MONASH University

Rob J Hyndman

Forecasting:

Principles and Practice

1. Introduction to forecasting

OTexts.org/fpp/1/
OTexts.org/fpp/2/3

Resources

- Slides
- Exercises
- Textbook
- Useful links

robjhyndman.com/uwa

Outline

Brief bio

- Director of Monash University's Business & Economic Forecasting Unit
- Editor-in-Chief, *International Journal of Forecasting*

How my forecasting methodology is used:

- Pharmaceutical Benefits Scheme

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robjhyndman.com

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?

Key reference

Hyndman, R. J. & Athanasopoulos, G. (2013) *Forecasting: principles and practice*.

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

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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?

Which version of R are you using?

Version: (try `getRversion()` if you don't know)

1. R 3.0.0 or higher
2. R 2.15.x
3. R 2.14.x
4. Something older.

Edition

1. Standard R (CRAN)
2. Standard R with RStudio
3. Revolution R: Community, Enterprise Workstation or Server
4. Something else?

Install required packages

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

Getting help with R

```
# Search for terms
help.search("forecasting")

# Detailed help
help(forecast)

# Worked examples
example("forecast.ar")

# Similar names
apropos("forecast")

#Help on package
help(package="fpp")
```

Approximate outline

Day	Topic	Chapter
1	The forecaster's toolbox	1,2
1	Seasonality and trends	6
1	Exponential smoothing	7
2	Time series decomposition	6
2	Time series cross-validation	2
2	Transformations	2
2	Stationarity and differencing	8
2	ARIMA models	8
3	State space models	–
3	Dynamic regression	9
3	Hierarchical forecasting	9
3	Advanced methods	9

Assumptions

- This is not an introduction to R. I assume you are broadly comfortable with R code and the R environment.
- This is not a statistics course. I assume you are familiar with concepts such as the mean, standard deviation, quantiles, regression, normal distribution, 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.

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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.

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- 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.

- 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.

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- 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!

Problem: How to do the forecasting better?

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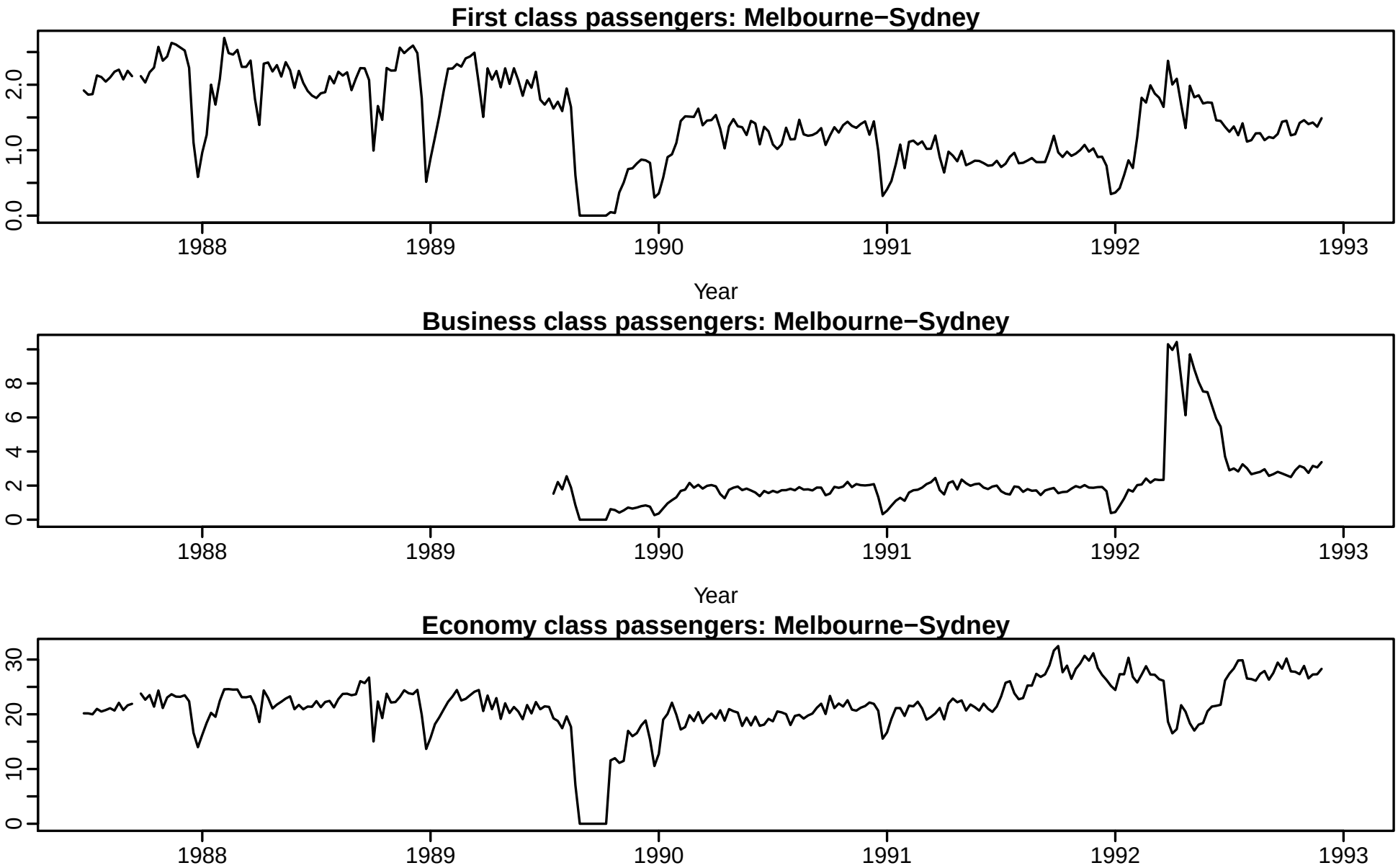

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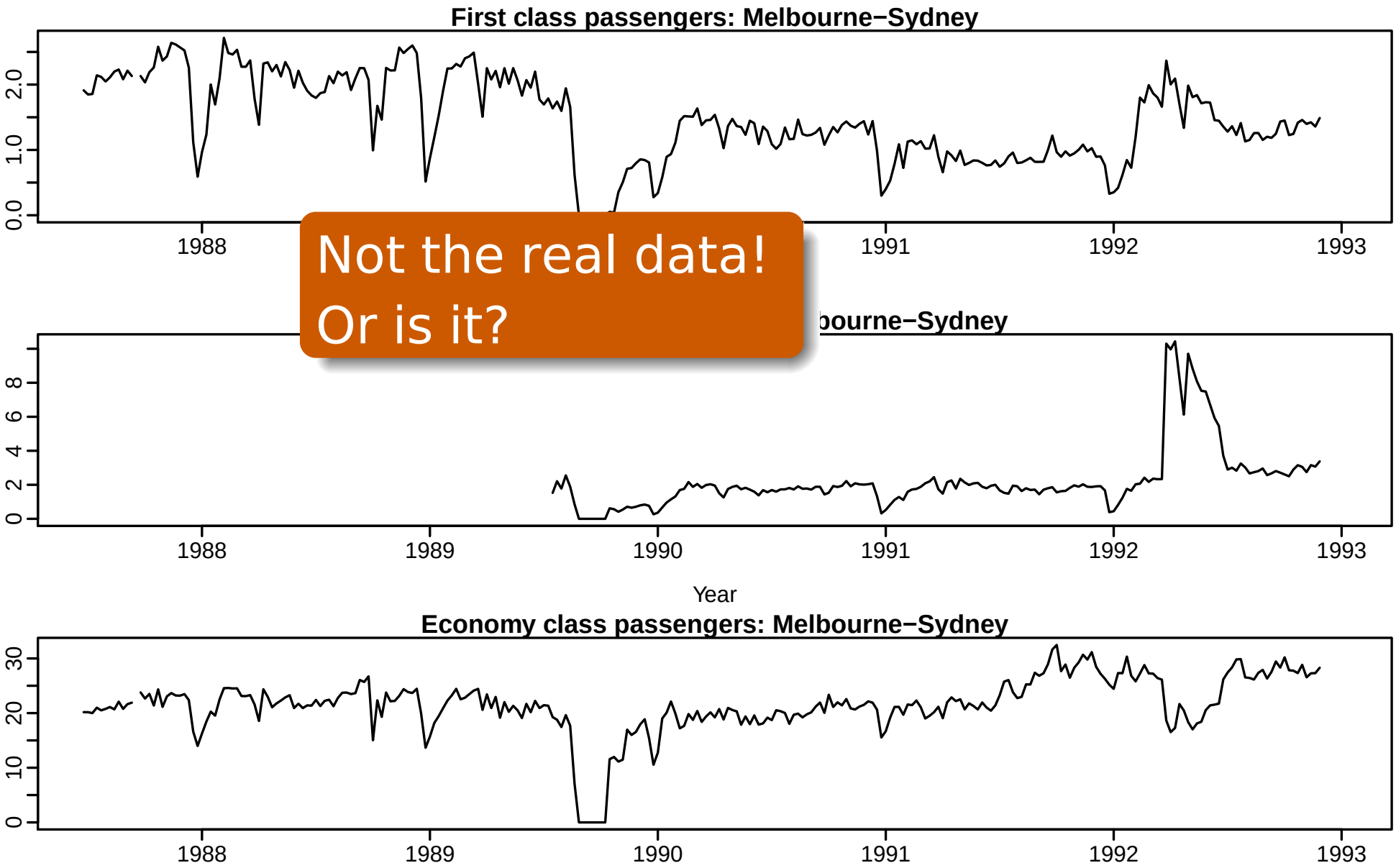

