MONASH University

MONASH BUSINESS SCHOOL

# ETC3550/ETC5550 Applied forecasting

## Week 1

`af.numbat.space`

# Contact details

**Chief Examiner: Professor Rob Hyndman**

rob.hyndman@monash.edu
robjhyndman.com
@robjhyndman

**Tutors**

- **Mitchell O'Hara-Wild**
- Elena Sanina
- Xiaoqian Wang
- Yangzhouran (Fin) Yang
- Zhixiang (Elvis) Yang

# Brief bio

- Professor of Statistics, Monash University
- Co-author of most popular forecasting textbook in the world
- 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
- TAC large claims

# 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 online videos each week.
- One 50 minute in-person workshop each Friday.
- One 90 minute in-person tutorial each week.
- One tutorial will be recorded each week and posted online.

# 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/**

# Key reference

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

**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 | The forecaster’s toolbox | 5 |
| 5–6 | Exponential smoothing | 8 |
| 7–9 | Forecasting with ARIMA models | 9 |
| 10–11 | Multiple regression and forecasting | 7 |
| 11–12 | Dynamic regression | 10 |

# Assessment

- Four assignments and one larger project: 40%
- Exam (2 hours): 60%.

# Assessment

- Four assignments and one larger project: 40%
- Exam (2 hours): 60%.

| Task | Due Date | Value |
|---|---|---|
| Assignment 1 | Fri 8 March | 2% |
| Assignment 2 | Fri 22 March | 6% |
| Assignment 3 | Fri 12 April | 6% |
| Assignment 4 | Fri 3 May | 6% |
| Project | Fri 24 May | 20% |
| Final exam | Official exam period | 60% |

# Assessment

- Four assignments and one larger project: 40%
- Exam (2 hours): 60%.

| Task | Due Date | Value |
|---|---|---|
| Assignment 1 | Fri 8 March | 2% |
| Assignment 2 | Fri 22 March | 6% |
| Assignment 3 | Fri 12 April | 6% |
| Assignment 4 | Fri 3 May | 6% |
| Project | Fri 24 May | 20% |
| Final exam | Official exam period | 60% |

