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# FORECASTING

## PRINCIPLES AND PRACTICE

A comprehensive introduction to the latest forecasting methods using R. Learn to improve your forecast accuracy using dozens of real data examples.



3RD EDITION

 **OTexts**  
Open Texts Publishing

## 9. ARIMA models

### 9.10 ARIMA vs ETS

[OTexts.org/fpp3/](http://OTexts.org/fpp3/)

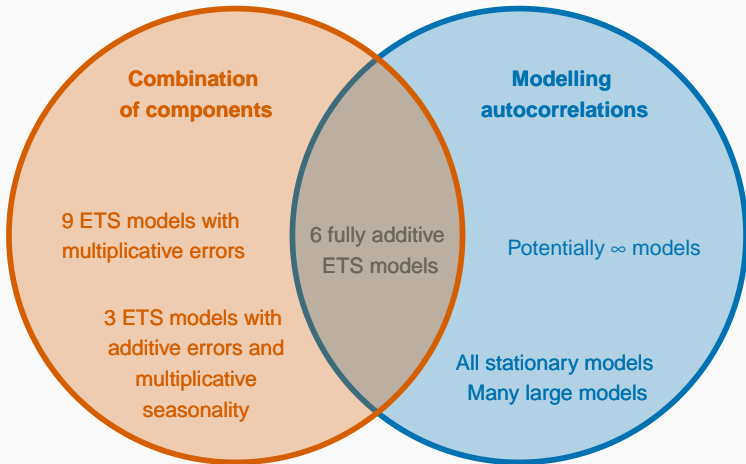
# ARIMA vs ETS

- Myth that ARIMA models are more general than exponential smoothing.
- Linear exponential smoothing models all special cases of ARIMA models.
- Non-linear exponential smoothing models have no equivalent ARIMA counterparts.
- Many ARIMA models have no exponential smoothing counterparts.
- ETS models all non-stationary. Models with seasonality or non-damped trend (or both) have two unit roots; all other models have one unit root.

# ARIMA vs ETS

## ETS models

## ARIMA models



# Equivalences

ETS model	ARIMA model	Parameters
ETS(A,N,N)	ARIMA(0,1,1)	$\theta_1 = \alpha - 1$
ETS(A,A,N)	ARIMA(0,2,2)	$\theta_1 = \alpha + \beta - 2$ $\theta_2 = 1 - \alpha$
ETS(A,A <sub>d</sub> ,N)	ARIMA(1,1,2)	$\phi_1 = \phi$ $\theta_1 = \alpha + \phi\beta - 1 - \phi$ $\theta_2 = (1 - \alpha)\phi$
ETS(A,N,A)	ARIMA(0,0,m)(0,1,0) <sub>m</sub>	
ETS(A,A,A)	ARIMA(0,1,m + 1)(0,1,0) <sub>m</sub>	
ETS(A,A <sub>d</sub> ,A)	ARIMA(1,0,m + 1)(0,1,0) <sub>m</sub>	

# Example: Australian population

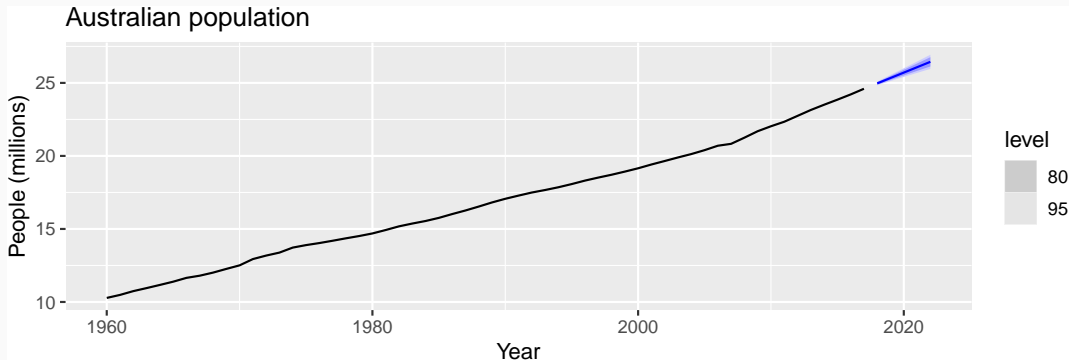
```
aus_economy <- global_economy |>
  filter(Code == "AUS") |>
  mutate(Population = Population / 1e6)
aus_economy |>
  slice(-n()) |>
  stretch_tsibble(.init = 10) |>
  model(ets = ETS(Population), arima = ARIMA(Population)) |>
  forecast(h = 1) |>
  accuracy(aus_economy) |>
  select(.model, ME:RMSSE)
```

```
## # A tibble: 2 x 8
```

##	.model	ME	RMSE	MAE	MPE	MAPE	MASE	RMSSE
##	<chr>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>
## 1	arima	0.0420	0.194	0.0789	0.277	0.509	0.317	0.746
## 2	ets	0.0202	0.0774	0.0543	0.112	0.327	0.218	0.298

# Example: Australian population

```
aus_economy |>  
  model(ETS(Population)) |>  
  forecast(h = "5 years") |>  
  autoplot(aus_economy) +  
  labs(title = "Australian population", y = "People (millions)")
```



# Example: Cement production

```
cement <- aus_production |>
  select(Cement) |>
  filter_index("1988 Q1" ~ .)
train <- cement |> filter_index(. ~ "2007 Q4")
fit <- train |>
  model(
    arima = ARIMA(Cement),
    ets = ETS(Cement)
  )
```

