



Forecasting: principles and practice

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3.4 Practical issues

Outline

- 1 Models for different frequencies**
- 2 Ensuring forecasts stay within limits
- 3 Forecast combinations
- 4 Missing values
- 5 Outliers

Models for different frequencies

Models for annual data

- ETS, ARIMA, Dynamic regression

Models for different frequencies

Models for annual data

- ETS, ARIMA, Dynamic regression

Models for quarterly data

- ETS, ARIMA/SARIMA, Dynamic regression, Dynamic harmonic regression, STL+ETS, STL+ARIMA

Models for different frequencies

Models for annual data

- ETS, ARIMA, Dynamic regression

Models for quarterly data

- ETS, ARIMA/SARIMA, Dynamic regression, Dynamic harmonic regression, STL+ETS, STL+ARIMA

Models for monthly data

- ETS, ARIMA/SARIMA, Dynamic regression, Dynamic harmonic regression, STL+ETS, STL+ARIMA

Models for different frequencies

Models for weekly data

- ARIMA/SARIMA, Dynamic regression, Dynamic harmonic regression, STL+ETS, STL+ARIMA, TBATS

Models for different frequencies

Models for weekly data

- ARIMA/SARIMA, Dynamic regression, Dynamic harmonic regression, STL+ETS, STL+ARIMA, TBATS

Models for daily, hourly and other sub-daily data

- ARIMA/SARIMA, Dynamic regression, Dynamic harmonic regression, STL+ETS, STL+ARIMA, TBATS

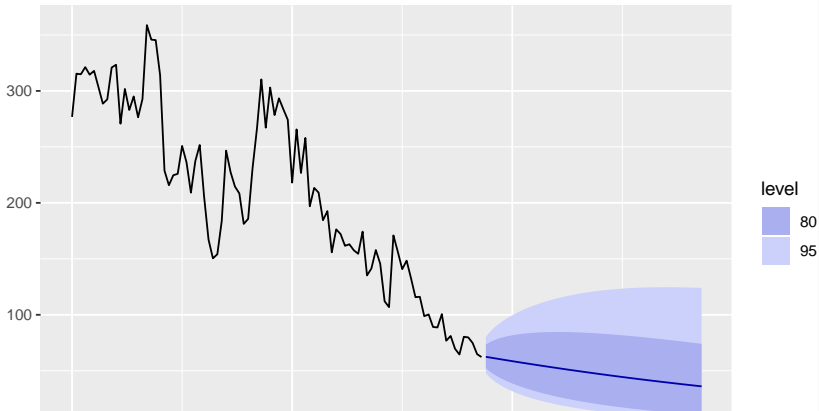
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Positive forecasts

```
eggs %>%  
  ets(model="AAN", damped=FALSE, lambda=0) %>%  
  forecast(h=50, biasadj=TRUE) %>%  
  autoplot()
```

Forecasts from ETS(A,A,N)



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Forecast combinations

Clemen (1989)

“The results have been virtually unanimous: combining multiple forecasts leads to increased forecast accuracy. ... In many cases one can make dramatic performance improvements by simply averaging the forecasts.”

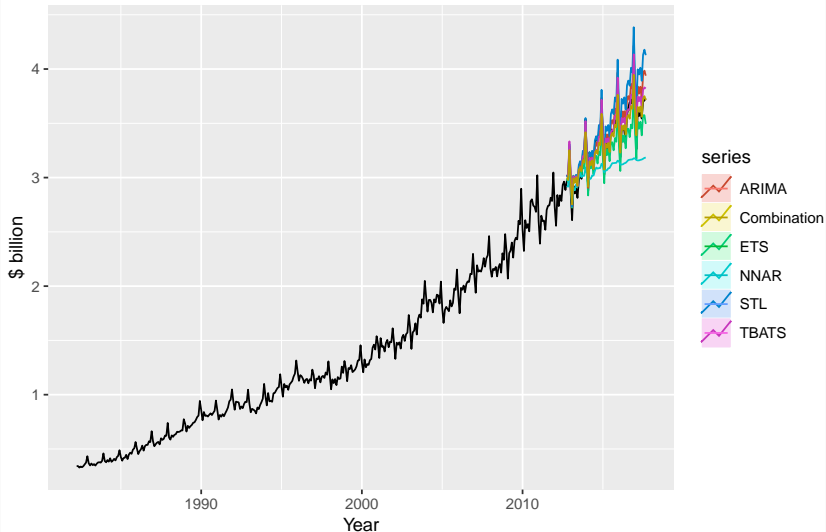
Forecast combinations

```
train <- window(auscafe, end=c(2012,9))
h <- length(auscafe) - length(train)
ETS <- forecast(ets(train), h=h)
ARIMA <- forecast(auto.arima(train, lambda=0, biasadj=TRUE),
  h=h)
STL <- stlf(train, lambda=0, h=h, biasadj=TRUE)
NNAR <- forecast(nnetar(train), h=h)
TBATS <- forecast(tbats(train, biasadj=TRUE), h=h)
Combination <- (ETS[["mean"]] + ARIMA[["mean"]] +
  STL[["mean"]] + NNAR[["mean"]] + TBATS[["mean"]])/5

autoplot(auscafe) +
  autolayer(ETS, series="ETS", PI=FALSE) +
  autolayer(ARIMA, series="ARIMA", PI=FALSE) +
  autolayer(STL, series="STL", PI=FALSE) +
  autolayer(NNAR, series="NNAR", PI=FALSE) +
  autolayer(TBATS, series="TBATS", PI=FALSE) +
  autolayer(Combination, series="Combination") +
  xlab("Year") + ylab("$ billion") +
  ggtitle("Australian monthly expenditure on eating out")
```

