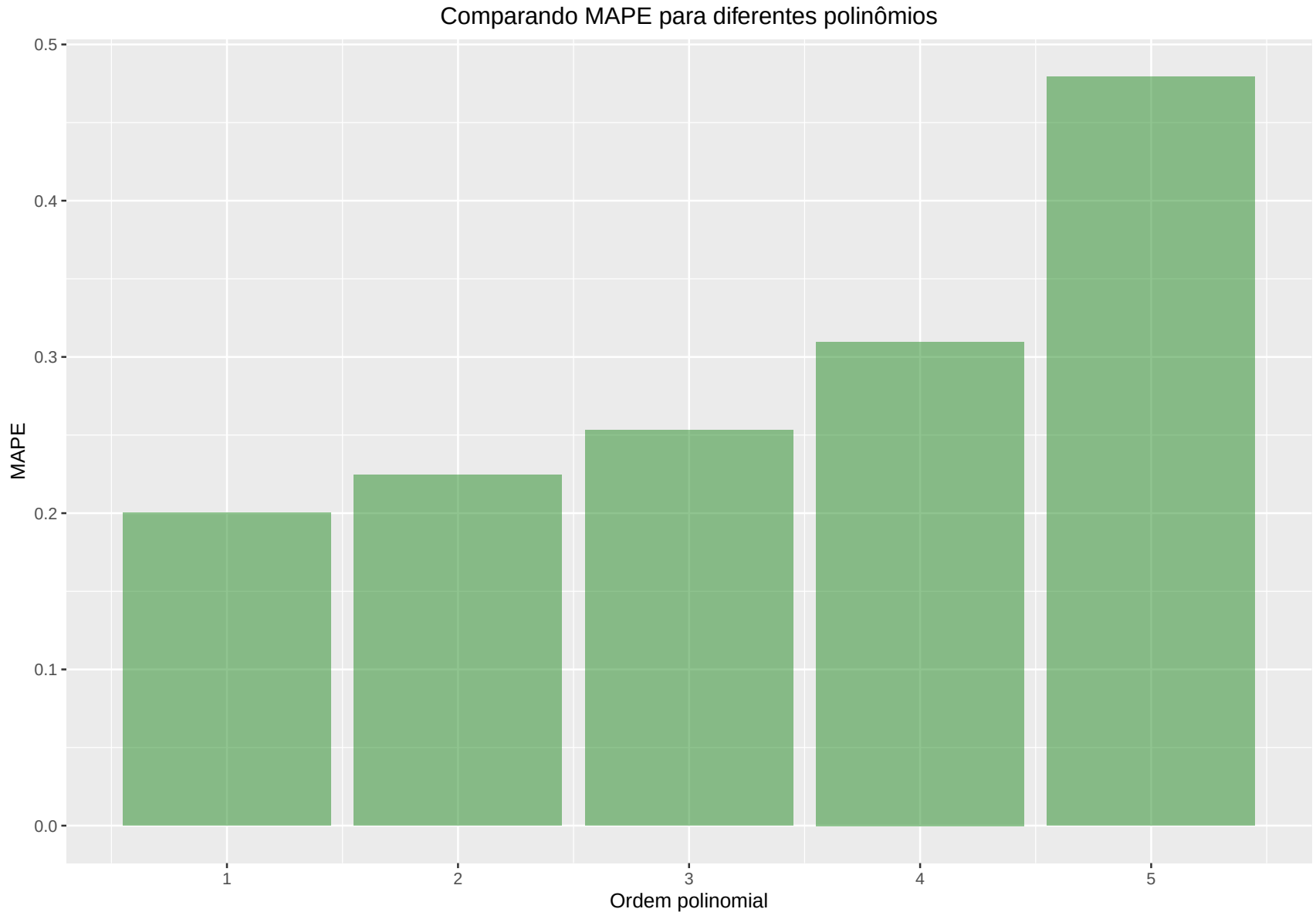
Modelo de regressão com tendência polinomial e dummies sazonais

```
qtd <- zooreg(make_df$Quantity, frequency = 12, start = c(2007,1))
Q <- factor(cycle(qtd))
t <- c(1:length(qtd))
make_df.new <- data.frame(Quantity=qtd, t, Q)
mod <- lm(Quantity~poly(t,3)+Q, data = make_df.new)
zhat <- predict(mod, newdata = data.frame(t=t[length(t)]+c(1,2,3), Q=levels(Q)[1:3]))
zhat
```

