

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

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

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How my forecasting methodology is used:

- Pharmaceutical Benefits Scheme
- Cancer incidence and mortality
- Electricity demand
- Ageing population
- Fertilizer sales

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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OTexts.org/fpp2/

- 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
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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



CASE STUDY 2: PBS

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



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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.

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Federal Election 2001

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[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



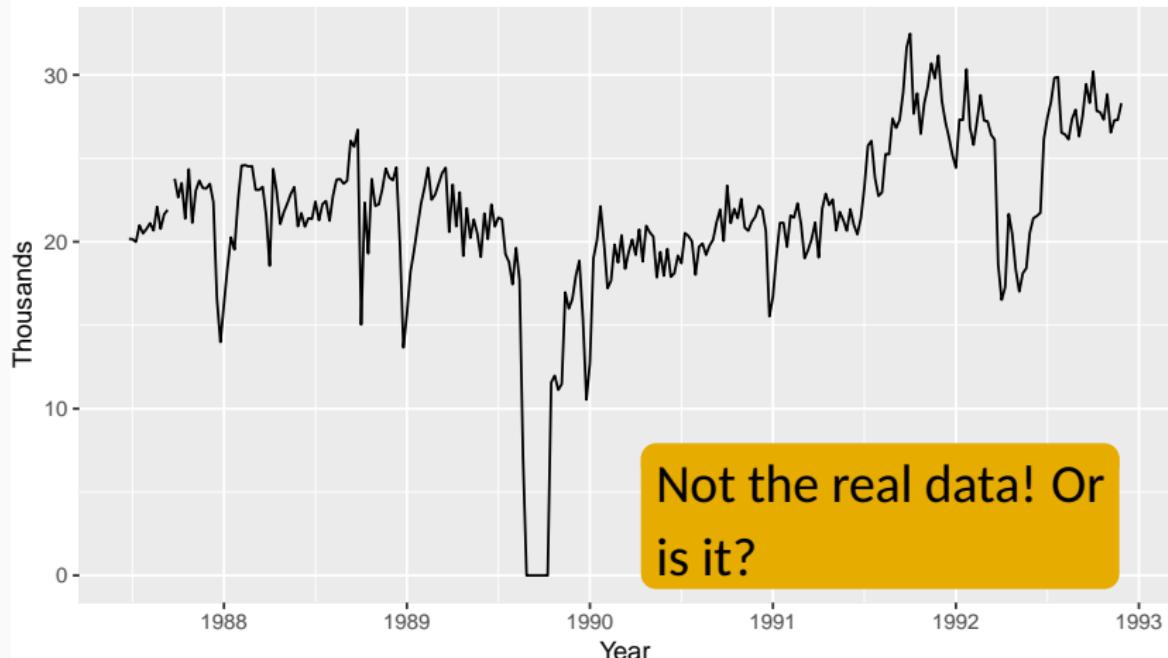
CASE STUDY 3: Airline

Economy class passengers: Melbourne–Sydney



CASE STUDY 3: Airline

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

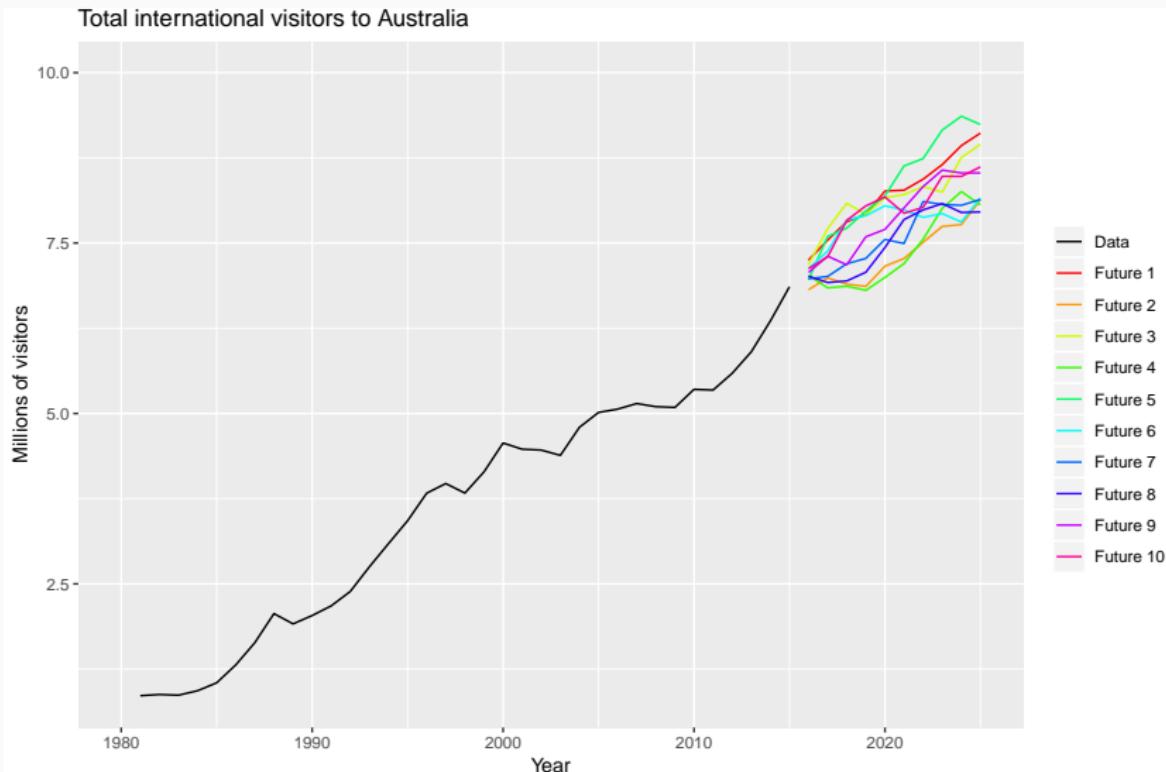
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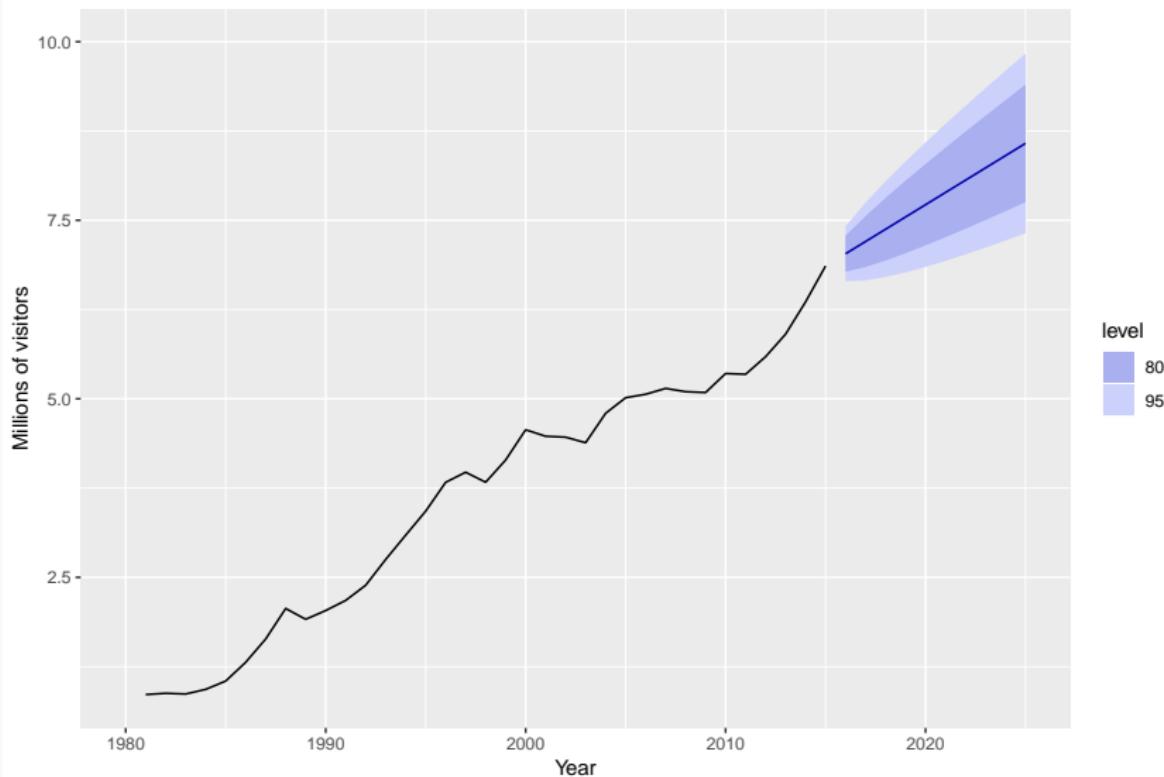
4 What can we forecast?

