

# Applied Time Series Analysis

## SS 2013 – Week 12

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### *Exponential Smoothing Revisited*

**Basic notion:**  $X_t = \mu_t + E_t$

- $\mu_t$  is the conditional expectation, which we try to estimate from the data. The estimate  $a_t$  is called level of the series.
- $E_t$  is a completely random innovation term.

**Estimation of the level:** two notions exist...

- Weighted updating:  $a_t = \alpha x_t + (1 - \alpha)a_{t-1}$
- Exponential smoothing:  $a_t = \sum_{i=0}^{\infty} \alpha(1 - \alpha)^i x_{t-i}$

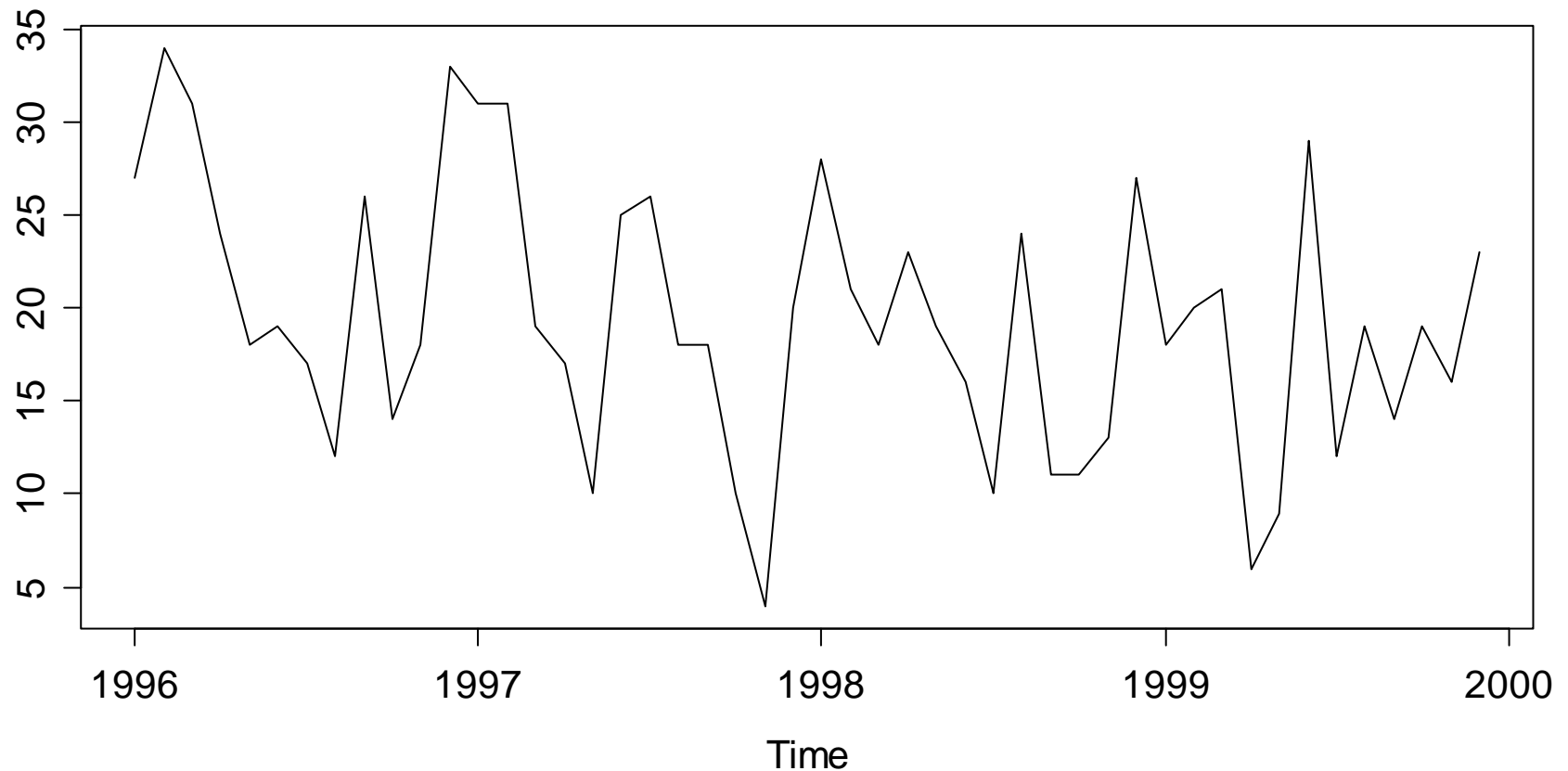
**Practice & Forecasting:** [see blackboard...](#)

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### *Exponential Smoothing: Example*

Complaints to a Motorizing Organization



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### *Exponential Smoothing: Example*

```
> fit <- HoltWinters(cmpl, beta=F, gamma=F)
```

Holt-Winters exponential smoothing without trend and without seasonal component.