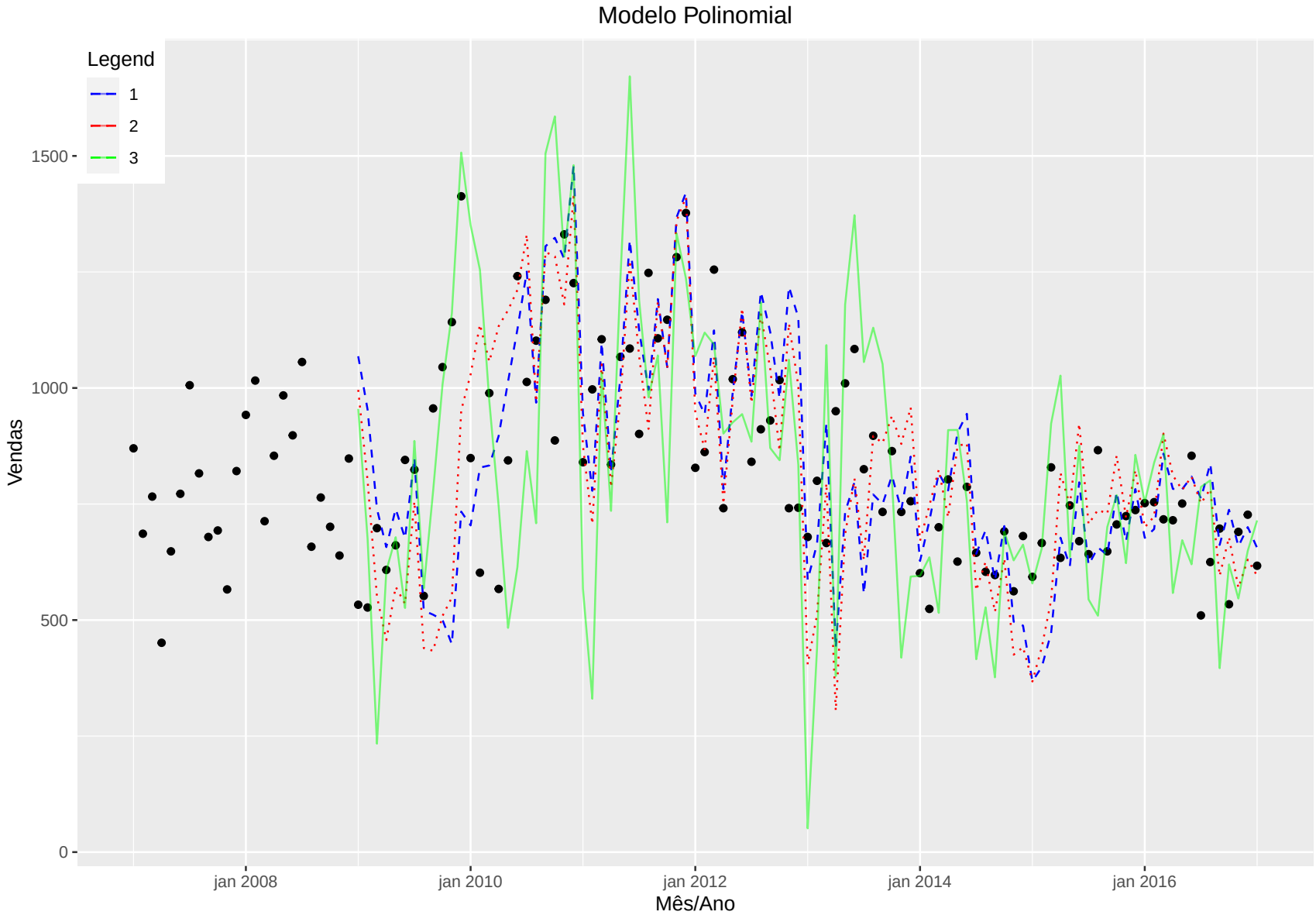
```
##        1        2        3
## 543.9795 527.4240 623.8815
```

Modelo de Regressão (Polinomial + Sazonal (12))

Podemos ver o resultado:

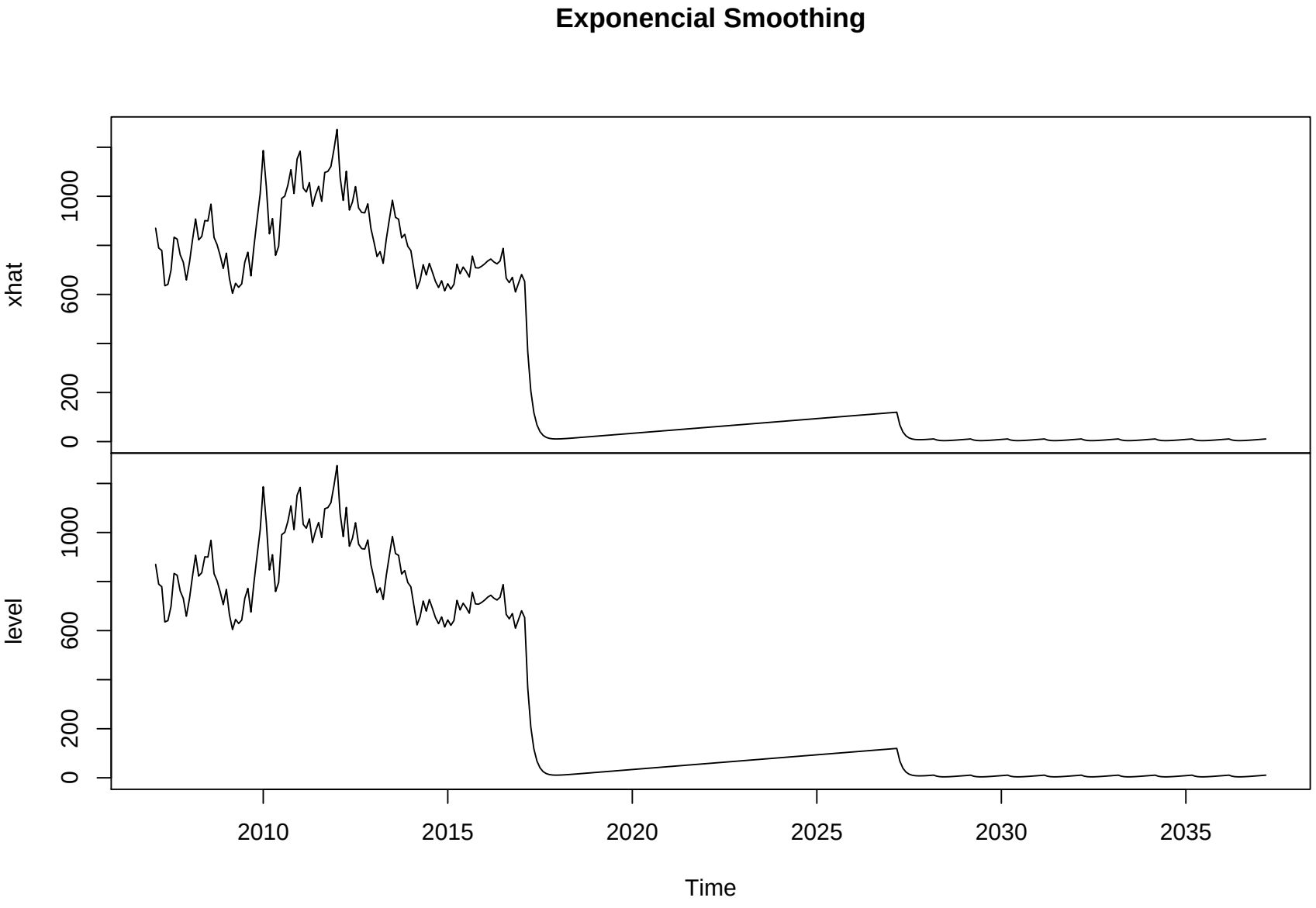


Modelo de Regressão (Polinomial + Sazonal (12)): Previsão



Modelo Exponencial Smoothing (Toda série)