CASE STUDY 3: Airline

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.
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Time series data

- Time series consist of sequences of observations collected over time.
- We will assume the time periods are equally spaced.

Time series examples

- Daily IBM stock prices

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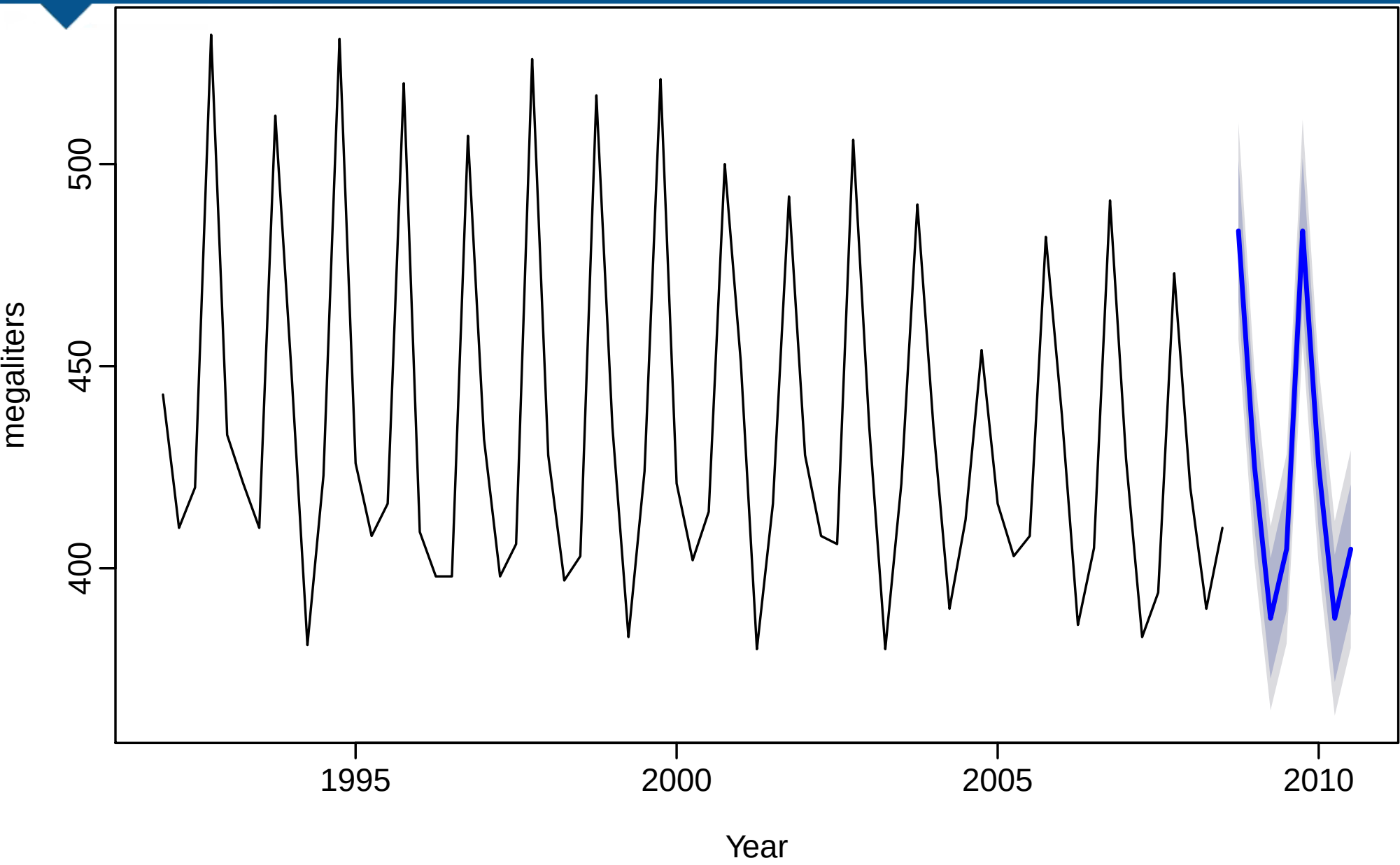
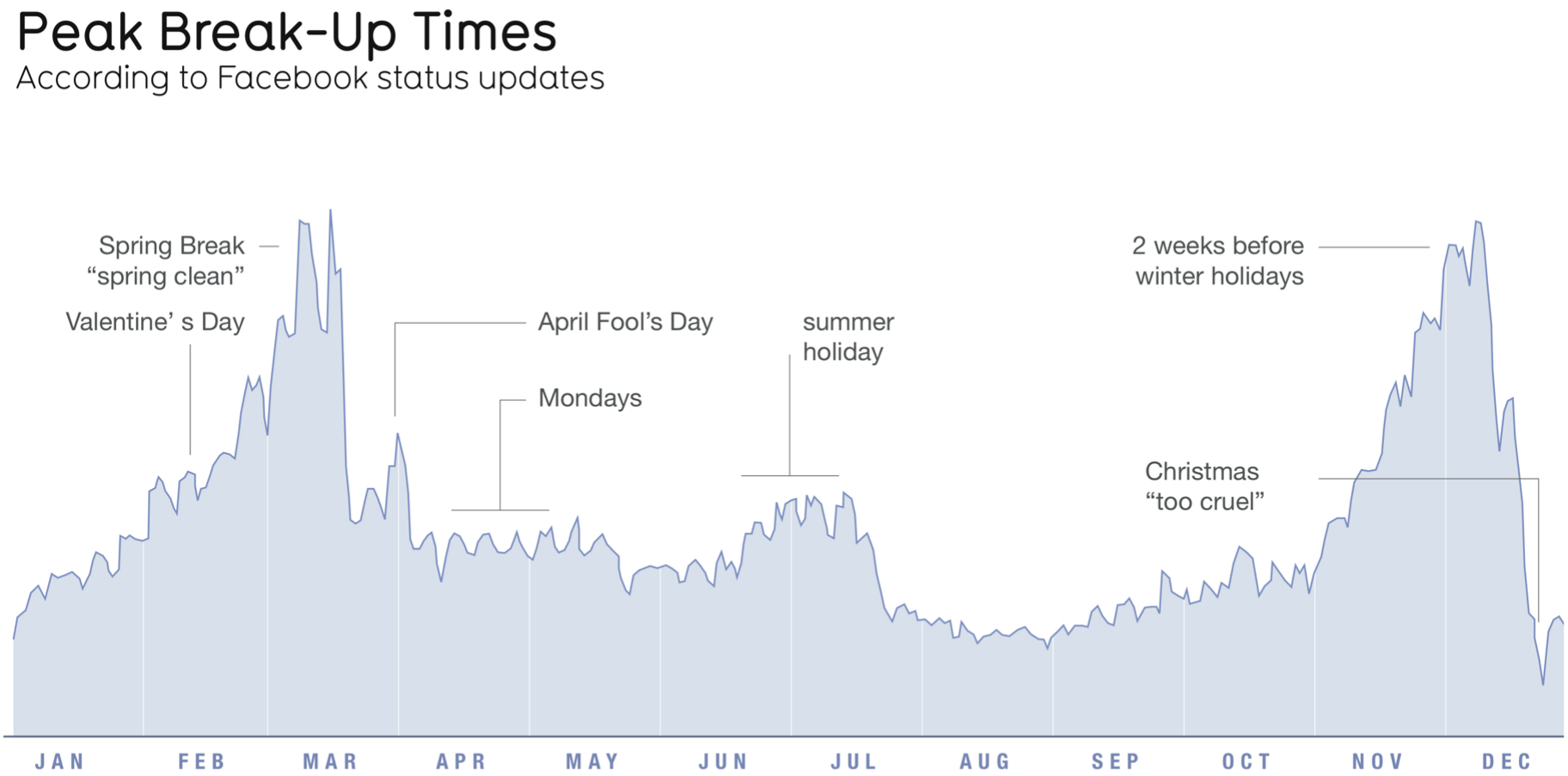
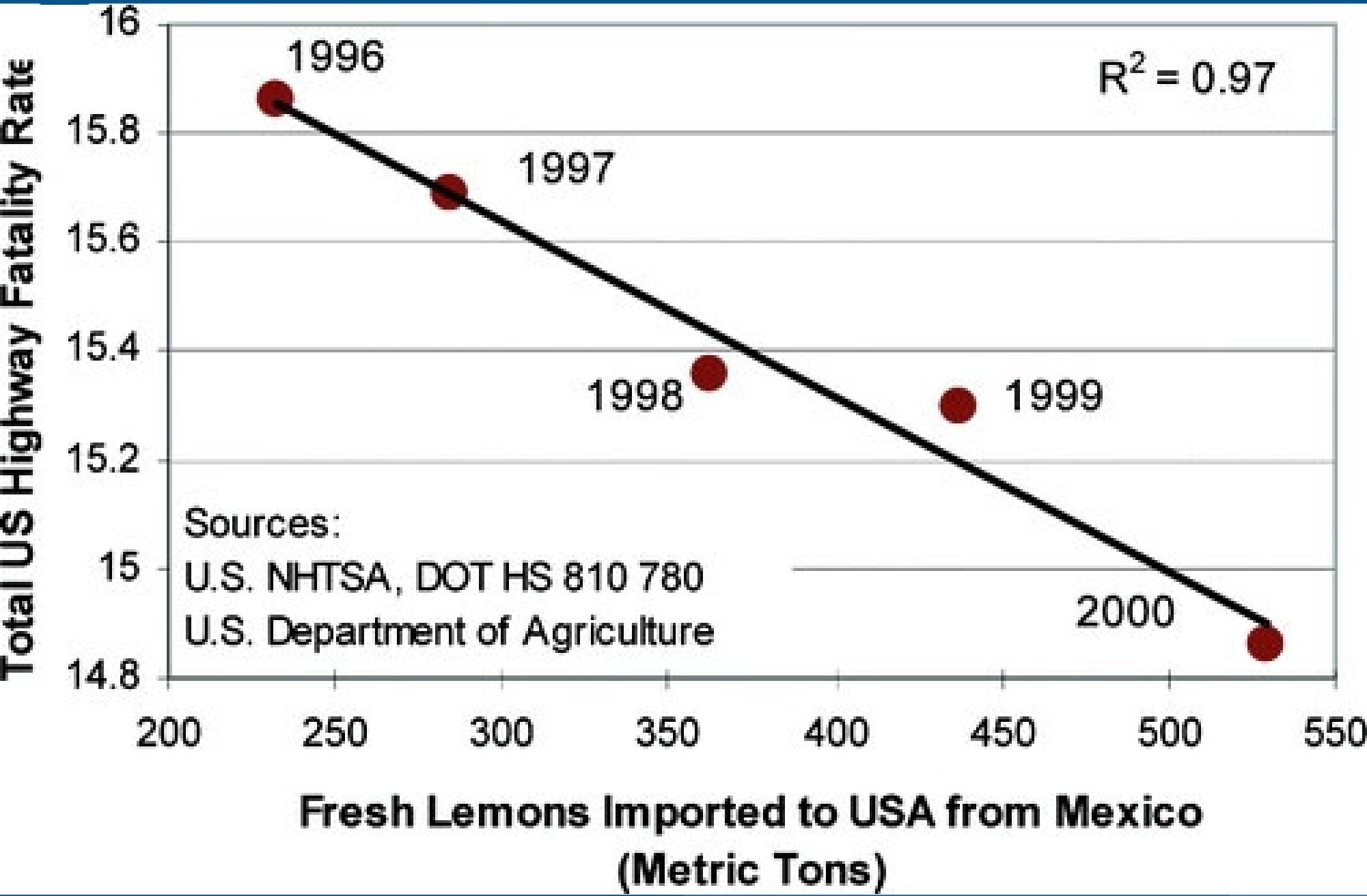


