

ETC3550/ETC5550

Applied forecasting

Week 1: Introduction to forecasting & R



Contact details

Chief Examiner: Professor Rob Hyndman

✉ rob.hyndman@monash.edu

🏠 robjhyndman.com

Tutors

- **Mitchell O'Hara-Wild**
- Maliny Po
- Nuwani Palihawadana
- Xiefei (Sapphire) Li

Brief bio

- Professor of Statistics, Monash University
- Co-author of most popular forecasting textbook in the world
- Lead developer of most popular forecasting software in the world

How my forecasting methodology is used:

- Pharmaceutical Benefits Scheme
- Electricity demand
- Australian tourism demand
- Ageing population
- COVID-19 cases

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 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.

- 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



NewsRadio

Streaming audio news

LISTEN: [WMP](#) | [Real](#)

Select a Topic
from the list below

[Top Stories](#)
[Just In](#)
[World](#)
[Asia-Pacific](#)
[Business](#)
[Sport](#)
[Arts](#)
[Sci Tech](#)
[Indigenous](#)
[Weather](#)
[Rural](#)
[Local News](#)
[Broadband](#)

Click "Refresh" or "Reload"
on your browser for the latest edition.

This Bulletin: **Wed, May 30 2001 6:22 PM AEST**

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

the Public Record

For full election coverage

FEATURES

the Public Record

Federal Election 2001

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

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: Car fleet company

Client: One of Australia's largest car fleet companies

Problem: how to forecast resale value of vehicles? How should this affect leasing and sales policies?

CASE STUDY 3: Car fleet company

Client: One of Australia's largest car fleet companies

Problem: how to forecast resale value of vehicles? How should this affect leasing and sales policies?

Additional information

- They can provide a large amount of data on previous vehicles and their eventual resale values.
- The resale values are currently estimated by a group of specialists. They see me as a threat and do not cooperate.

CASE STUDY 4: Airline



CASE STUDY 4: Airline



CASE STUDY 4: Airline



CASE STUDY 4: 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.

Unit objectives

- 1 To obtain an understanding of common statistical methods used in business and economic forecasting.
- 2 To develop the computer skills required to forecast business and economic time series data;
- 3 To gain insights into the problems of implementing and operating large scale forecasting systems for use in business.

Unit objectives

- 1 To obtain an understanding of common statistical methods used in business and economic forecasting.
- 2 To develop the computer skills required to forecast business and economic time series data;
- 3 To gain insights into the problems of implementing and operating large scale forecasting systems for use in business.

Teaching and learning approach

- Approximately one hour of pre-recorded online videos each week
- One hour online lecture each Monday
- One hour in-person workshop each Tuesday (focus on exam)
- One hour in-person tutorial each week (focus on assignments)

Key reference

Hyndman, R. J. & Athanasopoulos, G. (2021) *Forecasting: principles and practice*, 3rd edition

Key reference

Hyndman, R. J. & Athanasopoulos, G. (2021) *Forecasting: principles and practice*, 3rd edition

[OTexts.com/fpp3/](https://otexts.com/fpp3/)

Key reference

Hyndman, R. J. & Athanasopoulos, G. (2021) *Forecasting: principles and practice*, 3rd edition

[OTexts.com/fpp3/](https://otexts.com/fpp3/)

- Free and online
- Data sets in associated R packages
- R code for examples
- Embedded online lectures

Outline

Week	Topic	Chapter
1	Introduction to forecasting and R	1
2	Time series graphics	2
3	Time series decomposition	3
4	Simple forecasting methods	5
5	Accuracy evaluation	5
6-7	Exponential smoothing	8
8-10	ARIMA models	9
11	Multiple regression and forecasting	7
12	Dynamic regression	10

Assessment

Task	Due Date	Value
Forecasting Competition	Fri 7 Mar	2%
Weekly Quizzes	end of weeks 2–11	8%
Assignment 1	Fri 28 Mar	6%
Assignment 2	Fri 25 Apr	6%
Assignment 3	Tue 20 May	6%
Retail Project	Fri 30 May	12%
Final Exam	Official exam period	60%

Assessment

Task	Due Date	Value
Forecasting Competition	Fri 7 Mar	2%
Weekly Quizzes	end of weeks 2–11	8%
Assignment 1	Fri 28 Mar	6%
Assignment 2	Fri 25 Apr	6%
Assignment 3	Tue 20 May	6%
Retail Project	Fri 30 May	12%
Final Exam	Official exam period	60%

- Need at least 45% for exam, and 50% for total.
- **ETC5550 students:** Extra project and exam questions.

af.numbat.space

- Includes all course materials
- Links for assignment submissions
- Link to discussion forum.