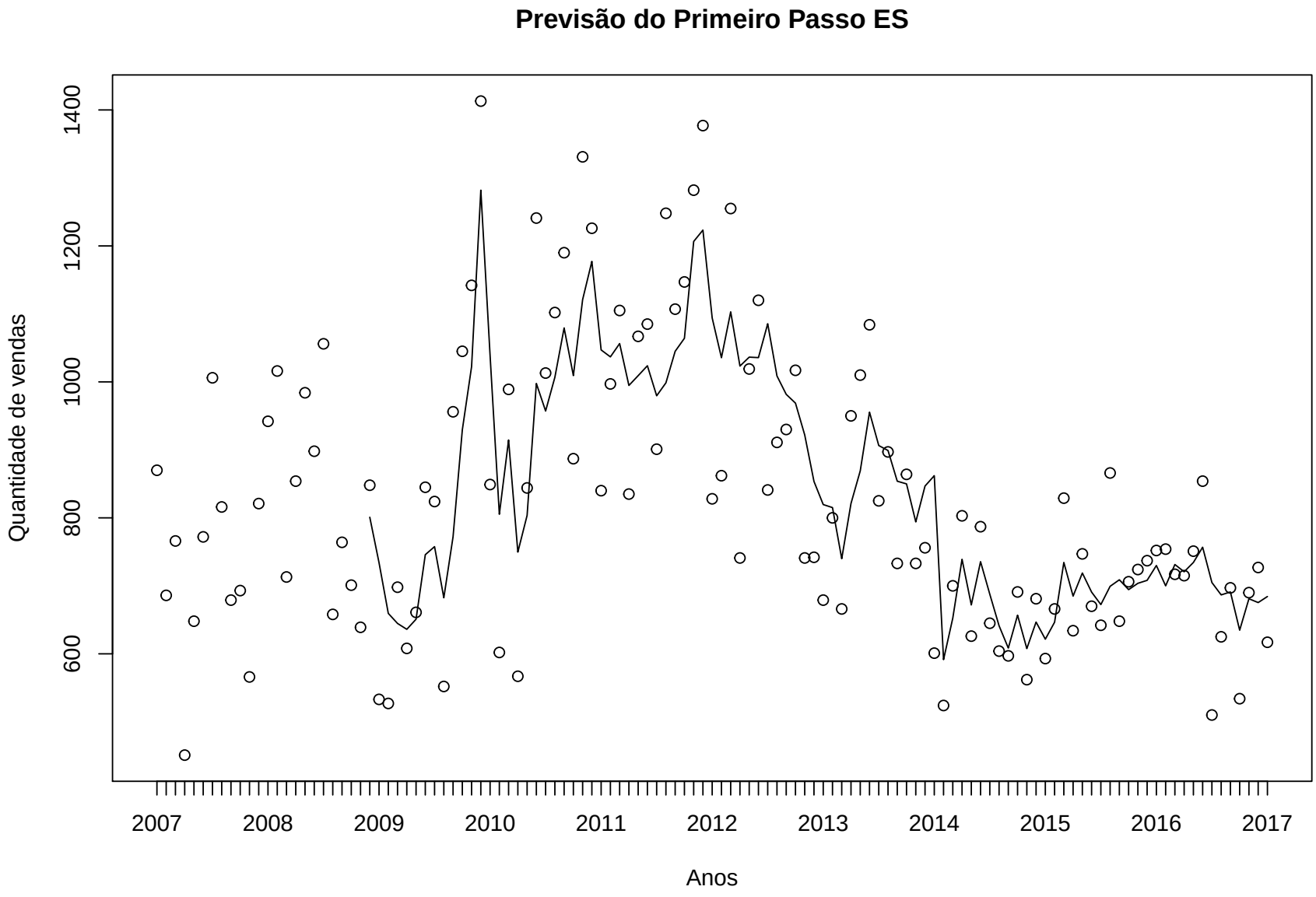
```
exp.smooth <- HoltWinters(ts(make_df_model, frequency = 12, start = 2007), beta = F, gamma = F)
plot(exp.smooth$fitted, main= 'Exponencial Smoothing')
```