Smoothing parameters:

```
alpha: 0.1429622
```

```
beta : FALSE
```

```
gamma: FALSE
```

Coefficients:

```
[,1]
```

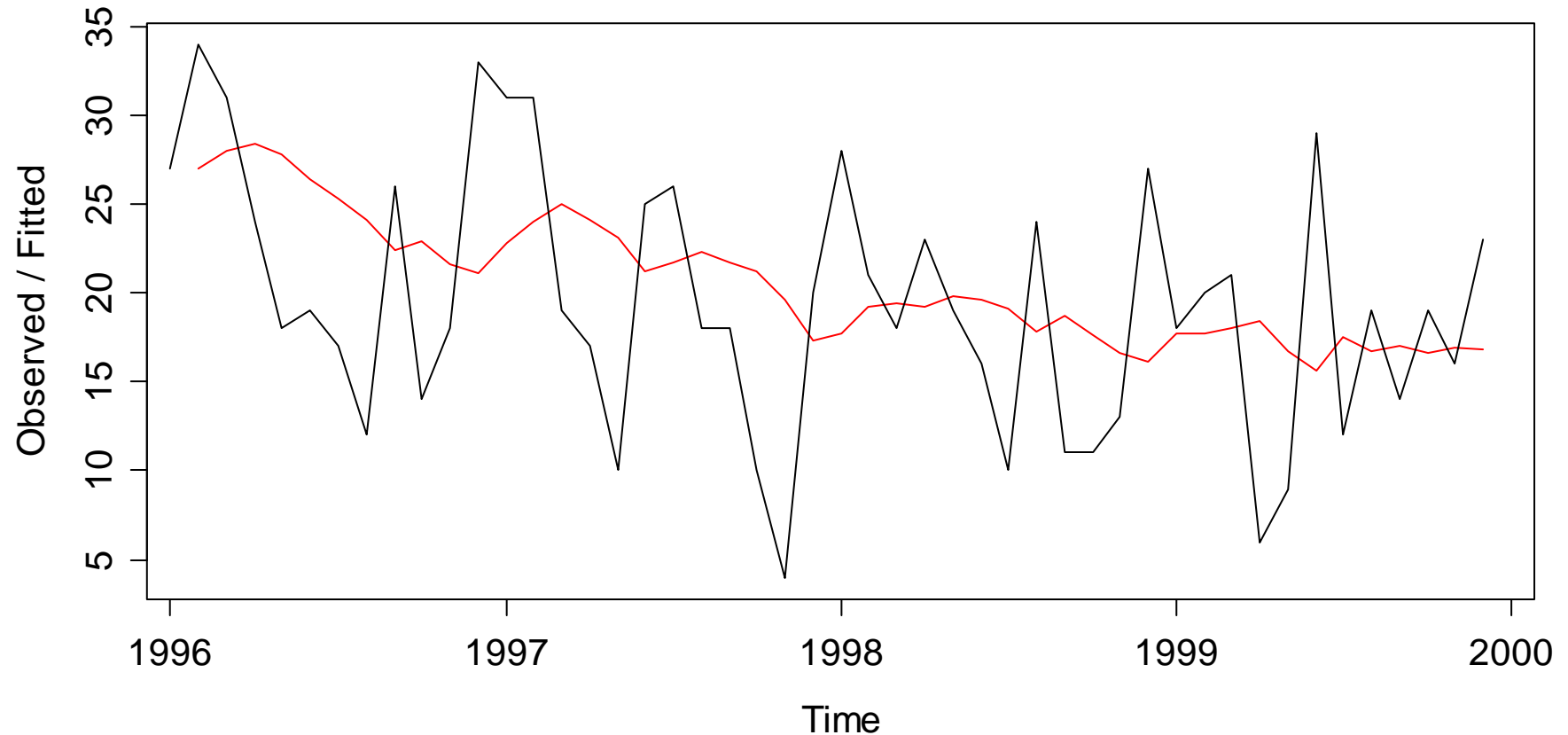
```
a 17.70343
```

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### *Exponential Smoothing: Example*

