

Time Series Analysis & Forecasting Using R

Introduction to forecasting

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Outline

- 1 Learning objectives
- 2 From decision making to forecasting
- 3 Forecasting process
- 4 What can be forecasted?
- 5 Time series data and models
- 6 How to present forecast
- 7 Lab session

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Learning outcomes

You should be able to:

- 1 Describe the forecasting process
- 2 Identify what to forecast
- 3 Explain factors affecting forecastability
- 4 Understand ways to communicate forecast

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Why do organisations need forecasting?

Why do you use forecast?

Why do organisations need forecasting?

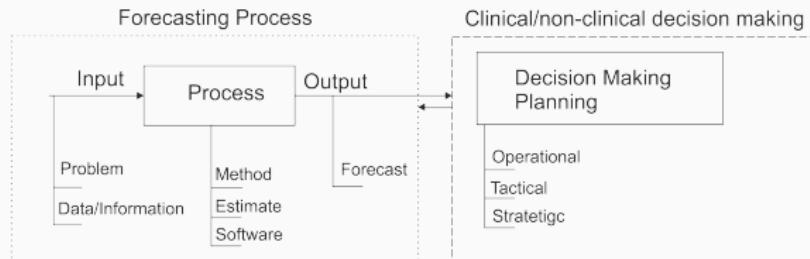
Why do you use forecast?

Forecasting required in many situation	Forecast
Whether to build a new hospital in next 10 years?	?
How many staff does an A&E need next week?	?
How many units of bandages is required next month?	?

- An important aid to planning and decision making
 - ▶ To inform decisions
 - ▶ To provide evidences

Forecasting and decision making

- A forecast does not exist for its own purpose.
There is at least one reason why we want a forecast, typically multiple reasons
- Most often the reason or reasons will make it adamantly clear what to forecast



Tailor forecasting to decisions

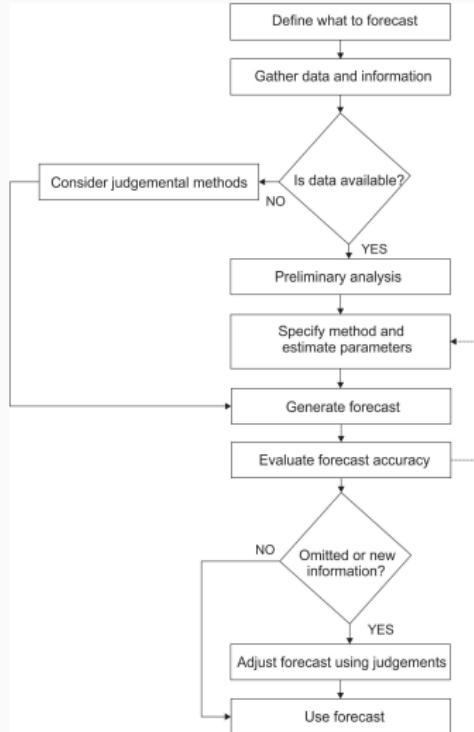
- It has implications on how we generate forecast and how we measure its accuracy



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Forecasting process



Statistical forecasting steps

- **Step 1:** Problem definition- what to forecast?
- **Step 2:** Gathering information
- **Step 3:** Preliminary (exploratory) analysis
- **Step 4:** Choosing and fitting models
- **Step 5:** Evaluating and using a forecasting model

What to forecast

- Forecast variable/s
- time granularity
- frequency
- horizon
- hierarchy/group granularity

Gathering information

- Historical data/ time series
- Knowledge of any future events
 - ▶ Deterministic variables, e.g. holidays
 - ▶ Stochastic variables, e.g. temperature
- Collective judgement
- Expertise of key personnel

Further considerations

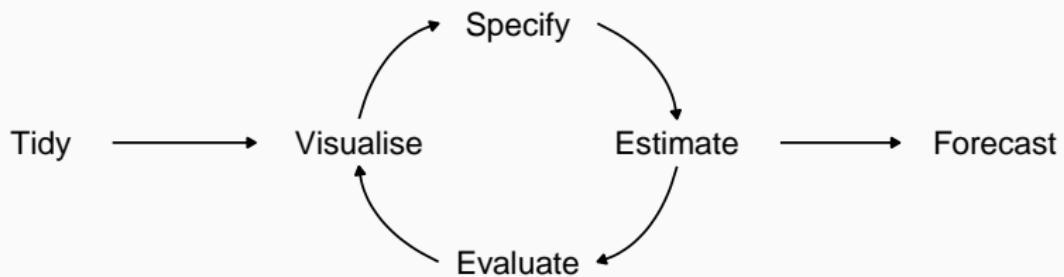
- How much will the forecast cost?
- Is the model easy to understand?
- Accuracy requirements
- Quality of data
- Forecasting support system, software, ...