Sample futures



Forecast intervals

Forecasts of total international visitors to Australia



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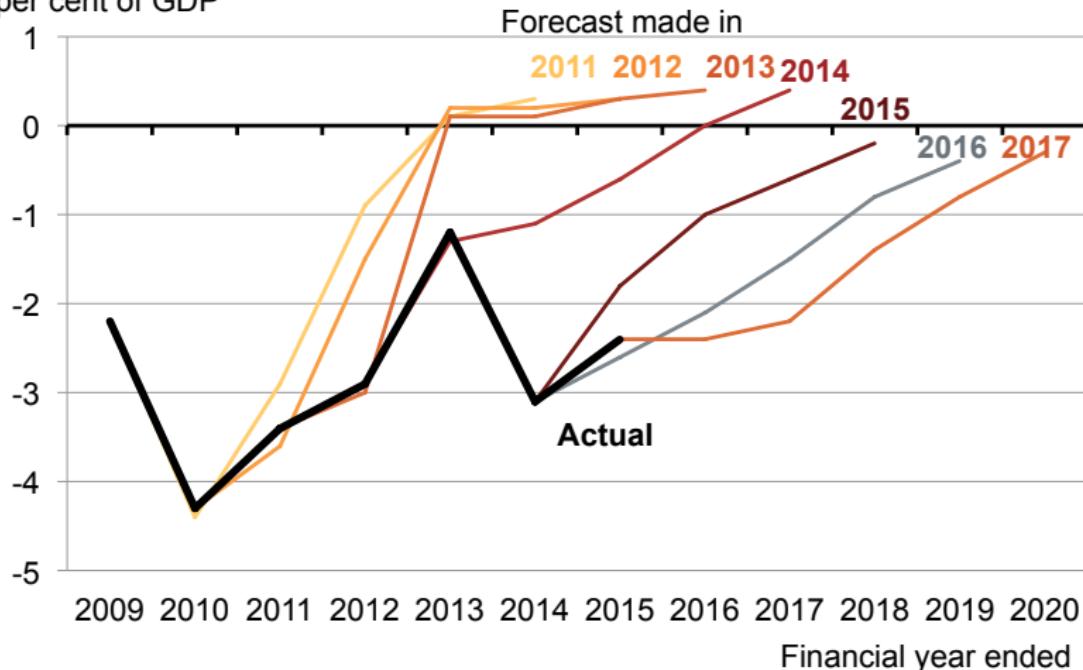
4 What can we forecast?

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?



What can we forecast?

