# Técnicas Estatísticas de Predição

Exercício 5

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**Questões**

**A)** Ajuste o melhor modelo de suavização exponencial Simples para os dados do IPCA.

**R:** Vale especificar que não existe necessidade em trabalhar com um valor de alpha específico porque a função 'ses()', do pacote 'forecast', já ajusta automaticamente o melhor valor para gerar o modelo de suavização exponencial simples.

```
# Suavização Exponencial Simples
SES = ses(base_ts)
```

**B)** Ajuste o melhor modelo de suavização exponencial de Holt para os dados do IPCA.

**R:** O caso experimentado antes se confirma no atual. A função 'holt()', também do pacote 'forecast', ajusta automaticamente os melhores valores de alpha e beta para gerar o modelo de suavização exponencial de Holt.

```
# Suavização Exponencial de Holt
HOLT = holt(base_ts)
```

**C)** Ajuste o melhor modelo de suavização exponencial de Holt-Winter para os dados do IPCA.

**R:**

```
# Suavização Exponencial de Holt-Winter
HW_ad = hw(base_ts, seasonal = "additive")
```

**D)** Indique qual dos três modelos se ajustou melhor aos dados. Qual medida você está utilizando para fazer essa conclusão?

**R:** O modelo que melhor se ajustou aos dados foi o de Holt-Winter.
Para tal afirmação, considerou-se principalmente a Medida de Erro Absoluto (MAE), na qual o modelo de Holt-Winter era detentor do menor (0.2494960) valor.

```
# Resumos Estatísticos dos Modelos
summary(SES)
```

```
##
## Forecast method: Simple exponential smoothing
##
## Model Information:
## Simple exponential smoothing
##
## Call:
##  ses(y = base_ts)
##
##   Smoothing parameters:
##     alpha = 0.7307
##
##   Initial states:
##     l = 1.8482
##
##   sigma:  0.3639
##
##      AIC     AICc      BIC
## 1346.654 1346.724 1358.228
##
## Error measures:
##                        ME     RMSE       MAE  MPE MAPE      MASE
ACF1
## Training set -0.006279753 0.362857 0.2606874 -Inf  Inf 0.6587839
0.05951103
##
## Forecasts:
##          Point Forecast      Lo 80     Hi 80      Lo 95    Hi 95
## Mar 2023      0.2422466 -0.2241078 0.7086009 -0.4709809 0.955474
## Apr 2023      0.2422466 -0.3353332 0.8198264 -0.6410855 1.125579
## May 2023      0.2422466 -0.4283580 0.9128511 -0.7833546 1.267848
## Jun 2023      0.2422466 -0.5099652 0.9944583 -0.9081620 1.392655
## Jul 2023      0.2422466 -0.5835467 1.0680398 -1.0206952 1.505188
## Aug 2023      0.2422466 -0.6510879 1.1355811 -1.1239907 1.608484
## Sep 2023      0.2422466 -0.7138698 1.1983630 -1.2200073 1.704500
## Oct 2023      0.2422466 -0.7727759 1.2572690 -1.3100963 1.794589
## Nov 2023      0.2422466 -0.8284460 1.3129392 -1.3952365 1.879730
## Dec 2023      0.2422466 -0.8813613 1.3658545 -1.4761634 1.960657
```

```
summary(HOLT)
```

```
##
## Forecast method: Holt's method
##
## Model Information:
## Holt's method
##
## Call:
##  holt(y = base_ts)
##
##   Smoothing parameters:
##     alpha = 0.7274
##     beta  = 1e-04
```

```
##
##   Initial states:
##     l = 1.8382
##     b = -0.0046
##
##   sigma:  0.3649
##
##      AIC     AICc      BIC
## 1350.600 1350.774 1369.890
##
## Error measures:
##                       ME     RMSE       MAE  MPE MAPE      MASE
ACF1
## Training set 0.000125196 0.362829 0.2608868 -Inf  Inf 0.6592877
0.06208698
##
## Forecasts:
##          Point Forecast      Lo 80     Hi 80      Lo 95    Hi 95
## Mar 2023      0.2356095 -0.2320545 0.7032736 -0.4796210 0.950840
## Apr 2023      0.2310184 -0.3473061 0.8093429 -0.6534526 1.115489
## May 2023      0.2264272 -0.4445725 0.8974269 -0.7997783 1.252633
## Jun 2023      0.2218360 -0.5305294 0.9742015 -0.9288076 1.372480
## Jul 2023      0.2172448 -0.6085268 1.0430165 -1.0456639 1.480154
## Aug 2023      0.2126537 -0.6805292 1.1058365 -1.1533516 1.578659
## Sep 2023      0.2080625 -0.7478058 1.1639308 -1.2538120 1.669937
## Oct 2023      0.2034713 -0.8112330 1.2181756 -1.3483850 1.755328
## Nov 2023      0.1988802 -0.8714456 1.2692059 -1.4380418 1.835802
## Dec 2023      0.1942890 -0.9289214 1.3174993 -1.5235130 1.912091
```

```
summary(HW_ad)
```