A tidy forecasting workflow

The process of producing forecasts can be split up into a few fundamental steps.

- 1 Preparing data
- 2 Data visualisation
- 3 Specifying a model
- 4 Model estimation
- 5 Accuracy & performance evaluation
- 6 Producing forecasts

A tidy forecasting workflow



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Forecasting is difficult



What can we forecast?



What can we forecast?



What can we forecast?



What can we forecast?



What can we forecast?



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

Factors affecting forecastability

- What makes something easy/difficult to forecast?

Factors affecting forecastability

- What makes something easy/difficult to forecast?

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

Key step in forecasting

- Often in forecasting, a key step is knowing:
 - ▶ when something can be forecast accurately
 - ▶ when forecasts are no better than tossing a coin
- Good forecasting models capture the genuine patterns and relationships which exist in the historical data, but do not replicate past events that will not occur again.

Forecasting situation and models

- Forecasting situations vary widely in their time horizons, factors determining actual outcomes, types of data patterns, and many other aspects;
- The choice of model depends on data availability and forecast situation.

	No data	Past data	Exogenous variable
Judgemental	X		
Explanatory			X
Time series		X	

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What is a forecast?

Forecast:

- an honest estimation of the future
- based on all of the information available at the time when we generate the forecast

Available data/information

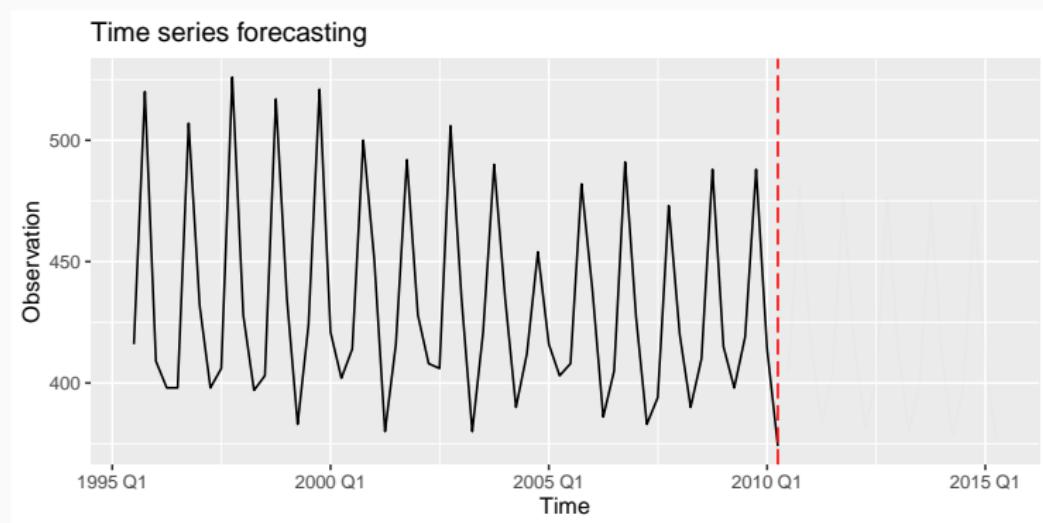
- 1 Historical data/time series
- 2 Knowledge of any future events/variables
 - ▶ Deterministic variables
 - ▶ Stochastic variables
 - ▶ New information

Time series data

- Time series consist of sequences of observations collected over time.
- We will assume the time periods are equally spaced.
 - ▶ Hourly patient attendance in a hospital
 - ▶ Daily average waiting time in A&E
 - ▶ Weekly calls in a Clinical Desk Service
 - ▶ Monthly consumption of cough medicine in NHS England

What will happen next?

- Time series forecasting is estimating how the sequence of observations will continue into the future.



Time Series forecasting models

- There are many different kinds of time series models:
 - ▶ Simple methods, e.g. naive
 - ▶ Exponential smoothing models
 - ▶ ARIMA
 - ▶ Regression
 - ▶ etc