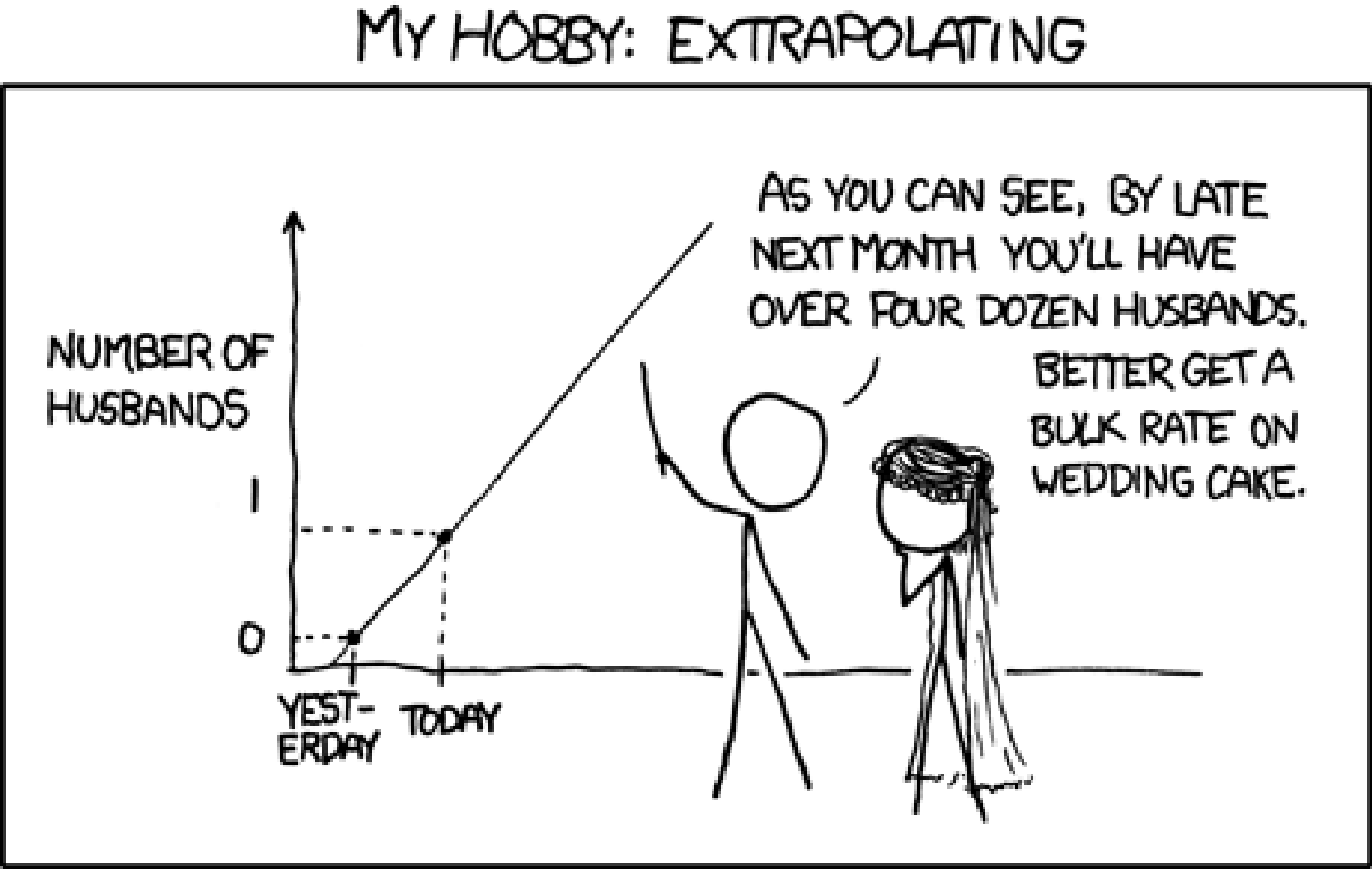
Looking for stories



Looking for stories that make sense



Think about what you're doing



Time series in R

Australian GDP

```
ausgdp <- ts(scan("gdp.dat"),frequency=4,
                                start=1971+2/4)
```

- Class: `ts`
- Print and plotting methods available.

```
> ausgdp
     Qtr1 Qtr2 Qtr3 Qtr4
1971                4612 4651
1972 4645 4615 4645 4722
1973 4780 4830 4887 4933
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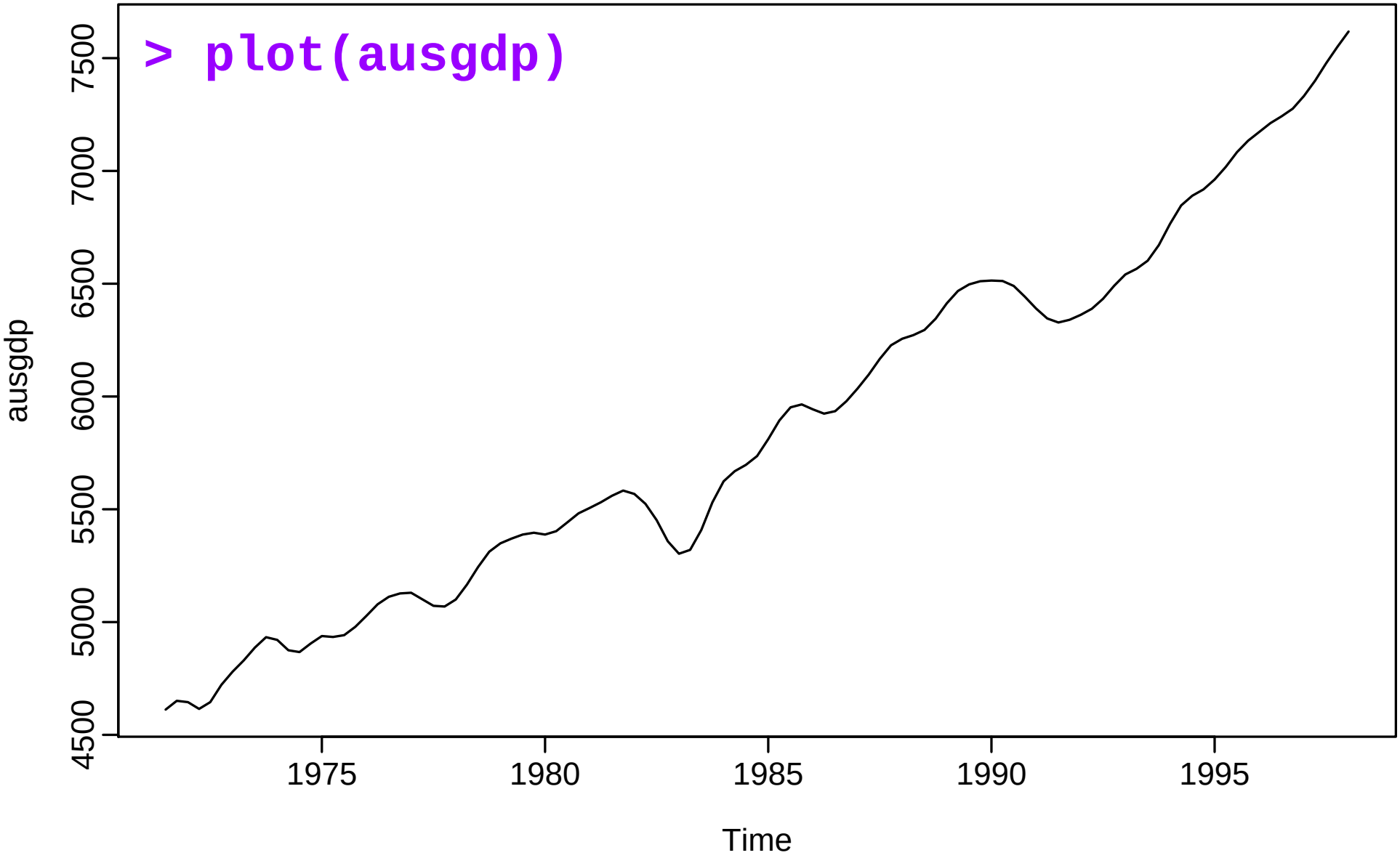
Time series in R

```
> plot(ausgdp)
```



Time series in R

Residential electricity sales

```
> elecsales
Time Series:
Start = 1989
End = 2008
Frequency = 1
 [1] 2354.34 2379.71 2318.52 2468.99 2386.09 2569.47
 [7] 2575.72 2762.72 2844.50 3000.70 3108.10 3357.50
[13] 3075.70 3180.60 3221.60 3176.20 3430.60 3527.48
[19] 3637.89 3655.00
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Time series in R

Main package used in this course

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> library(fpp)
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This loads:

- some data for use in examples and exercises
- **forecast** package (for forecasting functions)
- **tseries** package (for a few time series functions)
- fma package (for lots of time series data)
- expsmooth package (for more time series data)
- lmtest package (for some regression functions)