Please don't send emails. Use the forum.



- The IIF provides a prize to the top student in this subject each year.
- US\$100 plus one year membership.



Available for download from CRAN:

<https://cran.r-project.org>



Available for download from RStudio:

<https://www.rstudio.com/products/rstudio/download/>

Main packages



Main packages

```
# Install required packages (do once)
install.packages(c("tidyverse", "fpp3", "GGally"), dependencies = TRUE)
```

Main packages

```
# Install required packages (do once)  
install.packages(c("tidyverse", "fpp3", "GGally"), dependencies = TRUE)
```

```
# At the start of each session  
library(fpp3)
```

Exercises Week 1

- Make sure you are familiar with R, RStudio and the tidyverse packages.
- Do the first five modules of `startr.numbat.space`.
- Forecasting competition

Forecasting competition: forecast the following series

- 1 Google closing stock price on 24 March 2025
- 2 Maximum temperature at Melbourne airport on 14 April 2025
- 3 The difference in points (Collingwood minus Essendon) scored in the AFL match between Collingwood and Essendon for the Anzac Day clash. 25 April 2025
- 4 The seasonally adjusted estimate of total employment for April 2025. ABS CAT 6202, to be released around mid May 2025
- 5 Google closing stock price on 26 May 2025

Due Friday 14 March

For each of these, give a point forecast and an 80% prediction interval.

Forecasting competition: forecast the following series

- 1 Google closing stock price on 24 March 2025
- 2 Maximum temperature at Melbourne airport on 14 April 2025
- 3 The difference in points (Collingwood minus Essendon) scored in the AFL match between Collingwood and Essendon for the Anzac Day clash. 25 April 2025
- 4 The seasonally adjusted estimate of total employment for April 2025. ABS CAT 6202, to be released around mid May 2025
- 5 Google closing stock price on 26 May 2025

Due Friday 14 March

For each of these, give a point forecast and an 80% prediction interval.

Prize: \$50 cash prize

Forecasting competition: scoring

Y = actual, F = point forecast, $[L, U]$ = prediction interval

Point forecasts:

$$\text{Absolute Error} = |Y - F|$$

- Rank results for all students in class
- Add ranks across all five items

Prediction intervals:

$$\text{Interval Score} = (U - L) + 10(L - Y)_+ + 10(Y - U)_+$$

- $u_+ = \max(u, 0)$
- Rank results for all students
- Add ranks across all five items

tsibble objects

```
global_economy
```

```
# A tsibble: 15,150 x 6 [1Y]
```

```
# Key:      Country [263]
```

	Year	Country	GDP	Imports	Exports	Population
	<dbl>	<fct>	<dbl>	<dbl>	<dbl>	<dbl>
1	1960	Afghanistan	5377777811.	7.02	4.13	8996351
2	1961	Afghanistan	5488888896.	8.10	4.45	9166764
3	1962	Afghanistan	5466666678.	9.35	4.88	9345868
4	1963	Afghanistan	7511111191.	16.9	9.17	9533954
5	1964	Afghanistan	8000000044.	18.1	8.89	9731361
6	1965	Afghanistan	10066666638.	21.4	11.3	9938414
7	1966	Afghanistan	13999999967.	18.6	8.57	10152331
8	1967	Afghanistan	16733333418.	14.2	6.77	10372630
9	1968	Afghanistan	13733333367.	15.2	8.90	10604346
10	1969	Afghanistan	14088888922.	15.0	10.1	10854428

```
# i 15,140 more rows
```

tsibble objects

```
global_economy
```

```
# A tsibble: 15,150 x 6 [1Y]
```

```
# Key:           Country [263]
```

