

Venda de Carros na Noruega

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Importando os Dados

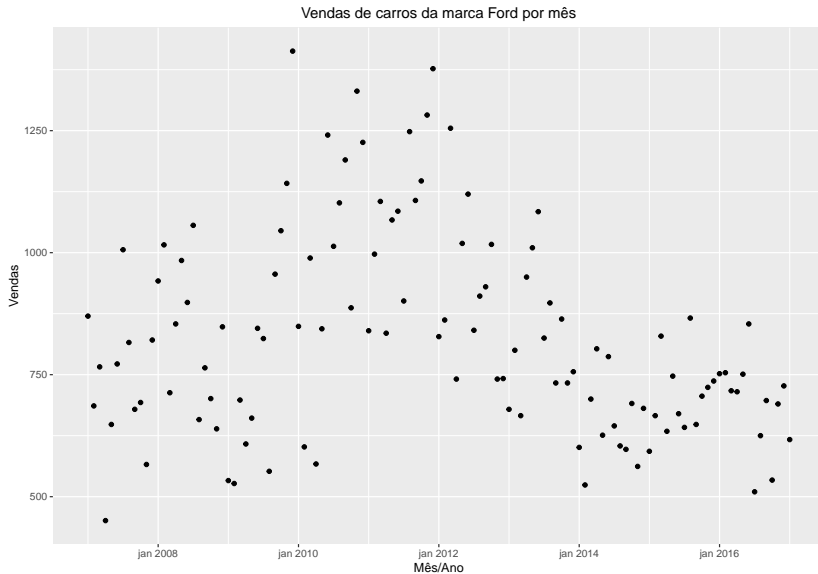
Primeiro, baixamos os dados e separamos a marca a ser estudada. Nesse caso, consideramos a marca Ford.

```
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")
```

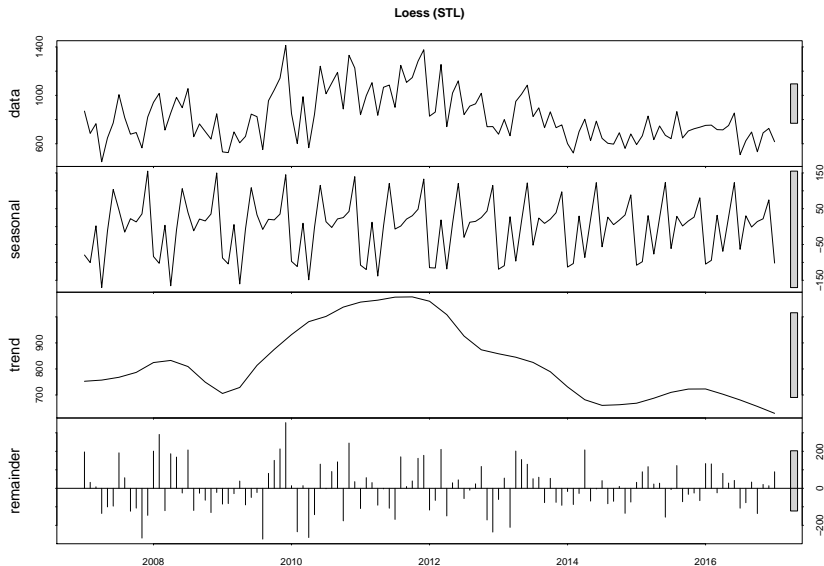
Série Temporal de Vendas

Podemos ver o gráfico da série.



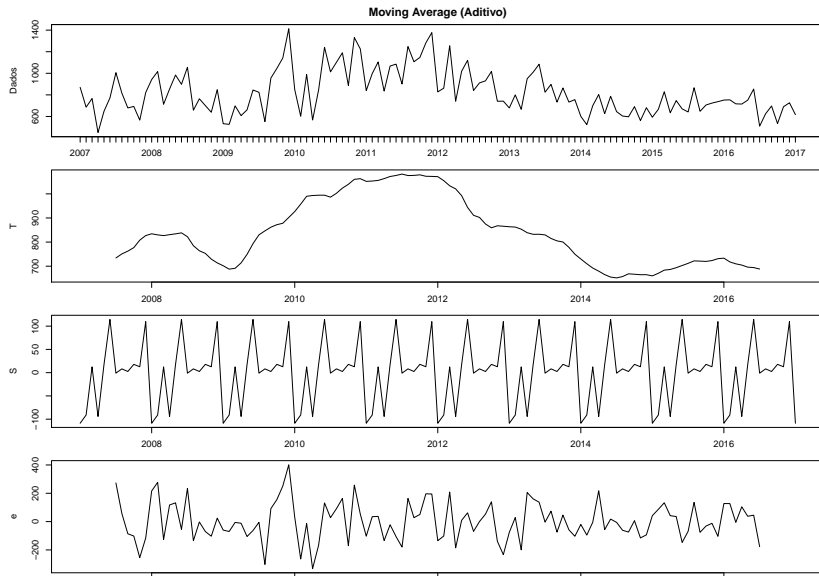
Decomposição STL (Loess)