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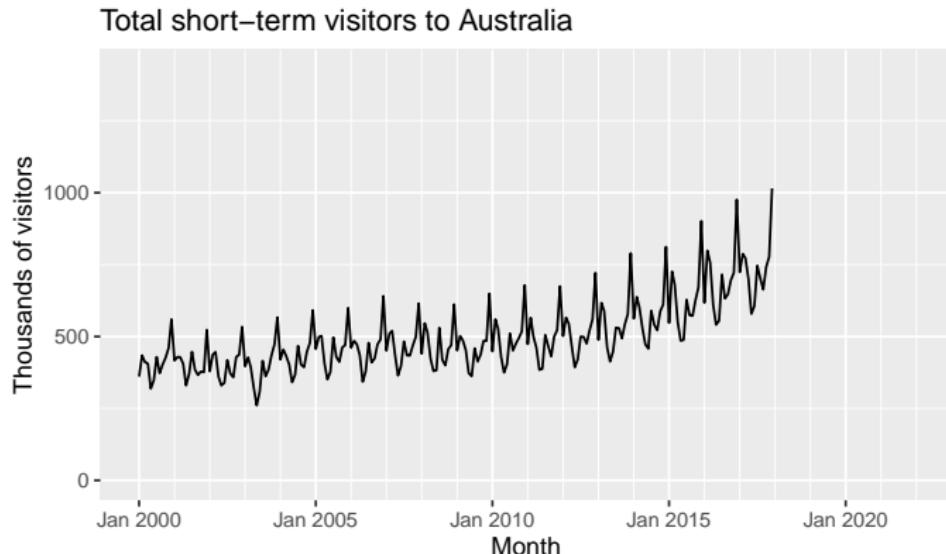
How to present forecasts?

- Point forecasts
- Prediction intervals
- Forecast as probability distribution

A forecast should acknowledge that the future is uncertain and provide information of that uncertainty.