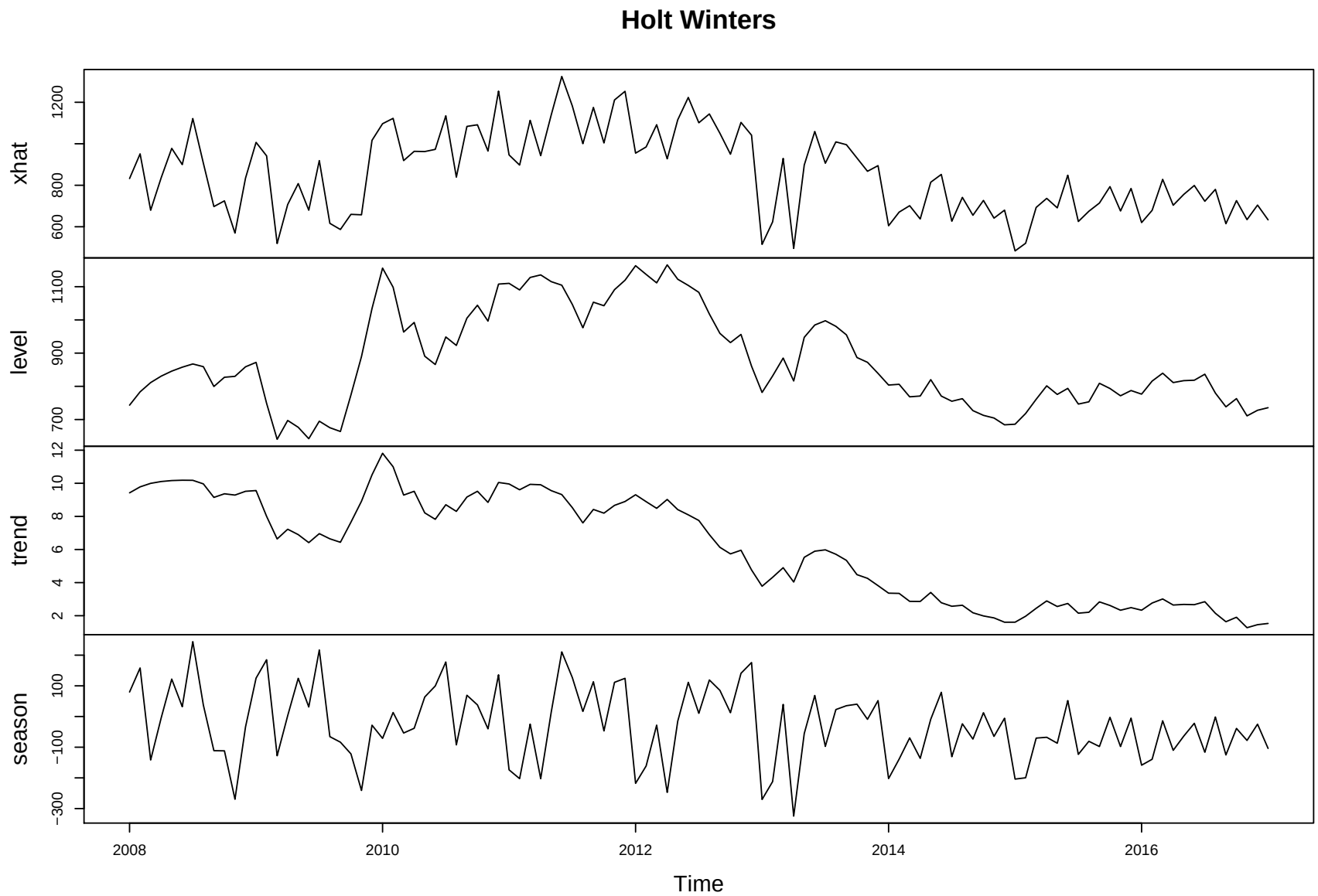
Modelo Exponencial Smoothing: MAPE

```
es <- function(x){
  model <- HoltWinters(x, beta = F, gamma = F)
  coef(model)
}

make_df.ts <- ts(make_df_model$Q, frequency = 12, start = 2007)

r.exp <- rollapply(make_df.ts, FUN = es,
                   width = 24, align = 'right')

mape_exp <- mean(abs((make_df.ts - r.exp)/make_df.ts))
```

Modelo Exponencial Smoothing: Previsão



Modelo Holt Winters Aditivo (Toda série)