Podemos fazer uma decomposição, considerando a janela de 12 meses para verificar tendência e sazonalidade.



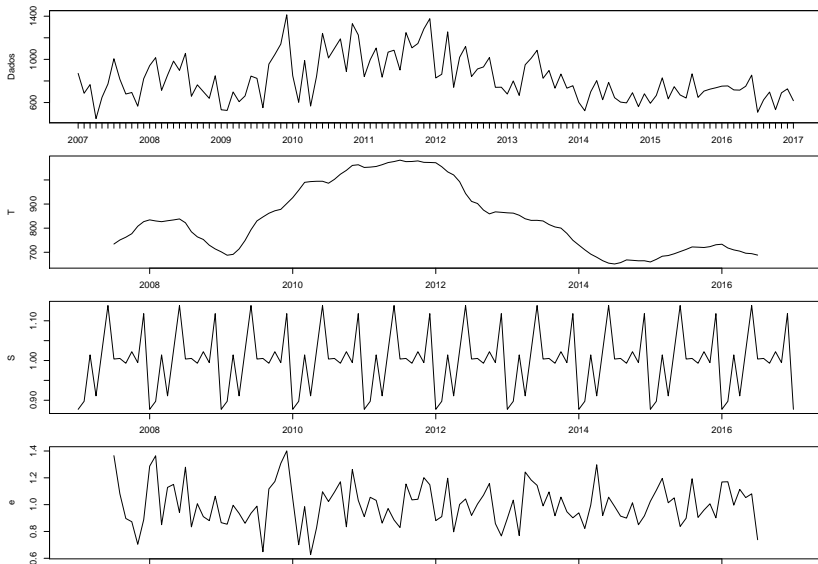
Decompose Aditivo (Moving Average)

Agora, vamos considerar a decomposição com moving average.



Decompose Multiplicativo (Moving Average)

Modelo multiplicativo:



Modelo de Regressão (Polinomial + Sazonal (12))

```
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)
```

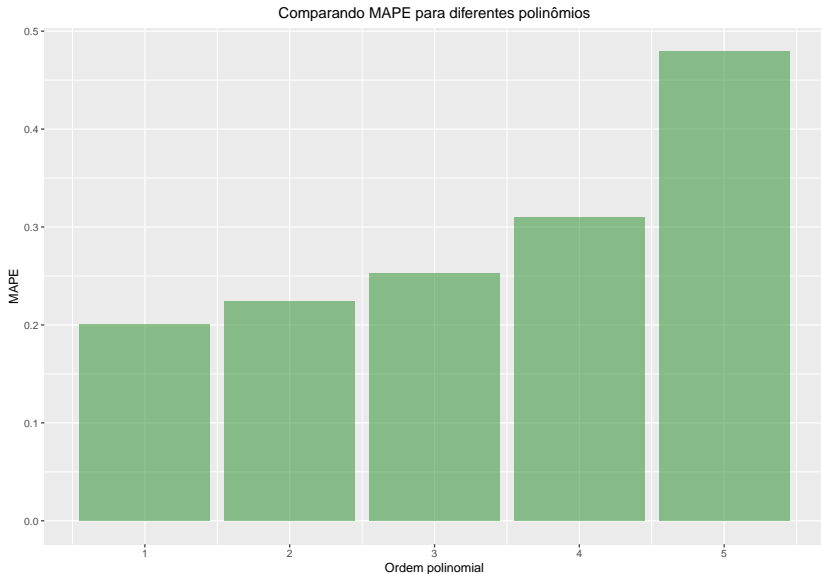
Modelo de regressão com tendência polinomial e dummies sazonais

```
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
```

