

# Forecasting: principles and practice

Rob J Hyndman

1.1 Introduction to Forecasting

# Outline

**1** Background

**2** Case studies

**3** The statistical forecasting perspective

**4** What can we forecast?

# Resources

- Slides
- Exercises
- Textbook
- Useful links

**[robjhyndman.com/nyc2018](http://robjhyndman.com/nyc2018)**

## Brief bio

- Professor of Statistics, Monash University
- Editor-in-Chief, *International Journal of Forecasting*

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- Pharmaceutical Benefits Scheme
- Cancer incidence and mortality
- Electricity demand
- Ageing population
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# Assumptions

- This is not an introduction to R. I assume you are broadly comfortable with R code and the RStudio environment.
- This is not a statistics course. I assume you are familiar with concepts such as the mean, standard deviation, quantiles, regression, normal distribution, likelihood, etc.
- This is not a theory course. I am not going to derive anything. I will teach you forecasting tools, when to use them and how to use them most effectively.

## Key reference

Hyndman, R. J. & Athanasopoulos, G.  
*(2018) Forecasting: principles and practice*, 2nd ed.

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[OTexts.org/fpp2/](https://otexts.org/fpp2/)

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- Free and online
- Data sets in associated R package
- R code for examples

## Poll: How experienced are you in forecasting

- 1 Guru: I wrote the book, done it for decades, now I do the conference circuit.
- 2 Expert: It has been my full time job for more than a decade.
- 3 Skilled: I have been doing it for years.
- 4 Comfortable: I understand it and have done it.
- 5 Learner: I am still learning.
- 6 Beginner: I have heard of it and would like to learn more.
- 7 Unknown: What is forecasting? Is that what the weather people do?

# Poll: How proficient are you in using R?

- 1 Guru: The R core team come to me for advice.
- 2 Expert: I have written several packages on CRAN.
- 3 Skilled: I use it regularly and it is an important part of my job.
- 4 Comfortable: I use it often and am comfortable with the tool.
- 5 User: I use it sometimes, but I am often searching around for the right function.
- 6 Learner: I have used it a few times.
- 7 Beginner: I've managed to download and install it.
- 8 Unknown: Why are you speaking like a pirate?

# Install required packages

```
install.packages("fpp2", dependencies=TRUE)
```

# Approximate outline

| Day | Topic                         | Chapter |
|-----|-------------------------------|---------|
| 1.1 | Time series graphics          | 2       |
| 1.2 | Benchmark methods             | 3       |
| 1.3 | Forecast evaluation           | 3       |
| 1.4 | Exponential smoothing         | 7       |
| 1.5 | ETS state space models        | 7       |
| 2.1 | Transformations               | 3       |
| 2.2 | Seasonality and trends        | 6       |
| 2.3 | Stationarity and differencing | 8       |
| 2.4 | Non-seasonal ARIMA models     | 8       |
| 2.5 | Seasonal ARIMA models         | 8       |
| 3.1 | Dynamic regression            | 9       |
| 3.2 | Multiple seasonality          | 11      |
| 3.3 | Hierarchical forecasting      | 10      |
| 3.4 | Some practical issues         | 12      |

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# CASE STUDY 1: Paperware company

**Problem:** Want forecasts of each of hundreds of items. Series can be stationary, trended or seasonal. They currently have a large forecasting program written in-house but it doesn't seem to produce sensible forecasts. They want me to tell them what is wrong and fix it.

## Additional information

- Program written in COBOL making numerical calculations limited. It is not possible to do any optimisation.
- Their programmer has little experience in numerical computing.
- They employ no statisticians and want the program to produce forecasts automatically.



# CASE STUDY 1: Paperware company

## Methods currently used

- A 12 month average
- C 6 month average
- E straight line regression over last 12 months
- G straight line regression over last 6 months
- H average slope between last year's and this year's values. (Equivalent to differencing at lag 12 and taking mean.)
- I Same as H except over 6 months.
- K I couldn't understand the explanation.

## CASE STUDY 2: PBS



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The **Pharmaceutical Benefits Scheme** (PBS) is the Australian government drugs subsidy scheme.

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The **Pharmaceutical Benefits Scheme** (PBS) is the Australian government drugs subsidy scheme.

- Many drugs bought from pharmacies are subsidised to allow more equitable access to modern drugs.
- The cost to government is determined by the number and types of drugs purchased. Currently nearly 1% of GDP.
- The total cost is budgeted based on forecasts of drug usage.