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

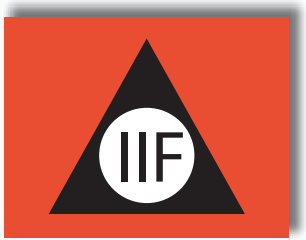
# Unit website

**af.numbat.space**

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

**Please don’t send emails. Use the forum.**

# International Institute of Forecasters




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

# R

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"))
```

# Main packages

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

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

# Exercises Week 1

- Make sure you are familiar with R, RStudio and the tidyverse packages.
- Do first five chapters of `learnr.numbat.space`.
- Assignment 1

# Assignment 1: forecast the following series

1. Google closing stock price on 20 March 2024
2. Maximum temperature at Melbourne airport on 10 April 2024
3. The difference in points (Collingwood minus Essendon) scored in the AFL match between Collingwood and Essendon for the Anzac Day clash. 25 April 2024
4. The seasonally adjusted estimate of total employment for April 2024. ABS CAT 6202, to be released around mid May 2024
5. Google closing stock price on 22 May 2024

**Due Friday 8 March**

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

# Assignment 1: forecast the following series

1. Google closing stock price on 20 March 2024
2. Maximum temperature at Melbourne airport on 10 April 2024
3. The difference in points (Collingwood minus Essendon) scored in the AFL match between Collingwood and Essendon for the Anzac Day clash. 25 April 2024
4. The seasonally adjusted estimate of total employment for April 2024. ABS CAT 6202, to be released around mid May 2024
5. Google closing stock price on 22 May 2024

**Due Friday 8 March**

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

Prize: $50 cash prize

# Assignment 1: 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

# 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

# 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

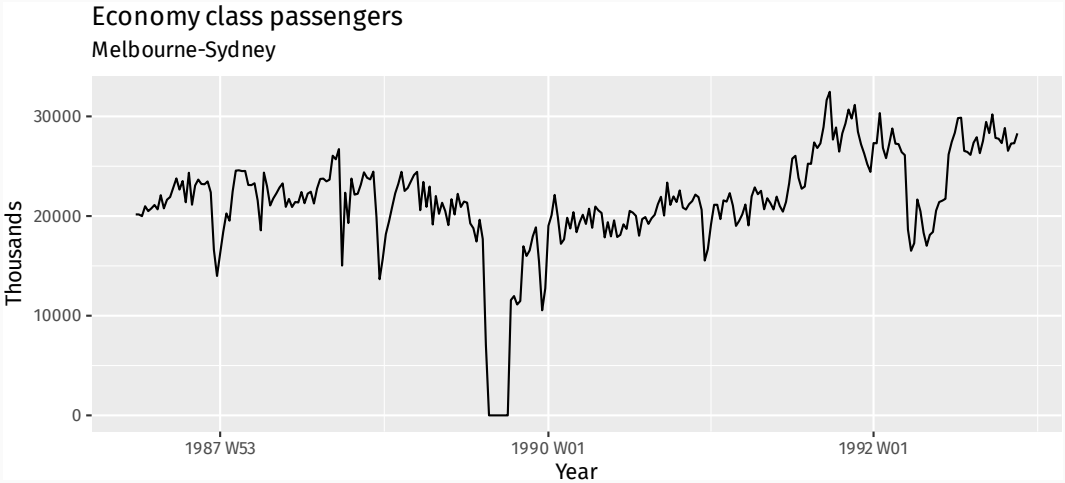
**Problem:** how to forecast resale value of vehicles? How should this affect leasing and sales policies?

## Additional information

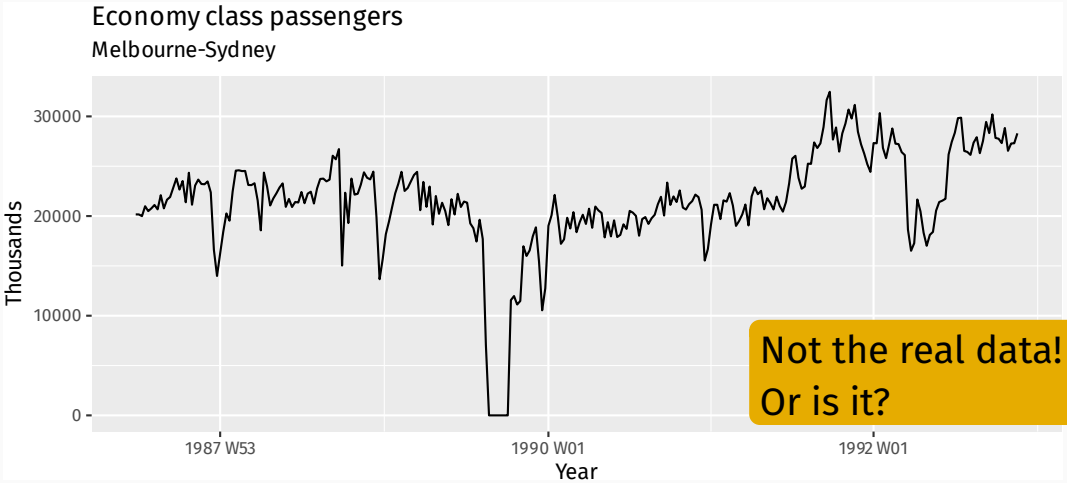
- They can provide a large amount of data on previous vehicles and their eventual resale values.
- The resale values are currently estimated by a group of specialists. They see me as a threat and do not cooperate.

# 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.

# `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  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

```
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  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

```
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  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

```
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  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
```

Index | Key | Measured variables

# 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
   Index   <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
   Index   Keys                    <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 | `start:end` |
| Quarterly | `yearquarter()` |
| Monthly | `yearmonth()` |
| Weekly | `yearweek()` |
| Daily | `as_date()`, `ymd()` |
| Sub-daily | `as_datetime()` |

# Your turn

1. Download `tourism.xlsx` from `http://robjhyndman.com/data/tourism.xlsx`, and read it into R using `read_excel()` from the `readxl` package.
2. Create a tsibble which is identical to the tourism tsibble from the `tsibble` package.
3. Find what combination of Region and Purpose had the maximum number of overnight trips on average.
4. Create a new tsibble which combines the Purposes and Regions, and just has total trips by State.