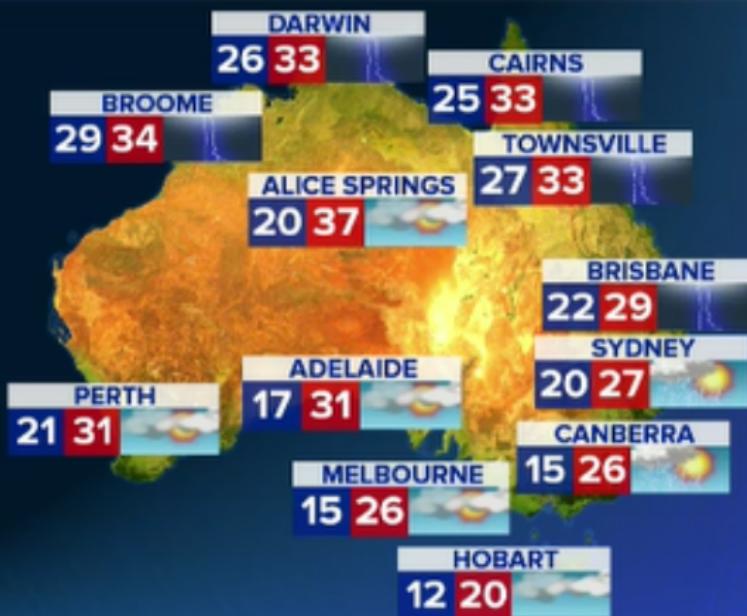


What can we forecast?



What can we forecast?

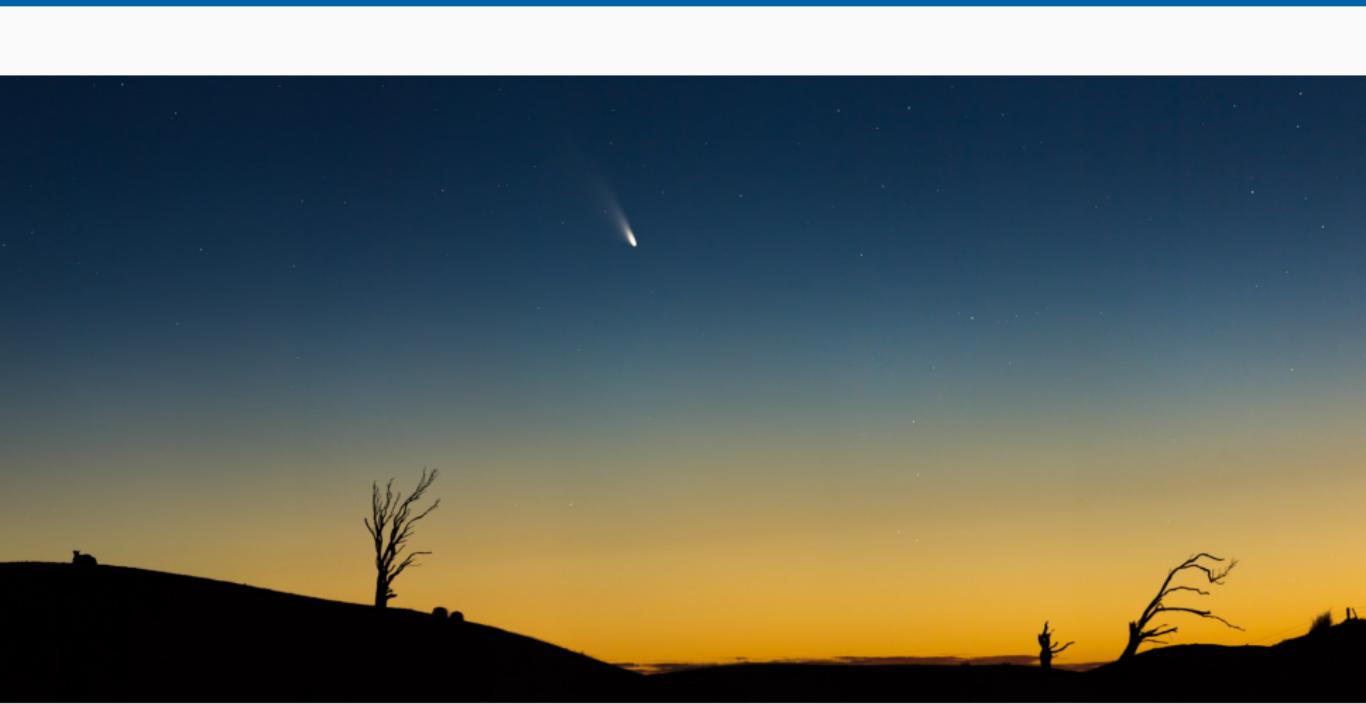
TOMORROW



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