# CASE STUDY 2: PBS



# ABC News Online

AUSTRALIAN BROADCASTING CORPORATION



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Streaming audio news

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## POLITICS

### Opp demands drug price restriction after PBS budget blow-out

The Federal Opposition has called for tighter controls on drug prices after the Pharmaceutical Benefits Scheme (PBS) budget blew out by almost \$800 million.

The money was spent on two new drugs including the controversial anti-smoking aid Zyban, which dropped in price from \$220 to \$22 after it was listed on the PBS.



## FEATURES



For a fresh perspective on the federal election, reach into ABC Online's campaign weblog, [The Poll Vault](#).

[Audio News Online](#)

## CASE STUDY 2: PBS

- In 2001: \$4.5 billion budget, under-forecasted by \$800~million.
- Thousands of products. Seasonal demand.
- Subject to covert marketing, volatile products, uncontrollable expenditure.
- Although monthly data available for 10 years, data are aggregated to annual values, and only the first three years are used in estimating the forecasts.
- All forecasts being done with the FORECAST function in MS-Excel!

## CASE STUDY 3: Airline



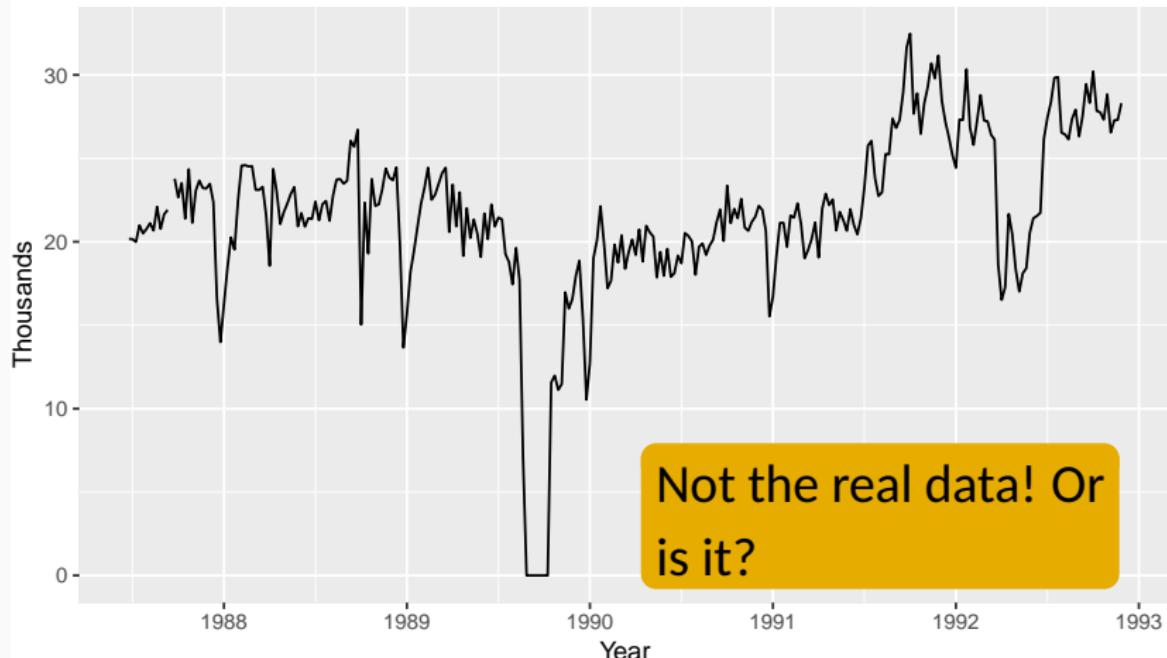
# CASE STUDY 3: Airline

Economy class passengers: Melbourne–Sydney



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Economy class passengers: Melbourne–Sydney



# CASE STUDY 3: Airline

**Problem:** how to forecast passenger traffic on major routes?

## Additional information

- They can provide a large amount of data on previous routes.
- Traffic is affected by school holidays, special events such as the Grand Prix, advertising campaigns, competition behaviour, etc.
- They have a highly capable team of people who are able to do most of the computing.