Holt-Winters filtering



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### *Holt-Winters Method*

#### **Purpose:**

- is for time series with deterministic trend and/or seasonality
- is still a heuristic, model-free approach
- again based on weighted averaging

#### **Is based on these 3 formulae:**

$$a_t = \alpha(x_t - s_{t-p}) + (1 - \alpha)(a_{t-1} + b_{t-1})$$

$$b_t = \beta(a_t - a_{t-1}) + (1 - \beta)b_{t-1}$$

$$s_t = \gamma(x_t - a_t) + (1 - \gamma)s_{t-p}$$

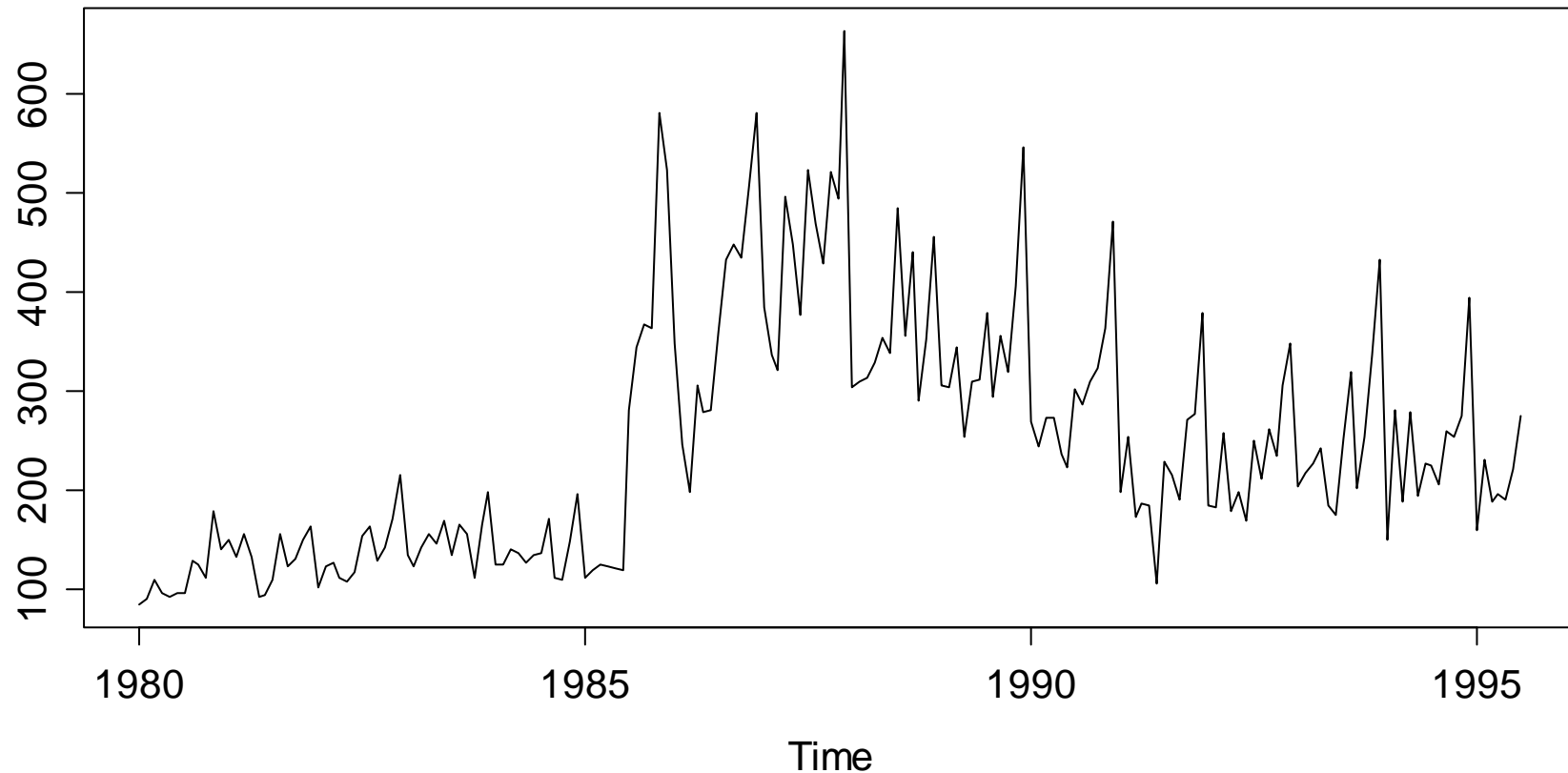
→ **See the blackboard for the derivation...**