# Example: Cement production

```
fit |>  
  select(arima) |>  
  report()
```

```
## Series: Cement
```

```
## Model: ARIMA(1,0,1)(2,1,1)[4] w/ drift
```

```
##
```

```
## Coefficients:
```

```
##          ar1      ma1      sar1      sar2      sma1      constant
```

```
##          0.8886  -0.237   0.081   -0.234  -0.898         5.39
```

```
## s.e.    0.0842   0.133   0.157   0.139   0.178         1.48
```

```
##
```

```
## sigma^2 estimated as 11456:  log likelihood=-464
```

```
## AIC=941   AICc=943   BIC=957
```



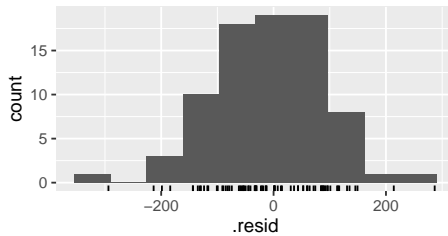
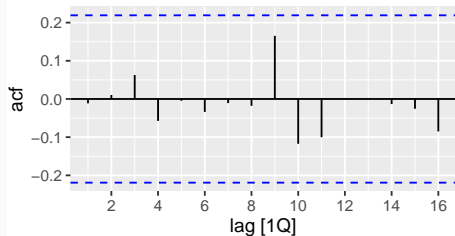
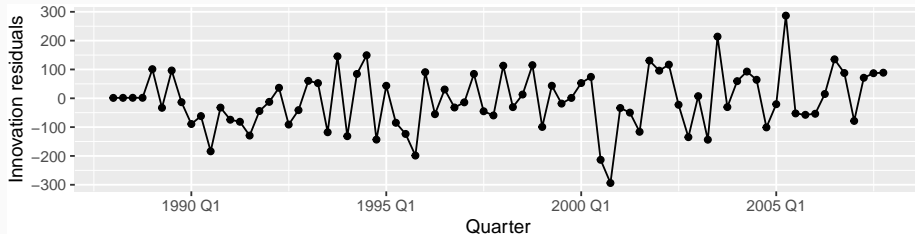
# Example: Cement production

```
fit |>  
  select(ets) |>  
  report()
```

```
## Series: Cement  
## Model: ETS(M,N,M)  
## Smoothing parameters:  
##   alpha = 0.753  
##   gamma = 1e-04  
##  
## Initial states:  
## l[0] s[0] s[-1] s[-2] s[-3]  
## 1695 1.03  1.05  1.01 0.912  
##  
## sigma^2:  0.0034  
##  
## AIC AICc BIC  
## 1104 1106 1121
```

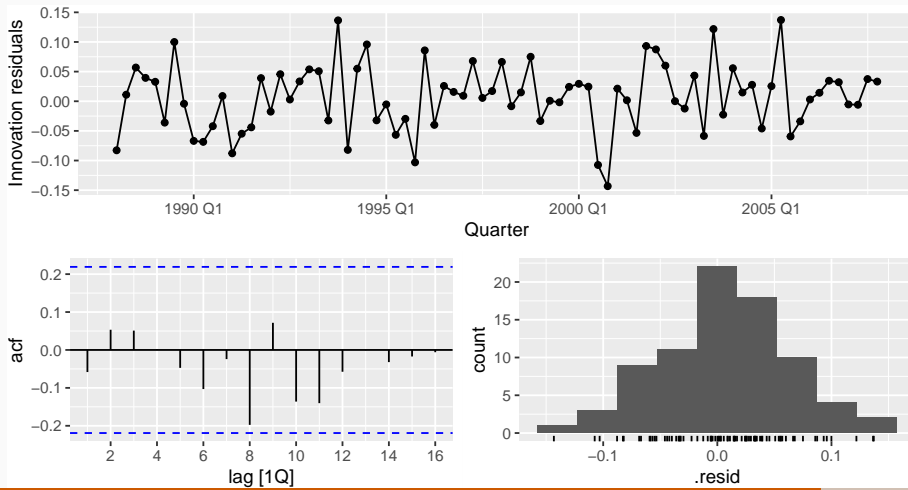
# Example: Cement production

```
gg_tsresiduals(fit |> select(arima), lag_max = 16)
```



# Example: Cement production

```
gg_tsresiduals(fit |> select(ets), lag_max = 16)
```



# Example: Cement production

```
fit |>
  select(arima) |>
  augment() |>
  features(.innov, ljung_box, lag = 16, dof = 6)
```

```
## # A tibble: 1 x 3
##   .model lb_stat lb_pvalue
##   <chr>    <dbl>    <dbl>
## 1 arima      6.37      0.783
```

# Example: Cement production

```
fit |>
  select(ets) |>
  augment() |>
  features(.innov, ljung_box, lag = 16)
```

```
## # A tibble: 1 x 3
##   .model lb_stat lb_pvalue
##   <chr>    <dbl>    <dbl>
## 1 ets      10.0      0.865
```

# Example: Cement production

```
fit |>  
  forecast(h = "2 years 6 months") |>  
  accuracy(cement) |>  
  select(-ME, -MPE, -ACF1)
```

```
## # A tibble: 2 x 7  
##   .model .type  RMSE    MAE  MAPE  MASE RMSSE  
##   <chr>  <chr> <dbl> <dbl> <dbl> <dbl> <dbl>  
## 1 arima  Test   216.  186.  8.68  1.27  1.26  
## 2 ets   Test   222.  191.  8.85  1.30  1.29
```

# Example: Cement production

```
fit |>  
  select(arima) |>  
  forecast(h = "3 years") |>  
  autoplot(cement) +  
  labs(title = "Cement production in Australia", y = "Tonnes ('000)")
```