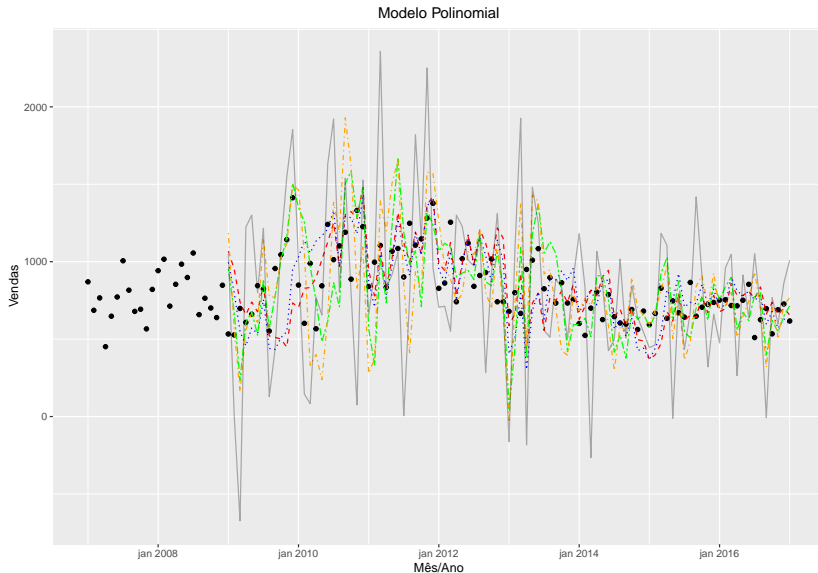
```
##           1           2           3
## 543.9795 527.4240 623.8815
```


Modelo de Regressão (Polinomial + Sazonal (12))

Podemos ver o resultado:



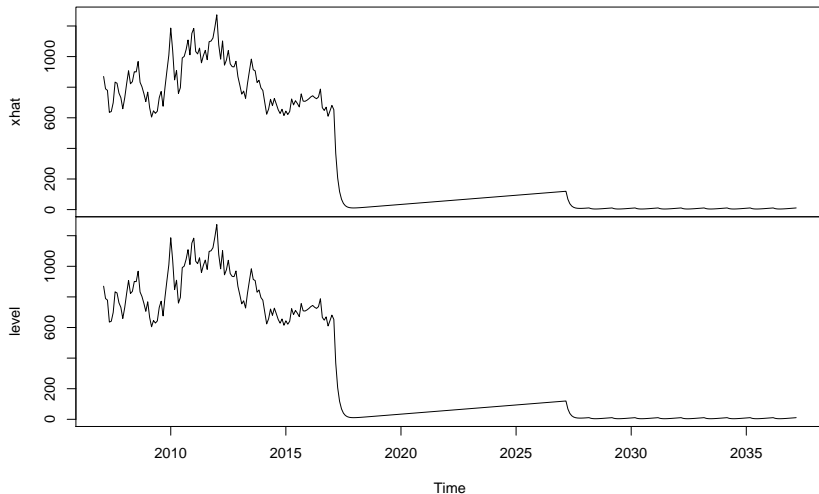
Modelo de Regressão (Polinomial + Sazonal (12)): Previsão



Modelo Exponential Smoothing

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

Exponential Smoothing



Modelo Exponencial Smoothing: MAPE

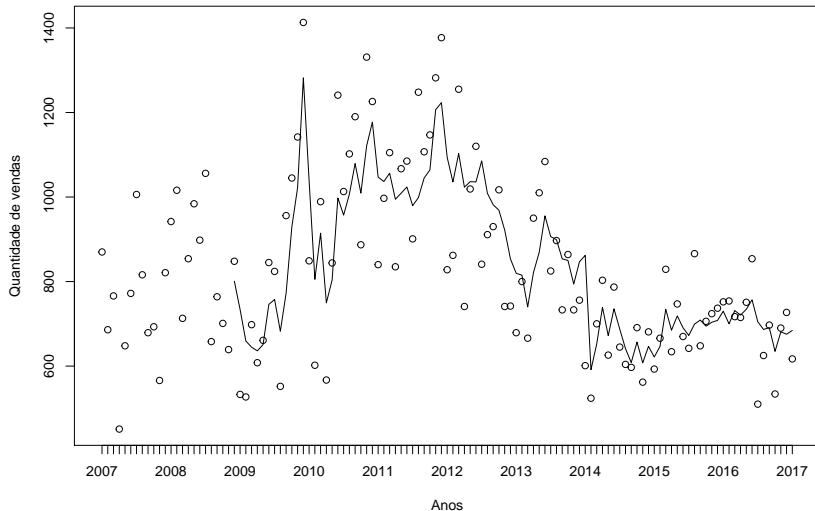
```
es <- function(x){  
  model <- HoltWinters(x, beta = F, gamma = F)  
  coef(model)  
}  
  
make_df.ts <- ts(make_df_model$Q, frequency = 12, start = 2007)  
  
r.exp <- rollapply(make_df.ts, FUN = es,  
  width = 24, align = 'right')  
  
mape_exp <- mean(abs((make_df.ts - r.exp)/make_df.ts))
```