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### *Holt-Winters: Example*

Sales of Australian White Wine

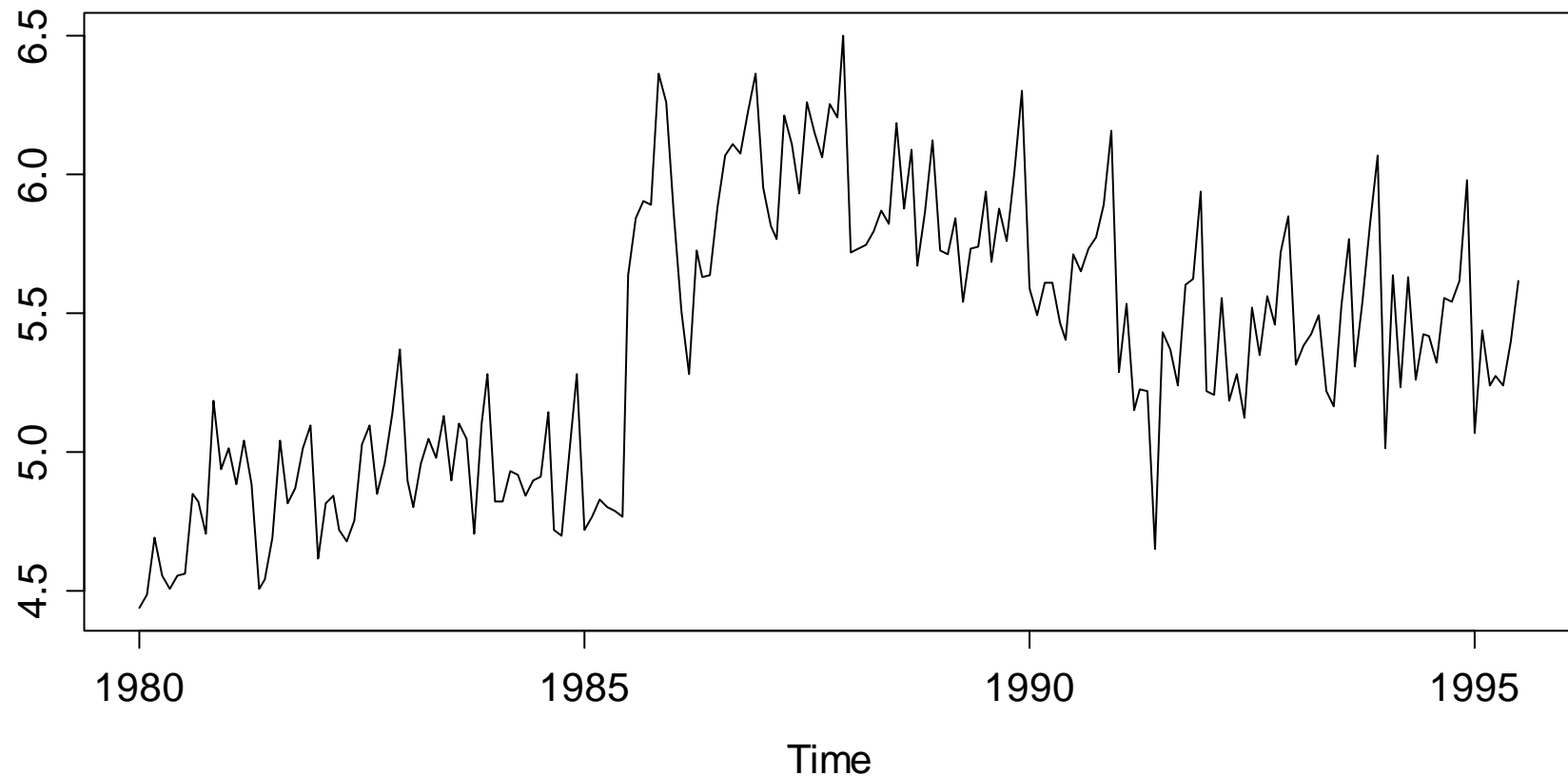


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### *Holt-Winters: Example*

**Logged Sales of Australian White Wine**





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### *Holt-Winters: R-Code and Output*

```
> HoltWinters(x = log(aww))
```

Holt-Winters exponential smoothing with trend and additive seasonal component.