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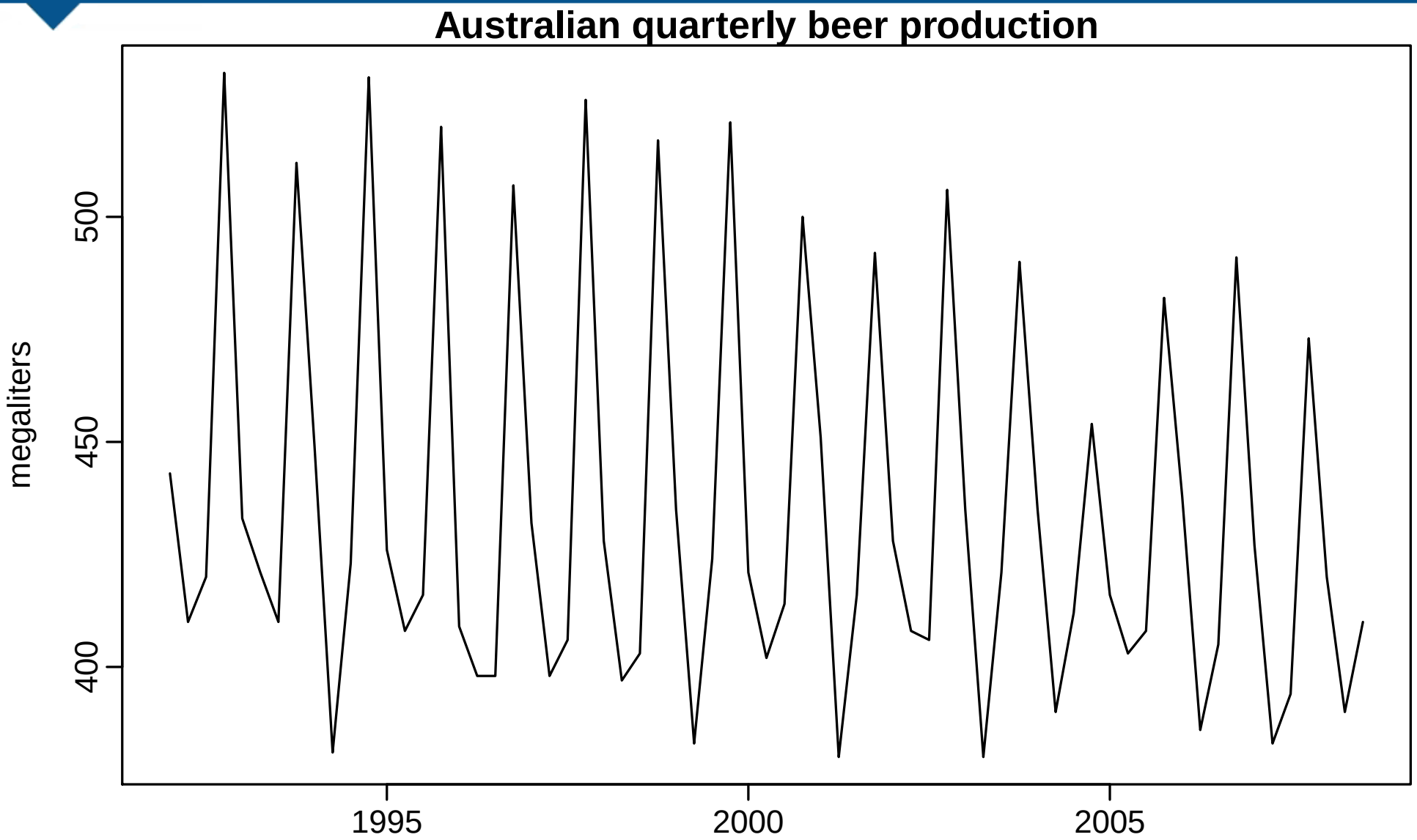
Some simple forecasting methods



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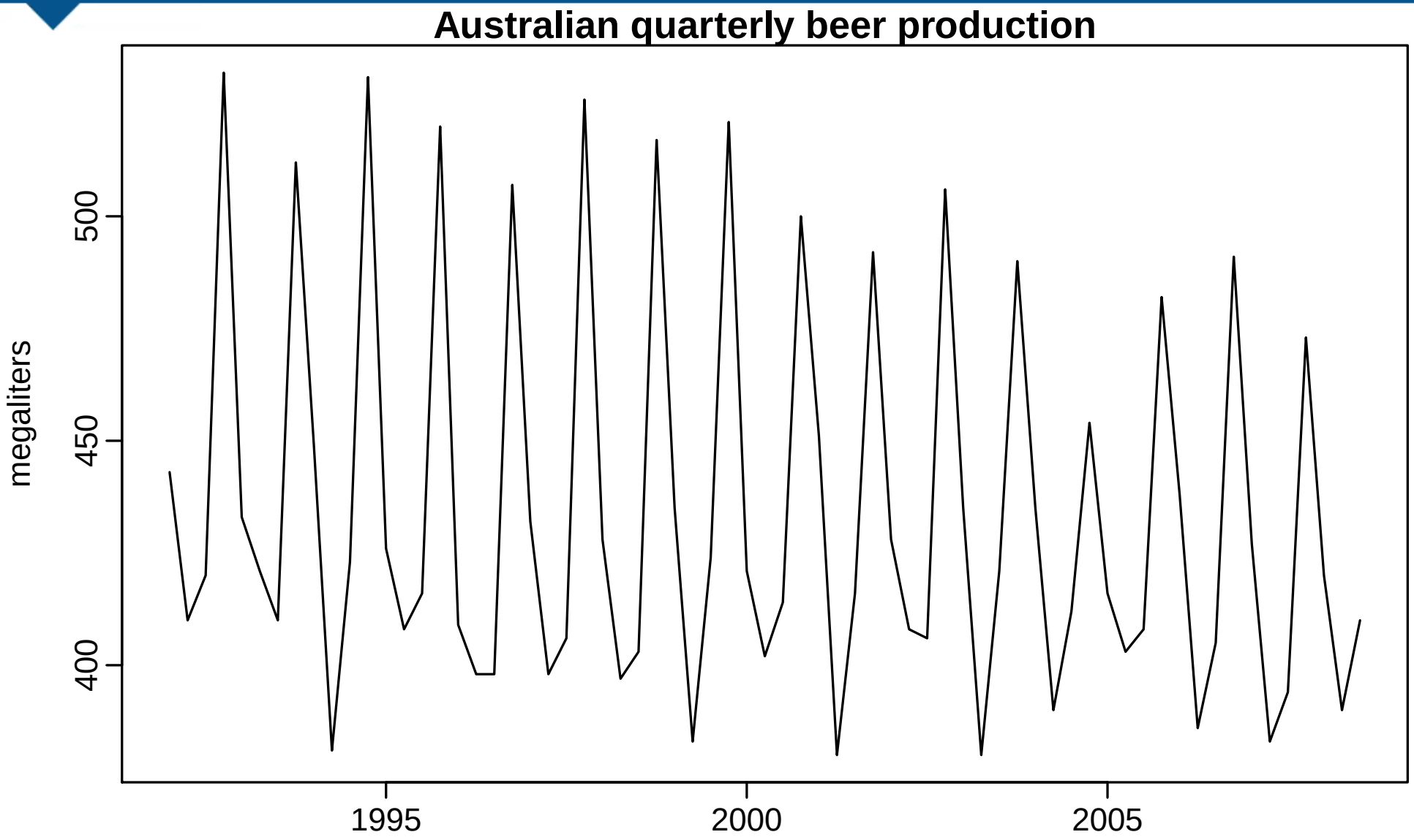