Previsão 1 mês a frente com janelas de 2 anos

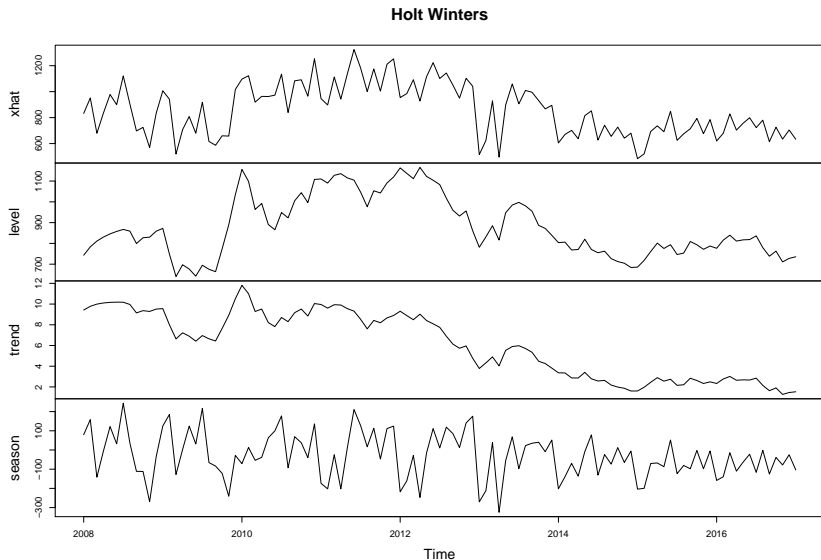
```
estim <- function(v_window) {  
  es1 <- HoltWinters(v_window, beta=F, gamma=F)  
  as.numeric(forecast(es1,1)$mean)  
}  
  
yhat <- rollapply(qtd,24,estim)  
yhat <- zooreg(yhat, frequency = 12, start = c(2009,1), end = c(2017,2))
```

Modelo Exponencial Smoothing: Previsão

Previsão do Primeiro Passo ES



Modelo Holt Winters Aditivo

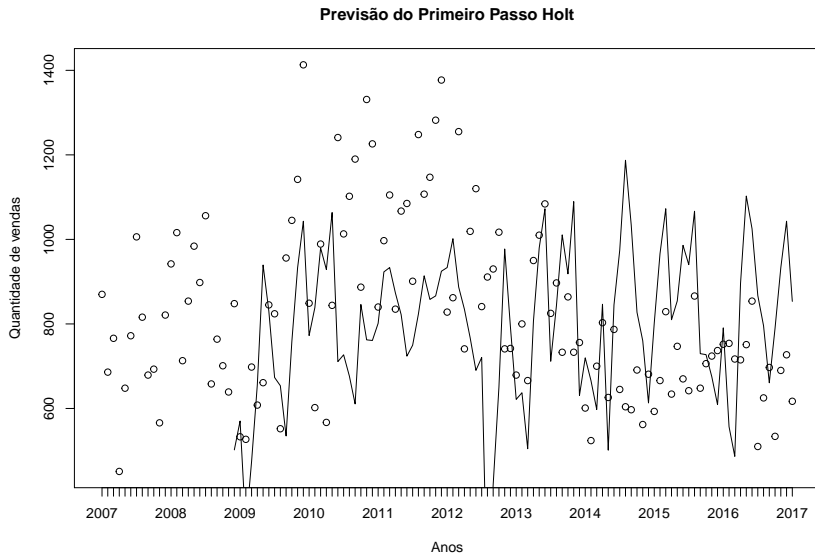


Modelo Holt: MAPE

```
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])
```



Comparando modelos