Smoothing parameters:

```
alpha: 0.4148028; beta : 0; gamma: 0.4741967
```

Coefficients:

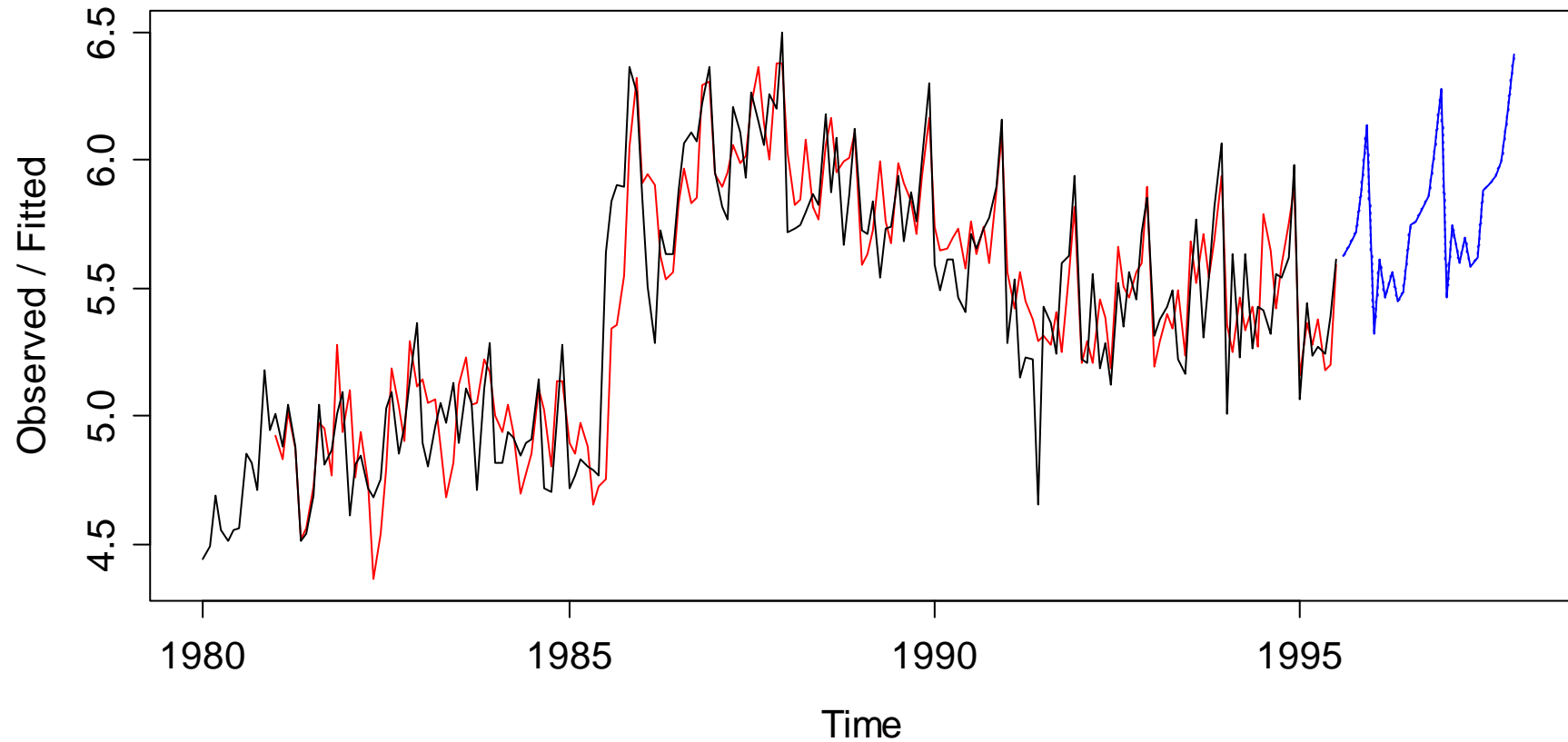
```
a      5.62591329; b      0.01148402
s1     -0.01230437; s2     0.01344762; s3     0.06000025
s4     0.20894897; s5     0.45515787; s6     -0.37315236
s7     -0.09709593; s8     -0.25718994; s9     -0.17107682
s10    -0.29304652; s11    -0.26986816; s12    -0.01984965
```