# Outline

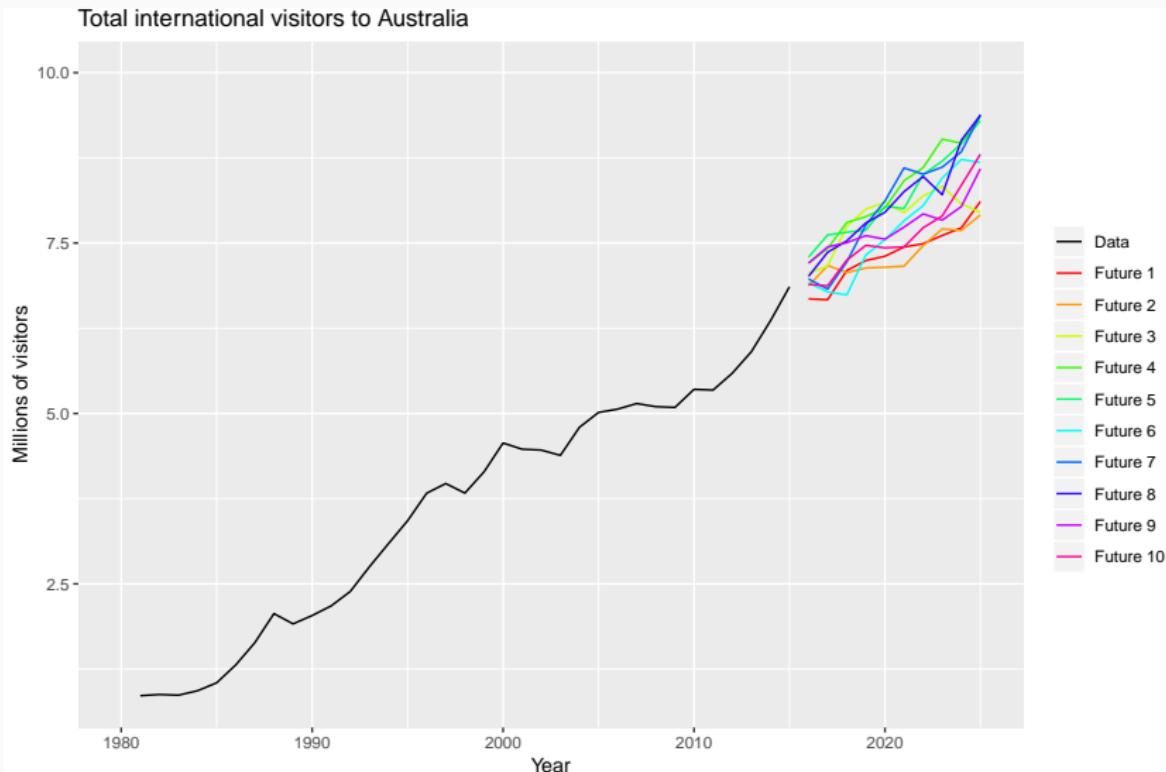
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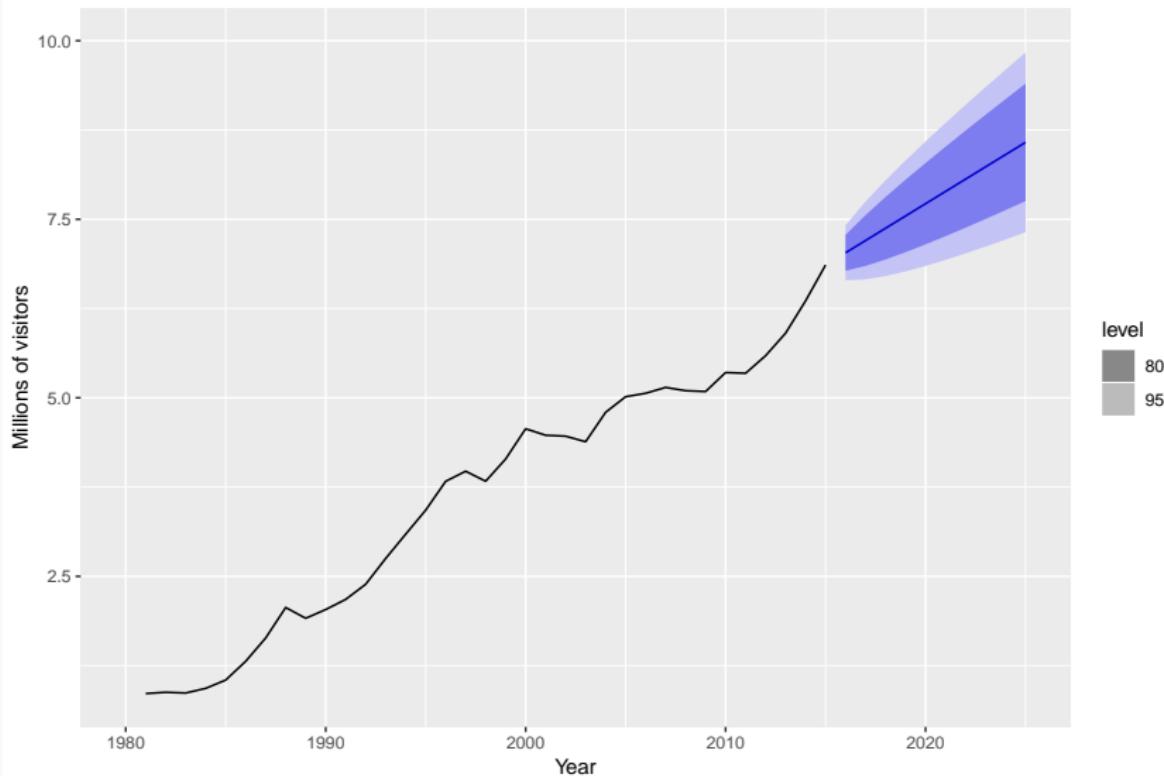
4 What can we forecast?