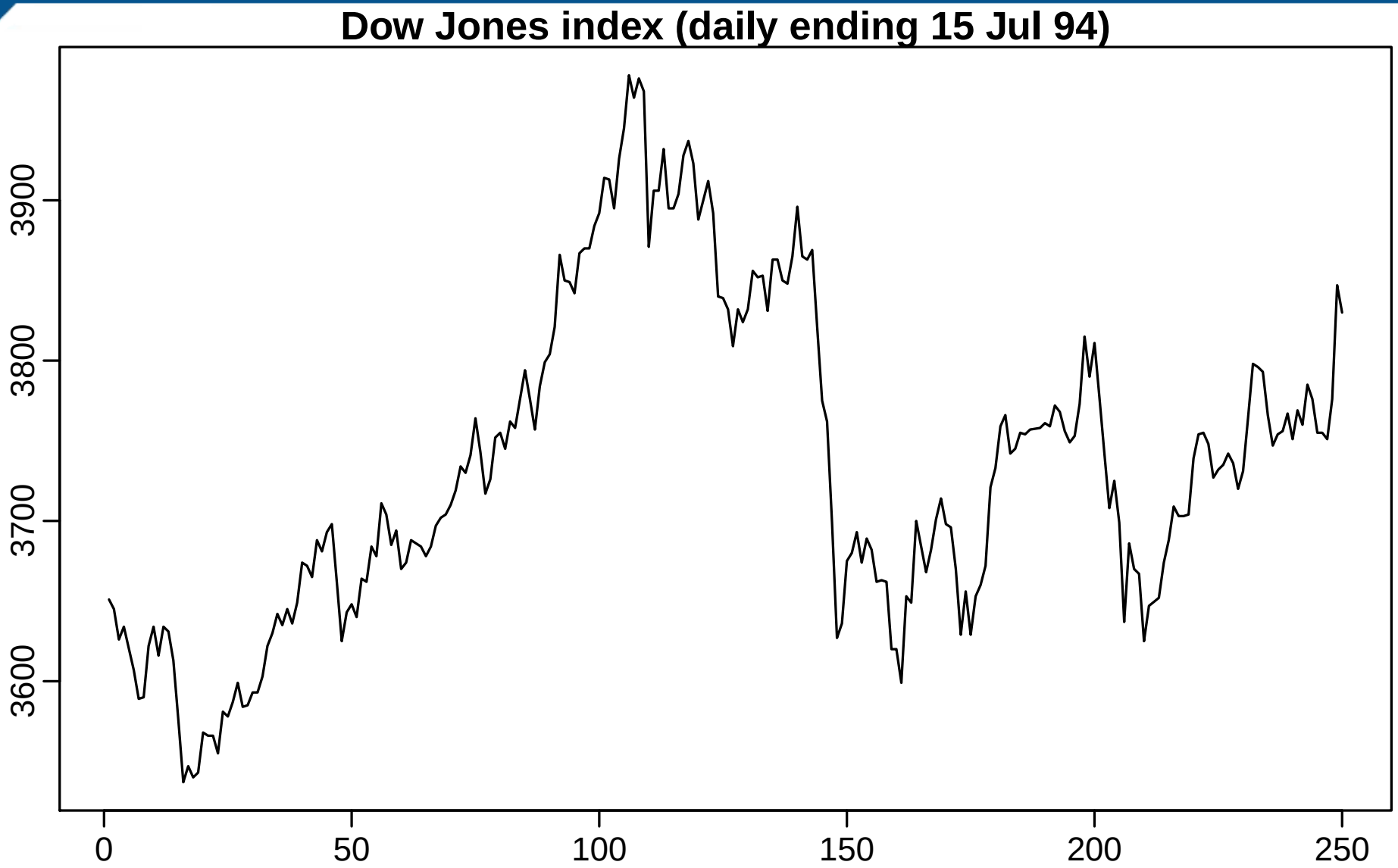
Can you think of any forecasting methods for these data?

Some simple forecasting methods

Some simple forecasting methods

How would you forecast these data?

Some simple forecasting methods



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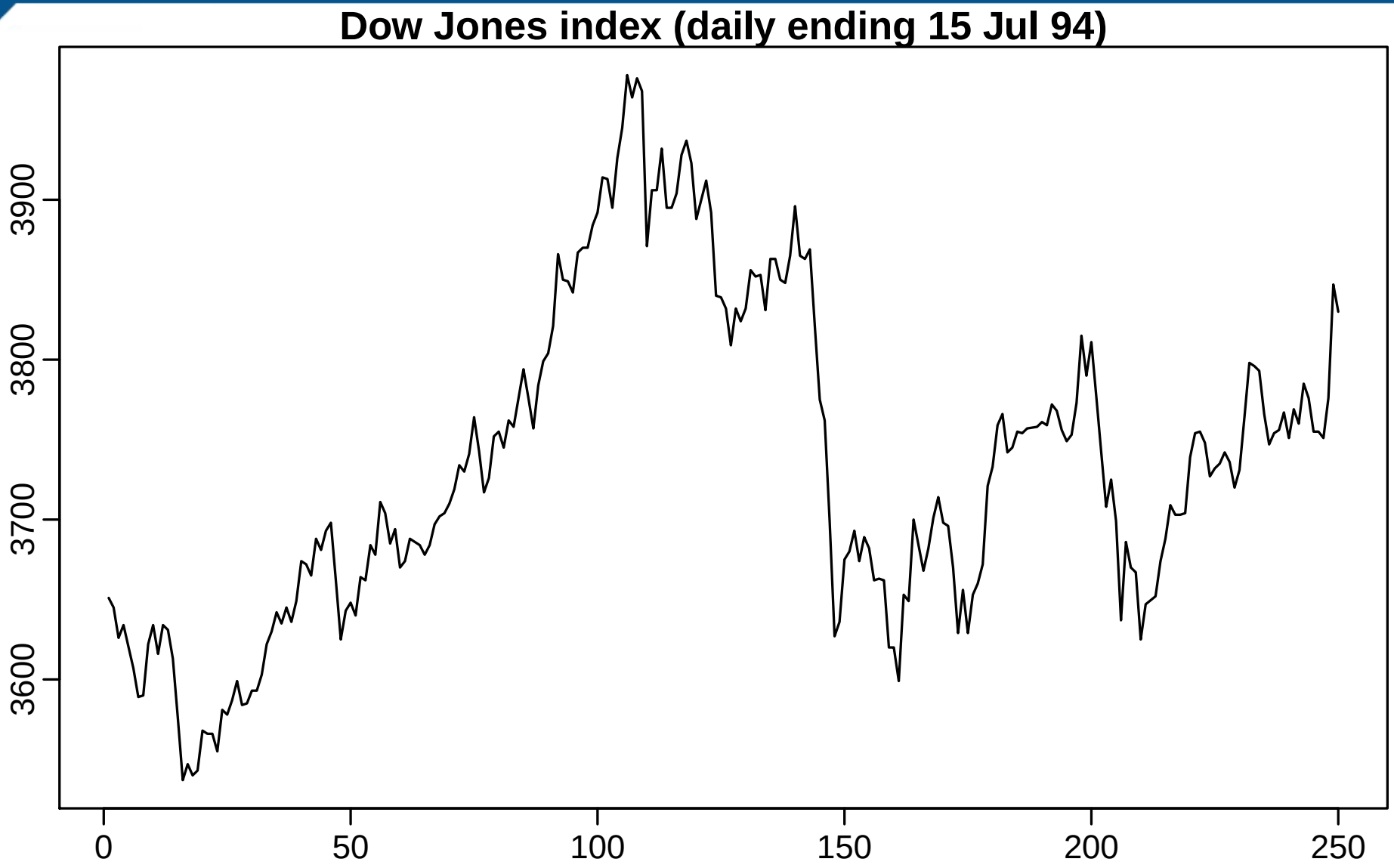

How would you forecast these data?

Some simple forecasting methods

Average method

- Forecast of all future values is equal to mean of historical data $\{y_1, \ldots, y_T\}$.
- Forecasts: $\hat{y}_{T+h|T} = \bar{y} = (y_1 + \cdots + y_T)/T$

Naïve method (for time series only)

Forecasts equal to last observed value

Seasonal naïve method

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- Forecasts: $\hat{y}_{T+h|T} = y_T$.
- Consequence of efficient market hypothesis.

Seasonal naïve method

- Forecasts equal to last value from same season.