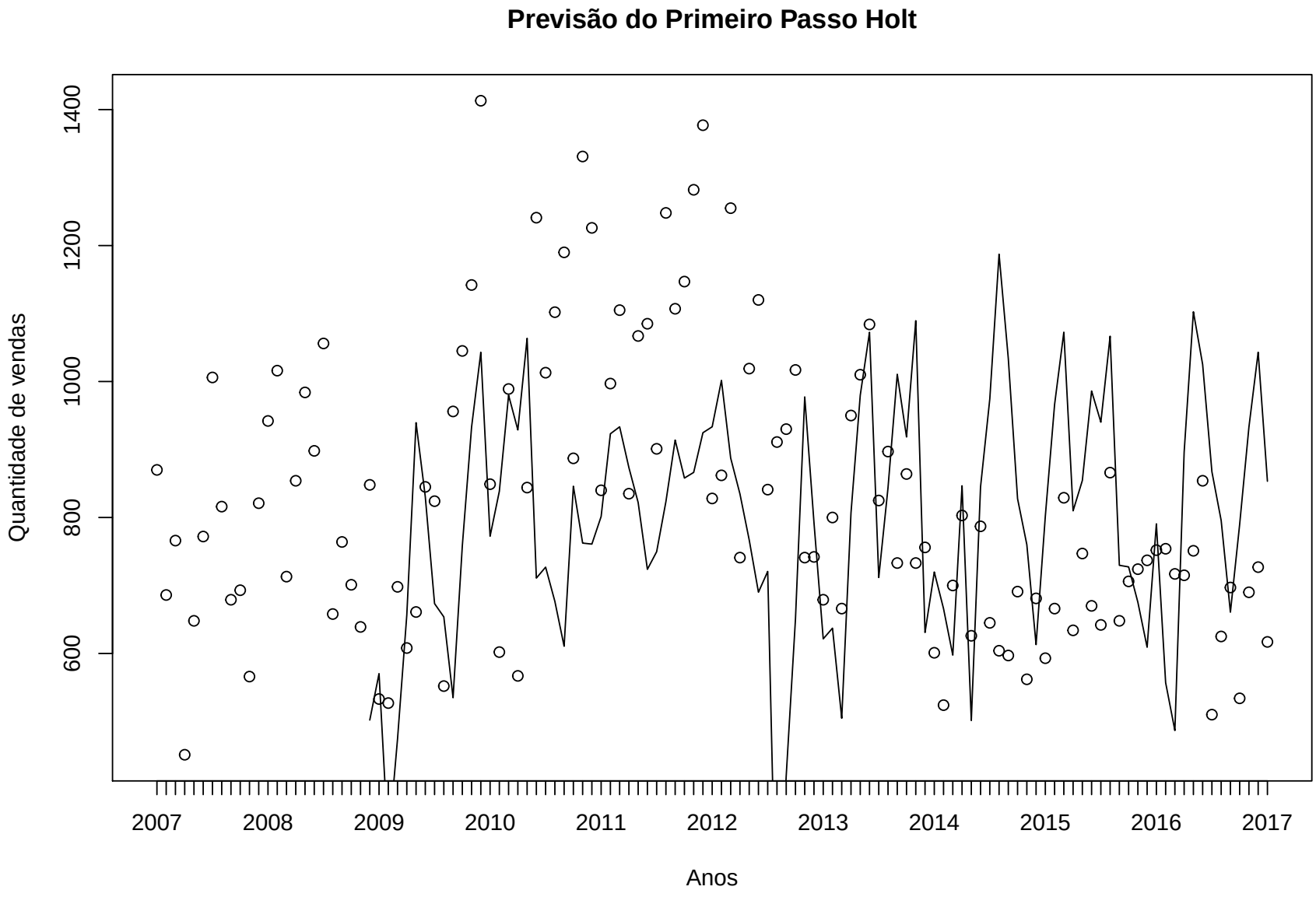


Modelo Holt: MAPE

```
h <- function(x){
  model <- HoltWinters(x, gamma = F)
  model$fitted
}

r.h <- rollapply(make_df.ts, FUN = h, width = 24, align = 'right')

mape_hw <- mean(abs((make_df.ts - r.h[,1])/make_df.ts))
```

Modelo Holt: Previsão

```
plot(make_df$Date, make_df$Quantity, xlab = 'Anos', ylab = 'Quantidade de vendas',
                                     main = 'Previsão do Primeiro Passo Holt')
lines(r.h[,1])
```