	Year	Country	GDP	Imports	Exports	Population
	Index	<fct>	<dbl>	<dbl>	<dbl>	<dbl>
1	1960	Afghanistan	5377777811.	7.02	4.13	8996351
2	1961	Afghanistan	5488888896.	8.10	4.45	9166764
3	1962	Afghanistan	5466666678.	9.35	4.88	9345868
4	1963	Afghanistan	7511111191.	16.9	9.17	9533954
5	1964	Afghanistan	8000000044.	18.1	8.89	9731361
6	1965	Afghanistan	10066666638.	21.4	11.3	9938414
7	1966	Afghanistan	13999999967.	18.6	8.57	10152331
8	1967	Afghanistan	16733333418.	14.2	6.77	10372630
9	1968	Afghanistan	13733333367.	15.2	8.90	10604346
10	1969	Afghanistan	14088888922.	15.0	10.1	10854428

```
# i 15,140 more rows
```

tsibble objects

```
global_economy
```

```
# A tsibble: 15,150 x 6 [1Y]
```

```
# Key:      Country [263]
```

	Year	Country	GDP	Imports	Exports	Population
	Index	Key	<dbl>	<dbl>	<dbl>	<dbl>
1	1960	Afghanistan	5377777811.	7.02	4.13	8996351
2	1961	Afghanistan	5488888896.	8.10	4.45	9166764
3	1962	Afghanistan	5466666678.	9.35	4.88	9345868
4	1963	Afghanistan	7511111191.	16.9	9.17	9533954
5	1964	Afghanistan	8000000044.	18.1	8.89	9731361
6	1965	Afghanistan	10066666638.	21.4	11.3	9938414
7	1966	Afghanistan	13999999967.	18.6	8.57	10152331
8	1967	Afghanistan	16733333418.	14.2	6.77	10372630
9	1968	Afghanistan	13733333367.	15.2	8.90	10604346
10	1969	Afghanistan	14088888922.	15.0	10.1	10854428

```
# i 15,140 more rows
```

tsibble objects

```
global_economy
```

```
# A tsibble: 15,150 x 6 [1Y]
```

```
# Key:      Country [263]
```

	Year	Country	GDP	Imports	Exports	Population
	Index	Key	Measured variables			
1	1960	Afghanistan	537777811.	7.02	4.13	8996351
2	1961	Afghanistan	548888896.	8.10	4.45	9166764
3	1962	Afghanistan	546666678.	9.35	4.88	9345868
4	1963	Afghanistan	751111191.	16.9	9.17	9533954
5	1964	Afghanistan	800000044.	18.1	8.89	9731361
6	1965	Afghanistan	1006666638.	21.4	11.3	9938414
7	1966	Afghanistan	1399999967.	18.6	8.57	10152331
8	1967	Afghanistan	1673333418.	14.2	6.77	10372630
9	1968	Afghanistan	1373333367.	15.2	8.90	10604346
10	1969	Afghanistan	1408888922.	15.0	10.1	10854428

```
# i 15,140 more rows
```

tsibble objects

```
tourism
```

```
# A tsibble: 24,320 x 5 [1Q]
# Key:           Region, State, Purpose [304]
  Quarter Region  State Purpose  Trips
   <qtr>  <chr>    <chr> <chr>    <dbl>
1 1998 Q1 Adelaide SA      Business 135.
2 1998 Q2 Adelaide SA      Business 110.
3 1998 Q3 Adelaide SA      Business 166.
4 1998 Q4 Adelaide SA      Business 127.
5 1999 Q1 Adelaide SA      Business 137.
6 1999 Q2 Adelaide SA      Business 200.
7 1999 Q3 Adelaide SA      Business 169.
8 1999 Q4 Adelaide SA      Business 134.
9 2000 Q1 Adelaide SA      Business 154.
10 2000 Q2 Adelaide SA      Business 169.
# i 24,310 more rows
```

tsibble objects

```
tourism
```

```
# A tsibble: 24,320 x 5 [1Q]
# Key:           Region, State, Purpose [304]
  Quarter Region  State Purpose  Trips
   <qtr>  <chr>    <chr> <chr>    <dbl>
1 1998 Q1 Adelaide SA      Business 135.
2 1998 Q2 Adelaide SA      Business 110.
3 1998 Q3 Adelaide SA      Business 166.
4 1998 Q4 Adelaide SA      Business 127.
5 1999 Q1 Adelaide SA      Business 137.
6 1999 Q2 Adelaide SA      Business 200.
7 1999 Q3 Adelaide SA      Business 169.
8 1999 Q4 Adelaide SA      Business 134.
9 2000 Q1 Adelaide SA      Business 154.
10 2000 Q2 Adelaide SA      Business 169.
# i 24,310 more rows
```