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### *Holt-Winters: Fitted Values & Predictions*

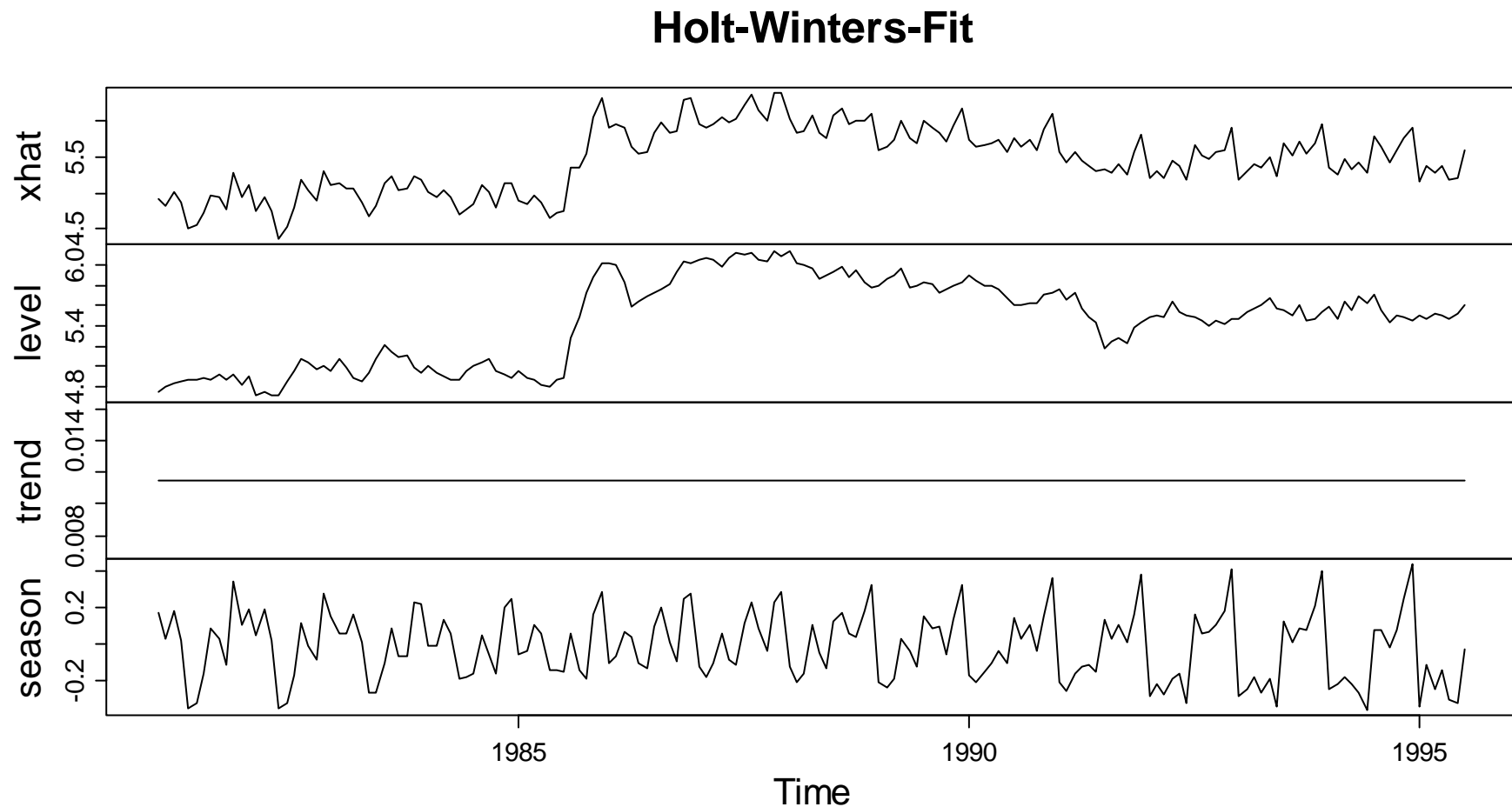
Holt-Winters filtering



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### *Holt-Winters: In-Sample Analysis*