Some simple forecasting methods

Average method

- Forecast of all future values is equal to mean of historical data $\{y_1, \ldots, y_T\}$.
- Forecasts: $\hat{y}_{T+h|T} = \bar{y} = (y_1 + \cdots + y_T)/T$

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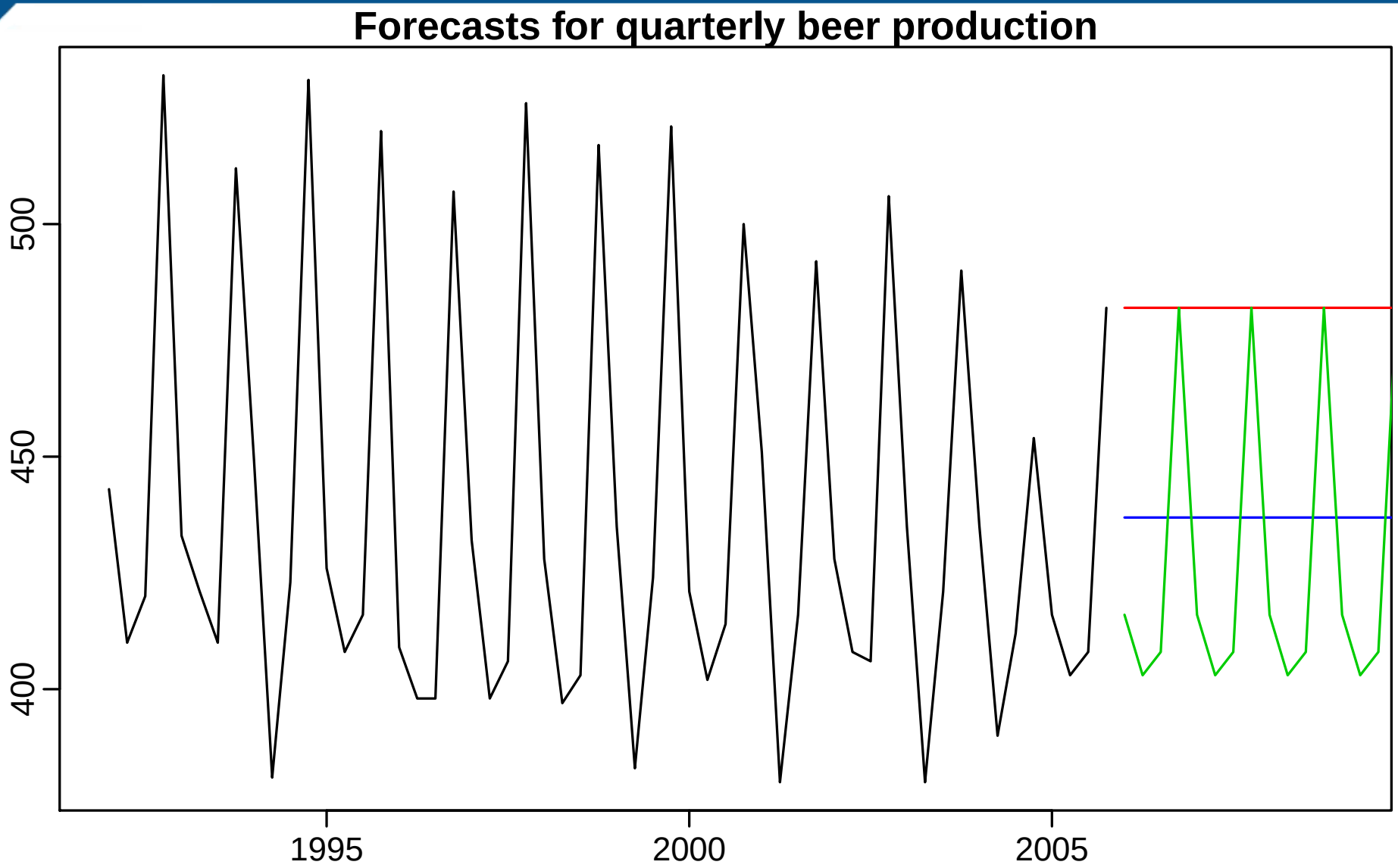

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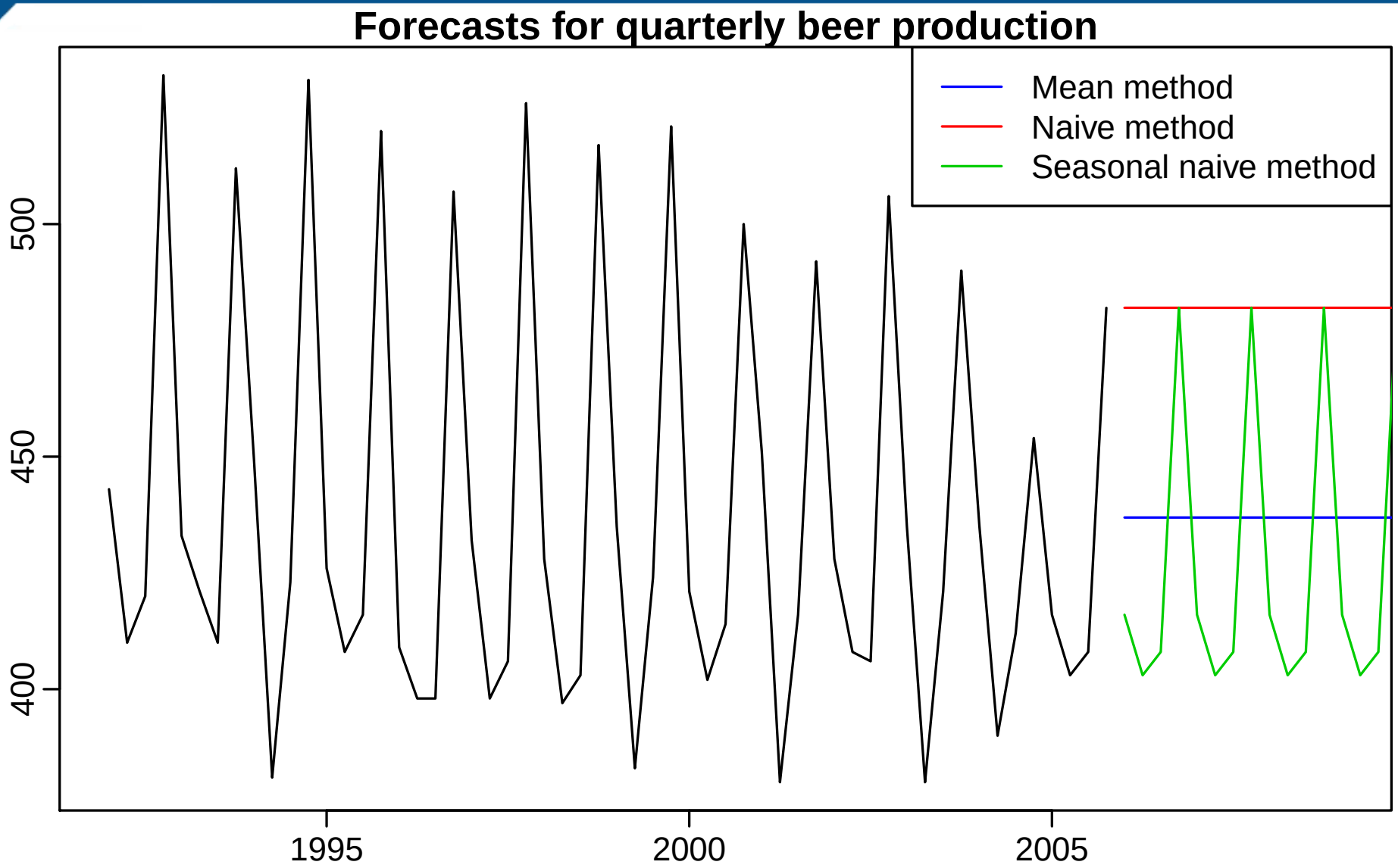
Some simple forecasting methods



Which method is which?