Domestic visitor
nights in
thousands by
state/region and
purpose.

tsibble objects

```
tourism
```

```
# A tsibble: 24,320 x 5 [1Q]
# Key:           Region, State, Purpose [304]
  Quarter Region State Purpose Trips
  <dbl>   <chr>   <chr> <chr>   <dbl>
1 1998 Q1 Adelaide SA      Business 135.
2 1998 Q2 Adelaide SA      Business 110.
3 1998 Q3 Adelaide SA      Business 166.
4 1998 Q4 Adelaide SA      Business 127.
5 1999 Q1 Adelaide SA      Business 137.
6 1999 Q2 Adelaide SA      Business 200.
7 1999 Q3 Adelaide SA      Business 169.
8 1999 Q4 Adelaide SA      Business 134.
9 2000 Q1 Adelaide SA      Business 154.
10 2000 Q2 Adelaide SA      Business 169.
# i 24,310 more rows
```

Domestic visitor
nights in
thousands by
state/region and
purpose.

tsibble objects

```
tourism
```

```
# A tsibble: 24,320 x 5 [1Q]
# Key:      Region, State, Purpose [304]
  Quarter Region State Purpose Trips
  <dbl>   <dbl> <dbl>   <dbl> <dbl>
1 1998 Q1 Adelaide SA      Business 135.
2 1998 Q2 Adelaide SA      Business 110.
3 1998 Q3 Adelaide SA      Business 166.
4 1998 Q4 Adelaide SA      Business 127.
5 1999 Q1 Adelaide SA      Business 137.
6 1999 Q2 Adelaide SA      Business 200.
7 1999 Q3 Adelaide SA      Business 169.
8 1999 Q4 Adelaide SA      Business 134.
9 2000 Q1 Adelaide SA      Business 154.
10 2000 Q2 Adelaide SA      Business 169.
# i 24,310 more rows
```

Domestic visitor
nights in
thousands by
state/region and
purpose.

tsibble objects

```
tourism
```

```
# A tsibble: 24,320 x 5 [1Q]  
# Key:      Region, State, Purpose [304]
```

	Quarter	Region	State	Purpose	Trips
	Index	Keys			Measure
1	1998 Q1	Adelaide	SA	Business	135.
2	1998 Q2	Adelaide	SA	Business	110.
3	1998 Q3	Adelaide	SA	Business	166.
4	1998 Q4	Adelaide	SA	Business	127.
5	1999 Q1	Adelaide	SA	Business	137.
6	1999 Q2	Adelaide	SA	Business	200.
7	1999 Q3	Adelaide	SA	Business	169.
8	1999 Q4	Adelaide	SA	Business	134.
9	2000 Q1	Adelaide	SA	Business	154.
10	2000 Q2	Adelaide	SA	Business	169.

```
# i 24,310 more rows
```

Domestic visitor
nights in
thousands by
state/region and
purpose.

tsibble objects

- A `tsibble` allows storage and manipulation of multiple time series in R.
- It contains:
 - ▶ An index: time information about the observation
 - ▶ Measured variable(s): numbers of interest
 - ▶ Key variable(s): optional unique identifiers for each series
- It works with tidyverse functions.

The tsibble index

Time index variables can be created with these functions:

Frequency	Function
-----------	----------

Annual	<code>start:end</code>
Quarterly	<code>yearquarter()</code>
Monthly	<code>yearmonth()</code>
Weekly	<code>yearweek()</code>
Daily	<code>as_date(), ymd()</code>
Sub-daily	<code>as_datetime()</code>