# Sample futures



# Forecast intervals

Forecasts of total international visitors to Australia



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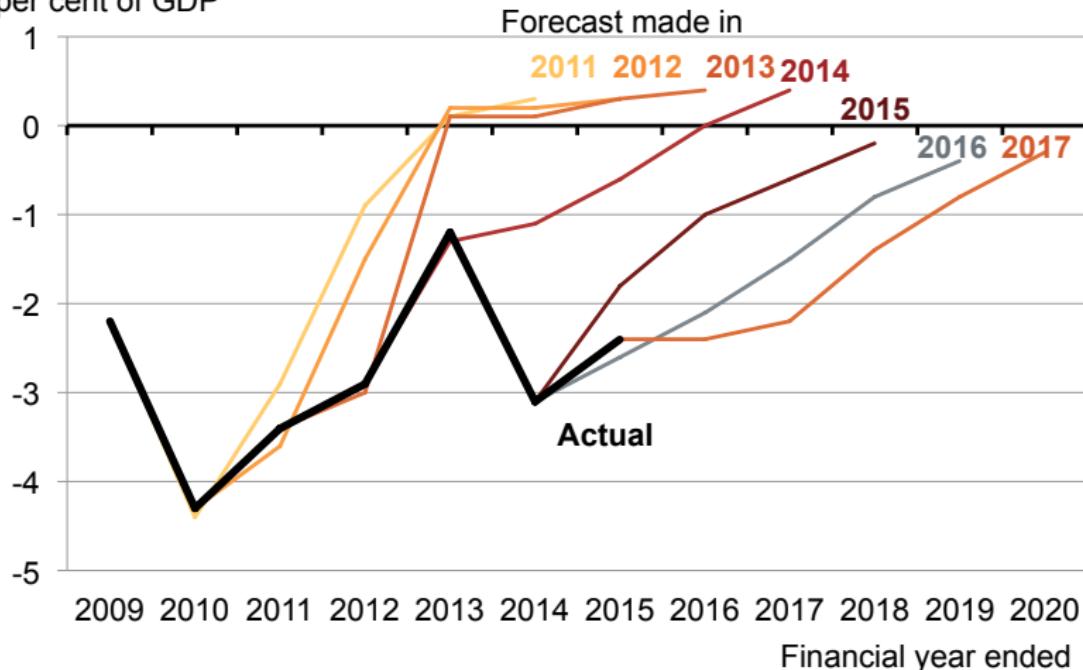
**4** What can we forecast?

# Forecasting is difficult

Commonwealth plans to drift back to surplus  
show the triumph of experience over hope

GRATTAN  
Institute

Actual and forecast Commonwealth underlying cash balance  
per cent of GDP



# What can we forecast?



# What can we forecast?



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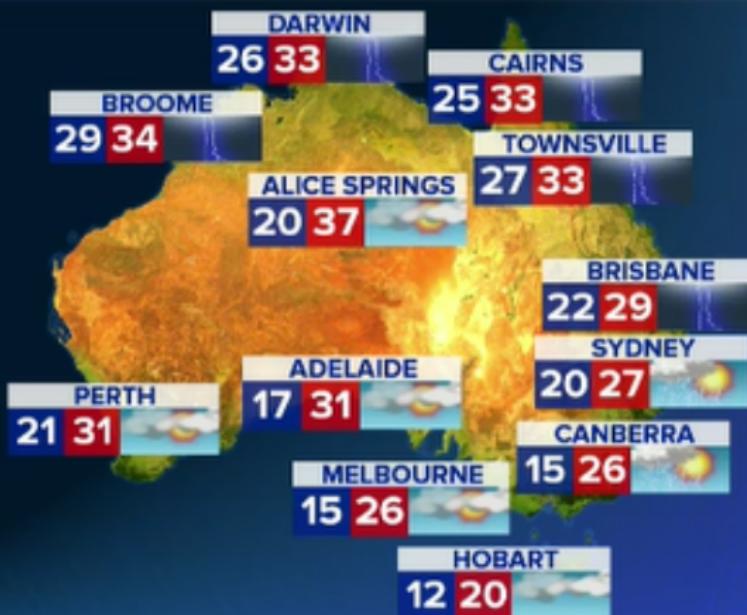