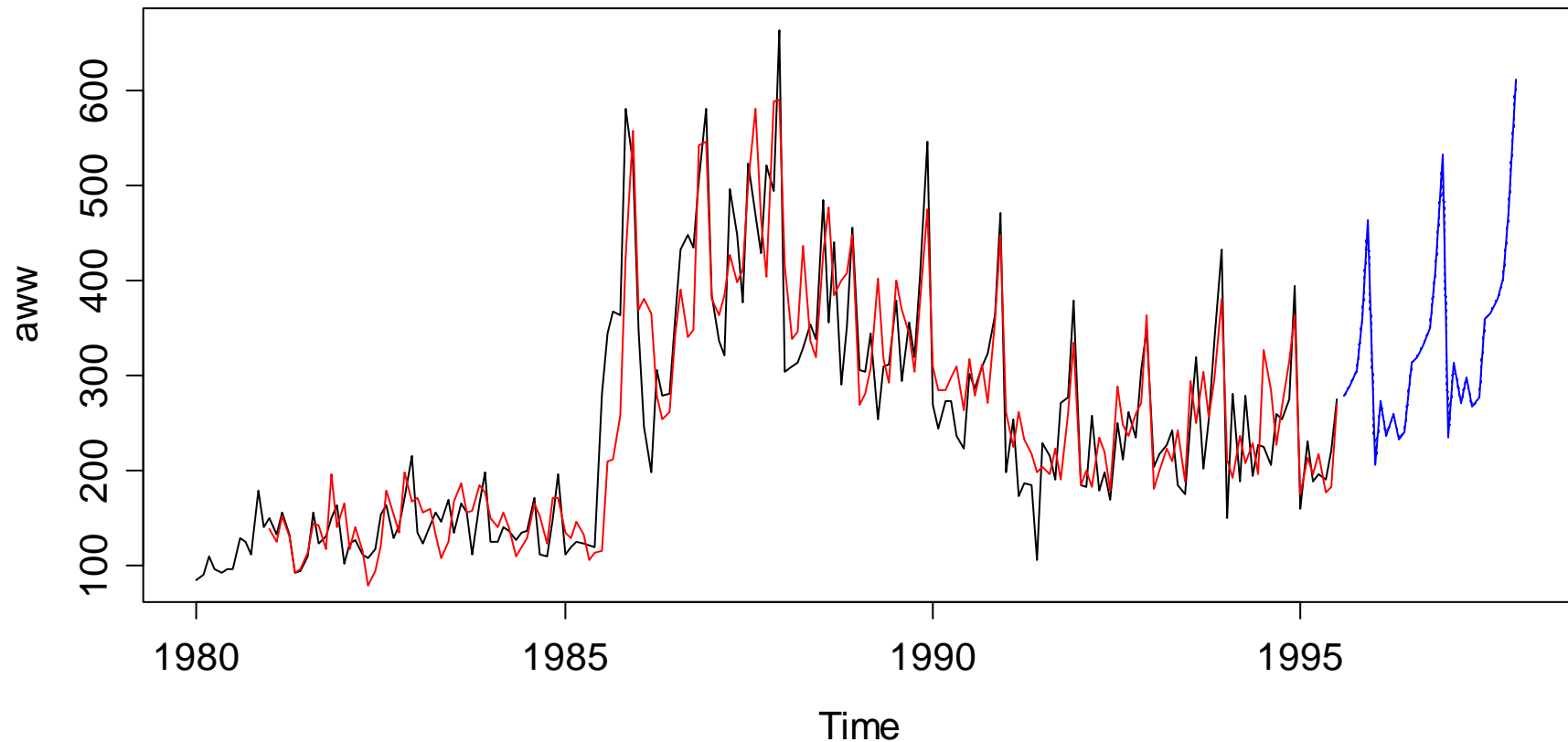


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### *Holt-Winters: Predictions on Original Scale*

Holt-Winters-Forecast for the Original Series



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### ***Exercise***

#### **Data:**

- *use the Australian white wine sales data...*
- *... or any other dataset you like*

#### **Goal:**

- *Find a good model describing these data*
- *Evaluate which model yields the best predictions*
- *Generate a 29-month forecast from this model*

#### **Method:**

- *Remove the last 29 observations and mimic oos-forecasting*