Drift method

- Forecasts equal to last value plus average change.
- Forecasts:

$$\hat{y}_{T+h|T} = y_T + \frac{h}{T-1}\sum_{t=2}^{T}(y_t - y_{t-1})$$

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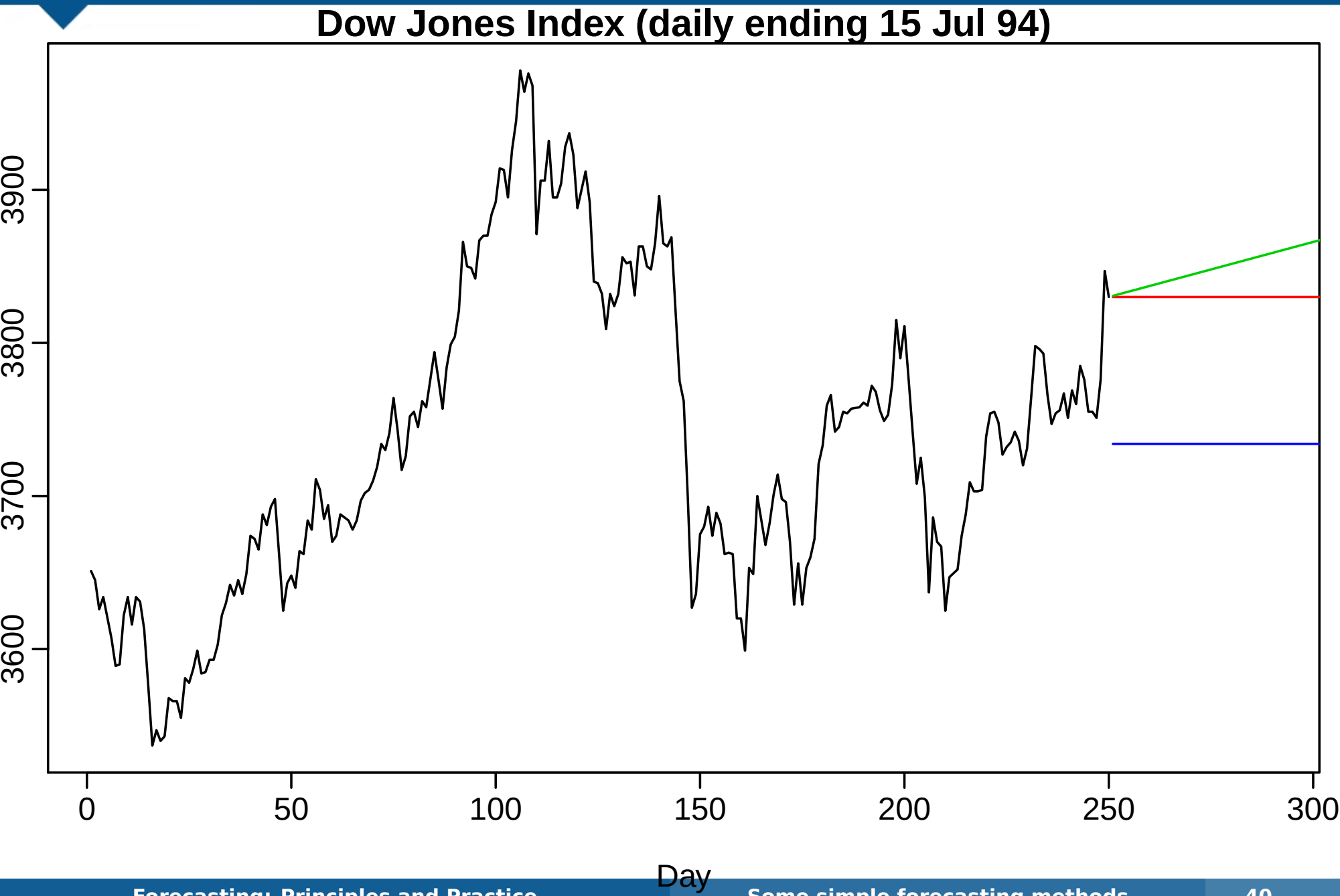

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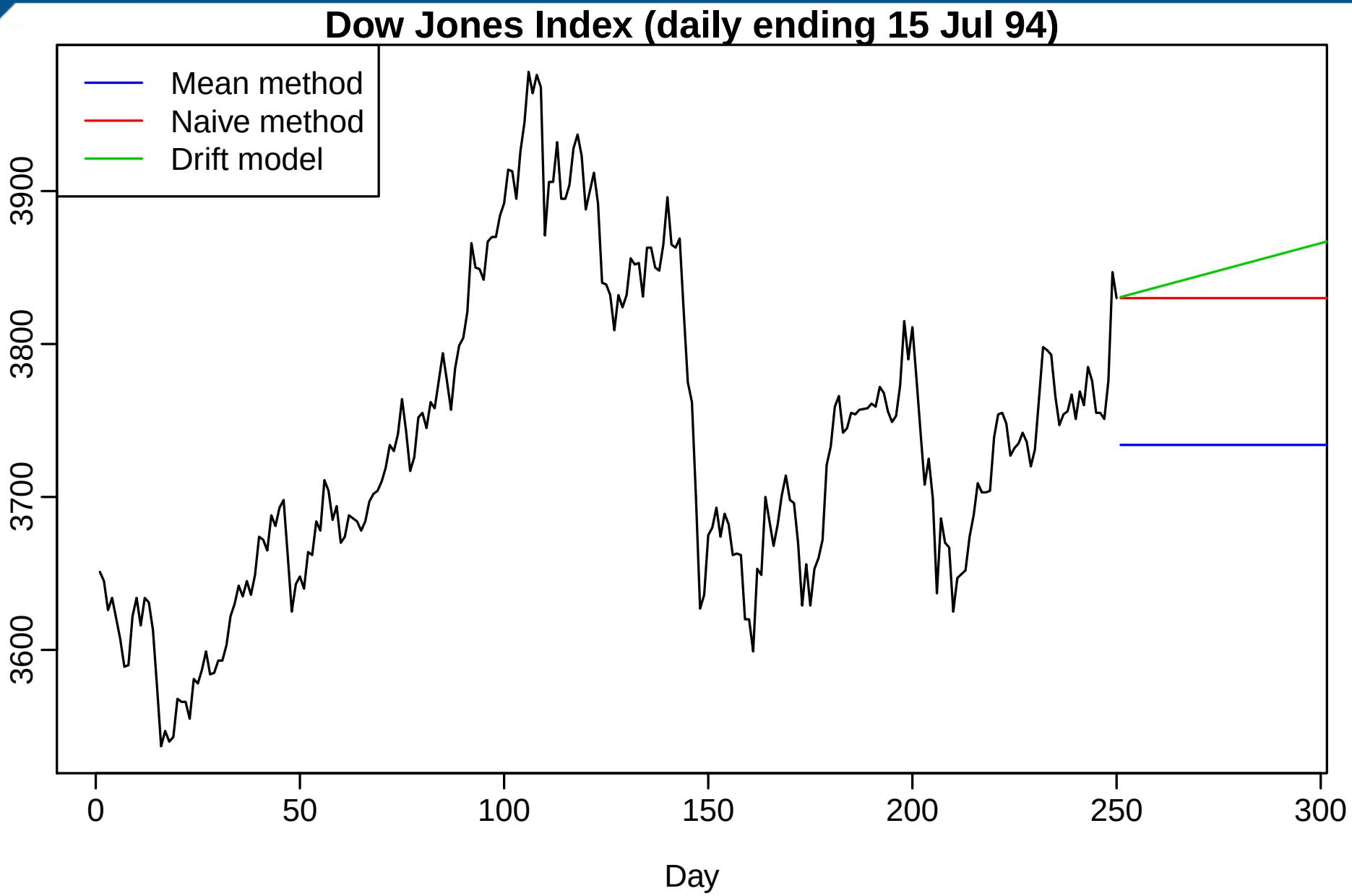

Some simple forecasting methods

- Mean: `meanf(x, h=20)`
- Naive: `naive(x, h=20)` or `rwf(x, h=20)`
- Seasonal naive: `snaive(x, h=20)`
- Drift: `rwf(x, drift=TRUE, h=20)`

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