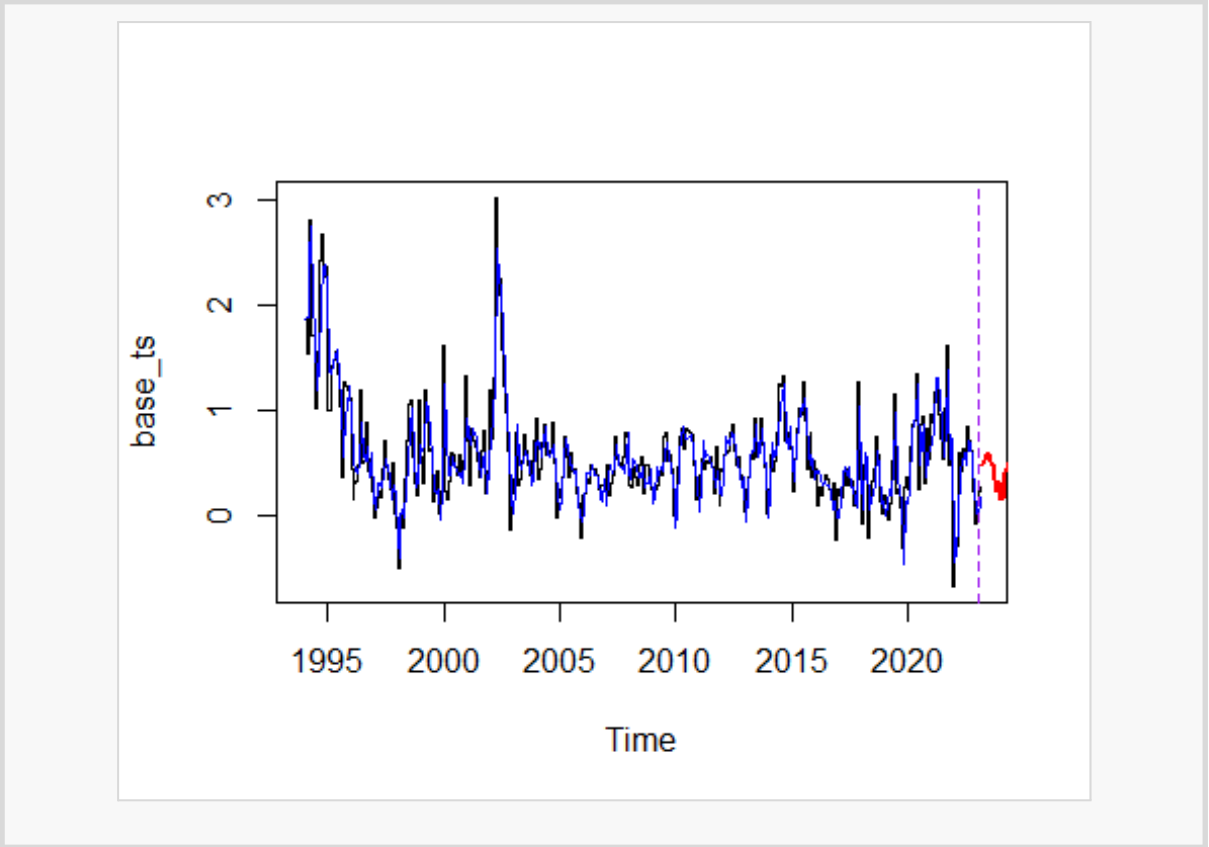
```
##
## Forecast method: Holt-Winters' additive method
##
## Model Information:
## Holt-Winters' additive method
##
## Call:
##  hw(y = base_ts, seasonal = "additive")
##
##   Smoothing parameters:
##     alpha = 0.7023
##     beta  = 1e-04
##     gamma = 1e-04
##
##   Initial states:
##     l = 2.1001
##     b = -0.0064
##     s = -0.0532 -0.1536 -0.0455 0.0676 0.0727 0.0996
##           0.1746 0.1444 0.0916 0.0387 -0.2073 -0.2295
##
##   sigma:  0.354
##
```

```
##      AIC     AICc      BIC
## 1340.963 1342.807 1406.548
##
## Error measures:
##                       ME      RMSE      MAE  MPE MAPE     MASE
ACF1
## Training set 0.002361196 0.3458065 0.249496 -Inf  Inf 0.630502
0.06372361
##
## Forecasts:
##          Point Forecast       Lo 80     Hi 80      Lo 95    Hi 95
## Mar 2023     0.46894465  0.01528520 0.9226041 -0.2248676 1.162757
## Apr 2023     0.51558372 -0.03881522 1.0699827 -0.3322963 1.363464
## May 2023     0.56218758 -0.07729541 1.2016706 -0.4158173 1.540192
## Jun 2023     0.58603374 -0.12849257 1.3005600 -0.5067399 1.678807
## Jul 2023     0.50480293 -0.27762036 1.2872262 -0.6918102 1.701416
## Aug 2023     0.47159233 -0.37330625 1.3164909 -0.8205685 1.763753
## Sep 2023     0.46029894 -0.44277916 1.3633770 -0.9208398 1.841438
## Oct 2023     0.34088444 -0.61686058 1.2986295 -1.1238602 1.805629
## Nov 2023     0.22657535 -0.78289484 1.2360455 -1.3172761 1.770427
## Dec 2023     0.32069807 -0.73798680 1.3793829 -1.2984207 1.939817
## Jan 2024     0.13811387 -0.96761045 1.2438382 -1.5529455 1.829173
## Feb 2024     0.15404872 -0.99680660 1.3049040 -1.6060326 1.914130
## Mar 2024     0.39368548 -0.80062101 1.5879920 -1.4328487 2.220220
## Apr 2024     0.44032455 -0.79590675 1.6765559 -1.4503281 2.330977
## May 2024     0.48692841 -0.78986316 1.7637200 -1.4657558 2.439613
## Jun 2024     0.51077456 -0.80533892 1.8268880 -1.5020473 2.523596
## Jul 2024     0.42954376 -0.92476114 1.7838487 -1.6416868 2.500774
## Aug 2024     0.39633315 -0.99512575 1.7877921 -1.7317196 2.524386
## Sep 2024     0.38503977 -1.04261675 1.8126963 -1.7983725 2.568452
## Oct 2024     0.26562527 -1.19734344 1.7285940 -1.9717923 2.503043
## Nov 2024     0.15131618 -1.34614196 1.6487743 -2.1388484 2.441481
## Dec 2024     0.24543889 -1.28574149 1.7766193 -2.0962994 2.587177
## Jan 2025     0.06285470 -1.50133039 1.6270398 -2.3293600 2.455069
## Feb 2025     0.07878955 -1.51772720 1.6753063 -2.3628721 2.520451
```