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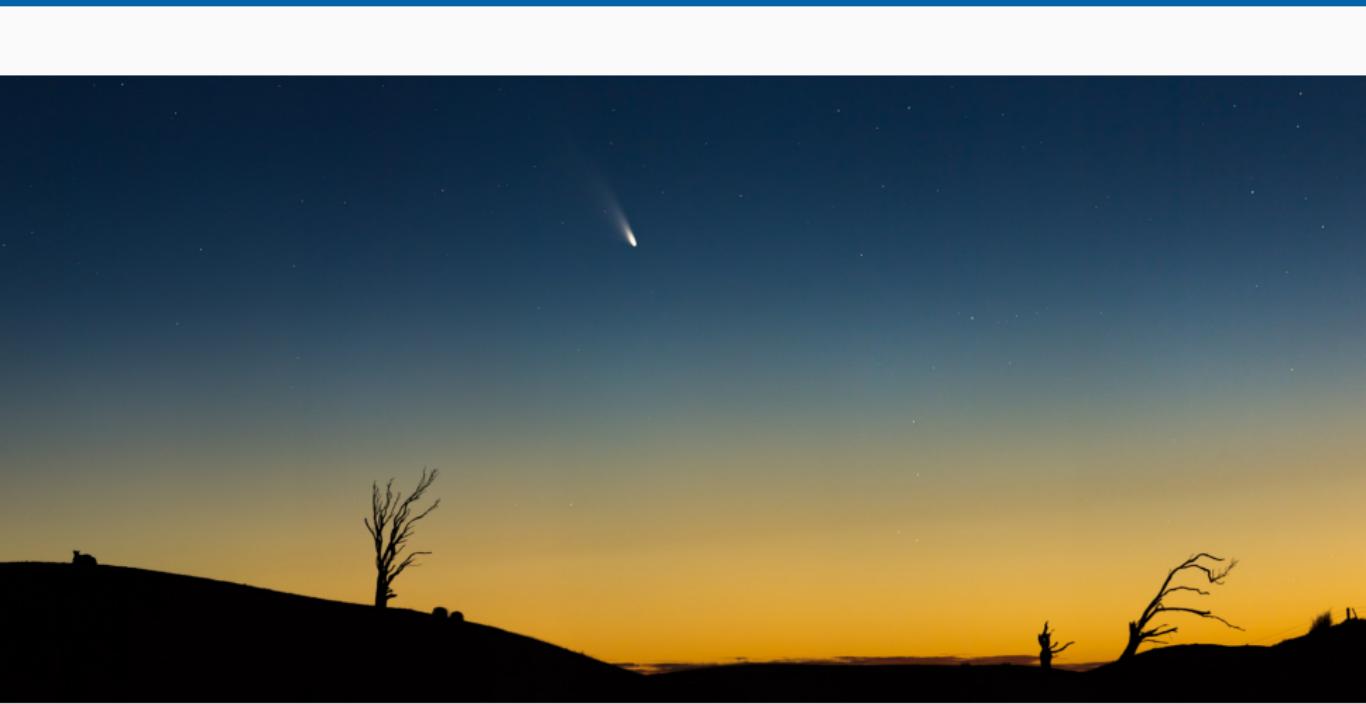
## TOMORROW



# What can we forecast?



# What can we forecast?



# Which is easiest to forecast?

- 1 daily electricity demand in 3 days time
- 2 timing of next Halley's comet appearance
- 3 time of sunrise this day next year
- 4 Google stock price tomorrow
- 5 Google stock price in 6 months time
- 6 maximum temperature tomorrow
- 7 exchange rate of \$US/AUS next week
- 8 total sales of drugs in Australian pharmacies next month

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- how do we measure “easiest”?
- what makes something easy/difficult to forecast? 33

# Factors affecting forecastability

Something is easier to forecast if:

- we have a good understanding of the factors that contribute to it
- there is lots of data available;
- the forecasts cannot affect the thing we are trying to forecast.
- there is relatively low natural/unexplainable random variation.
- the future is somewhat similar to the past