Modelo Holt Winters (Multiplicativo): MAPE

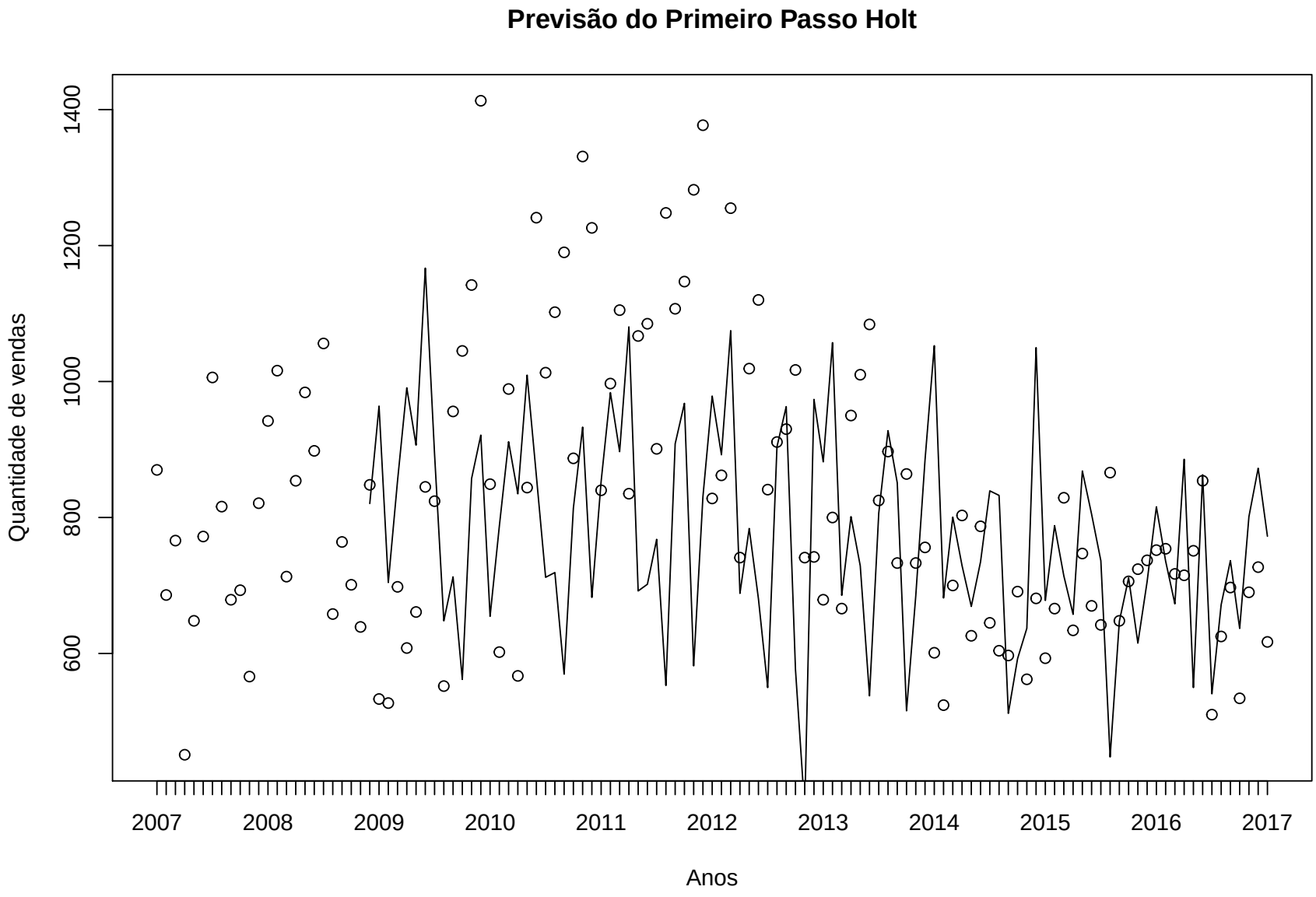
```
h2 <- function(x){
  model <- HoltWinters(ts(x, frequency = 12), seasonal = 'multiplicative')
  model$fitted
}

r.h2 <- rollapply(make_df.ts, FUN = h2, width = 24, align = 'right')
```

```
## Warning in HoltWinters(ts(x, frequency = 12), seasonal = "multiplicative"):
## optimization difficulties: ERROR: ABNORMAL_TERMINATION_IN_LNSRCH

## Warning in HoltWinters(ts(x, frequency = 12), seasonal = "multiplicative"):
## optimization difficulties: ERROR: ABNORMAL_TERMINATION_IN_LNSRCH
```

```
mape_hw2 <- mean(abs((make_df.ts - r.h2[,1])/make_df.ts))
```

Modelo Holt: Previsão

```
plot(make_df$Date, make_df$Quantity, xlab = 'Anos', ylab = 'Quantidade de vendas',
                                     main = 'Previsão do Primeiro Passo Holt')
lines(r.h2[,1])
```



Comparando modelos