**E)** Utilizando o melhor modelo, indicado no item (d), faça a previsão para os meses de outubro a dezembro de 2023.

**R:** Como evidenciado na análise gráfica feita, a tendência do IPCA para os últimos três meses do ano de 2023 é passar por um breve aumento com, logo em seguida, uma queda que não ultrapassa o ápice de seu último declínio.

```r
# Análise Gráfica
HWa.predito = summary(HW_ad)
lines(fitted(HW_ad), col="blue")
lines(HWa.predito$mean, col="red", lwd=2)
abline(v = c(2023, 10), col = "purple", lty = 2)
```




(Imagem do gráfico em melhor resolução)

### Sintaxe Completa

```r
library(forecast)
library(lubridate)

# Leitura e Preparação da Base de Dados
base = read.csv2("ipca.csv")
base_ts = ts(base$IPCA, frequency=12, start=c(1994,1))

# Visualização gráfica
plot(base_ts,type="s")

# Suavização Exponencial Simples
SES = ses(base_ts)

# Suavização Exponencial de Holt
HOLT = holt(base_ts)

# Suavização Exponencial de Holt-Winter
HW_ad = hw(base_ts, seasonal = "additive")

# Resumos Estatísticos dos Modelos
summary(SES)
```

```
##
## Forecast method: Simple exponential smoothing
##
## Model Information:
## Simple exponential smoothing
##
## Call:
##  ses(y = base_ts)
##
##   Smoothing parameters:
##     alpha = 0.7307
##
##   Initial states:
##     l = 1.8482
##
##   sigma:  0.3639
##
##      AIC     AICc      BIC
## 1346.654 1346.724 1358.228
##
## Error measures:
##                       ME     RMSE       MAE  MPE MAPE      MASE
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## Training set -0.006279753 0.362857 0.2606874 -Inf  Inf 0.6587839
0.05951103
##
## Forecasts:
##          Point Forecast      Lo 80     Hi 80      Lo 95    Hi 95
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```

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```
summary(HOLT)
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```

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```

```
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##
## Model Information:
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##
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##            0.1746 0.1444 0.0916 0.0387 -0.2073 -0.2295
##
##   sigma:  0.354
##
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```

```
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## Jan 2025     0.06285470 -1.50133039 1.6270398 -2.3293600 2.455069
## Feb 2025     0.07878955 -1.51772720 1.6753063 -2.3628721 2.520451
```

```r
# Análise Gráfica
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lines(HWa.predito$mean, col="red", lwd=2)
abline(v = c(2023, 10), col = "purple", lty = 2)
```