Forecast combinations

Australian monthly expenditure on eating out



Forecast combinations

```
c(ETS = accuracy(ETS, auscafe)["Test set", "RMSE"],  
  ARIMA = accuracy(ARIMA, auscafe)["Test set", "RMSE"],  
  STL-ETS = accuracy(STL, auscafe)["Test set", "RMSE"],  
  NNAR = accuracy(NNAR, auscafe)["Test set", "RMSE"],  
  TBATS = accuracy(TBATS, auscafe)["Test set", "RMSE"],  
  Combination =  
    accuracy(Combination, auscafe)["Test set", "RMSE"])
```

| | | | | |
|----|---------|-------------|---------|---------|
| ## | ETS | ARIMA | STL-ETS | NNAR |
| ## | 0.13700 | 0.12146 | 0.21446 | 0.33456 |
| ## | TBATS | Combination | | |
| ## | 0.09406 | 0.07225 | | |

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Missing values

Functions which can handle missing values

- `auto.arima()`, `Arima()`
- `tslm()`
- `nnetar()`

Models which cannot handle missing values

- `ets()`
- `stl()`
- `stlf()`
- `tbats()`

Missing values

Functions which can handle missing values

- `auto.arima()`, `Arima()`
- `tslm()`
- `nnetar()`

Models which cannot handle missing values

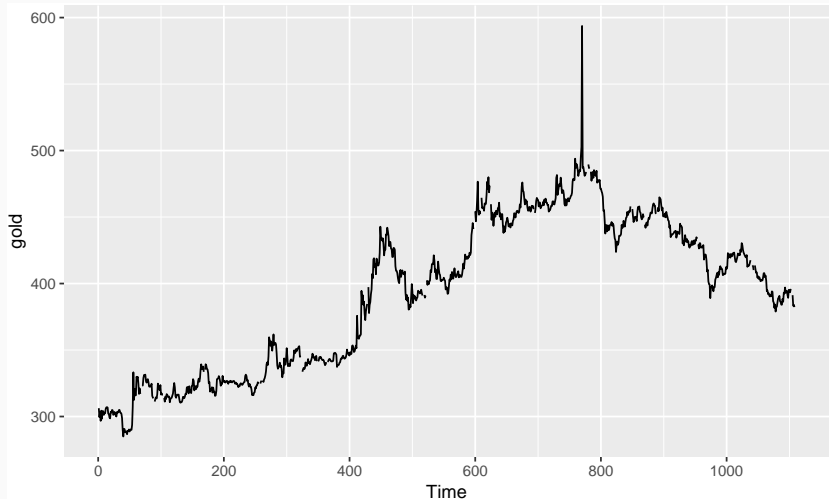
- `ets()`
- `stl()`
- `stlf()`
- `tbats()`

What to do?

- 1 Model section of data after last missing value.

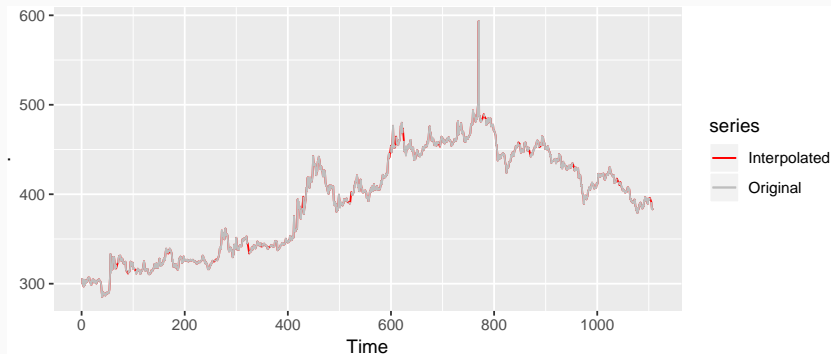
Missing values

```
autoplot(gold)
```



Missing values

```
gold %>% na.interp() %>%  
  autoplot(series="Interpolated") +  
  autolayer(gold, series="Original") +  
  scale_color_manual(  
    values=c(Interpolated="red",Original="gray"))
```

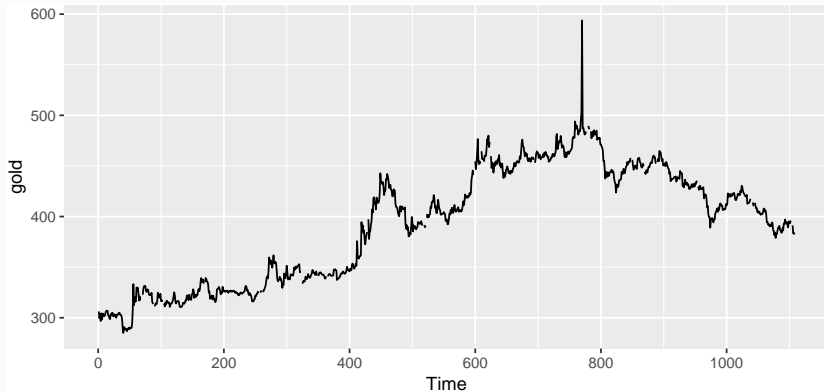


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Outliers

```
autoplot(gold)
```



Outliers

```
tsoutliers(gold)
```

```
## $index
```

```
## [1] 770
```

```
##
```

```
## $replacements
```

```
## [1] 494.9
```

Outliers

```
gold %>% tsclean() %>% autoplot()
```