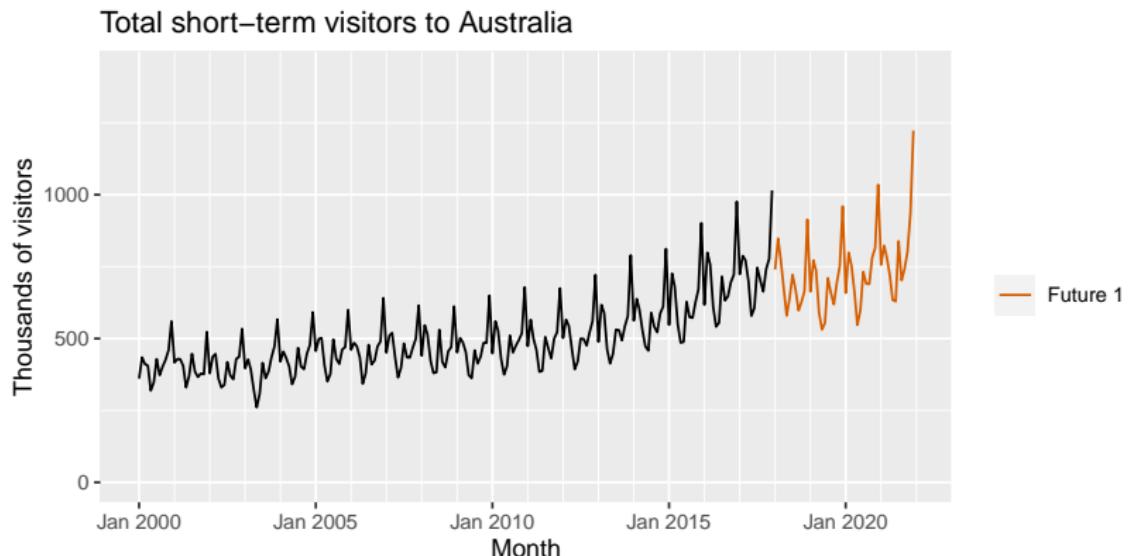
Random futures

A forecast is an estimate of the probabilities of possible futures



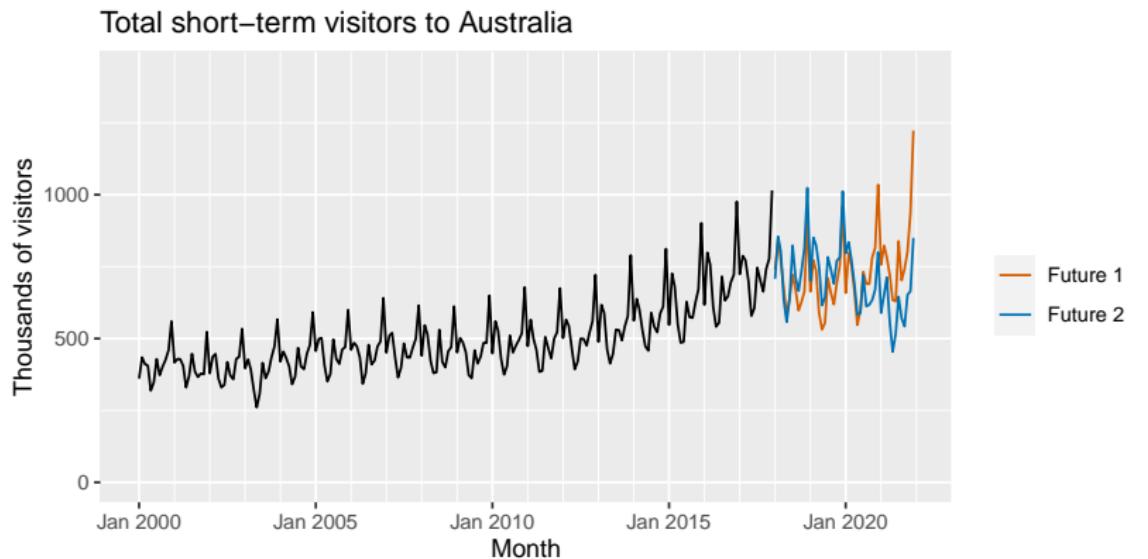
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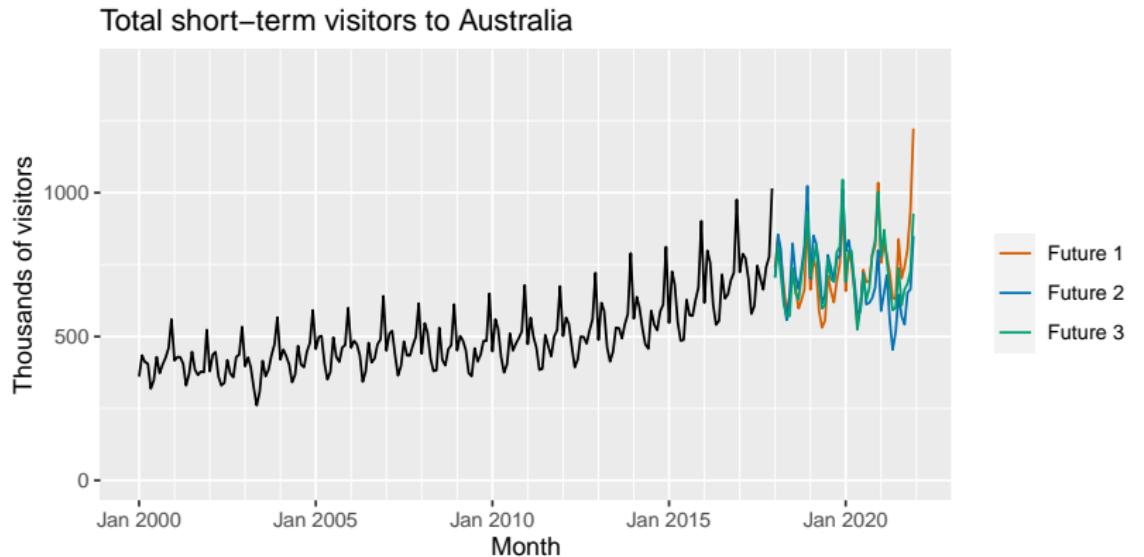
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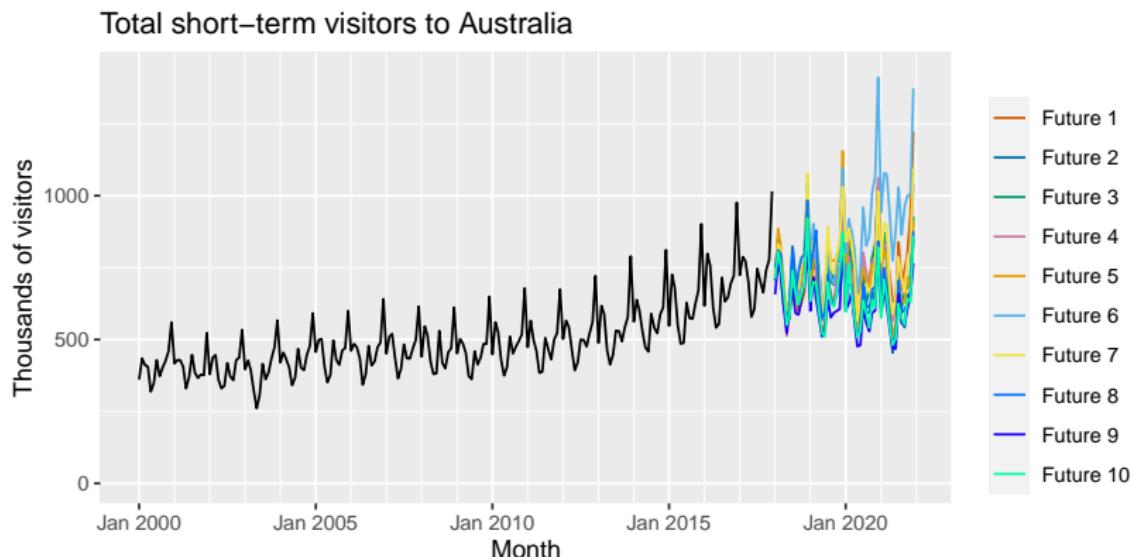
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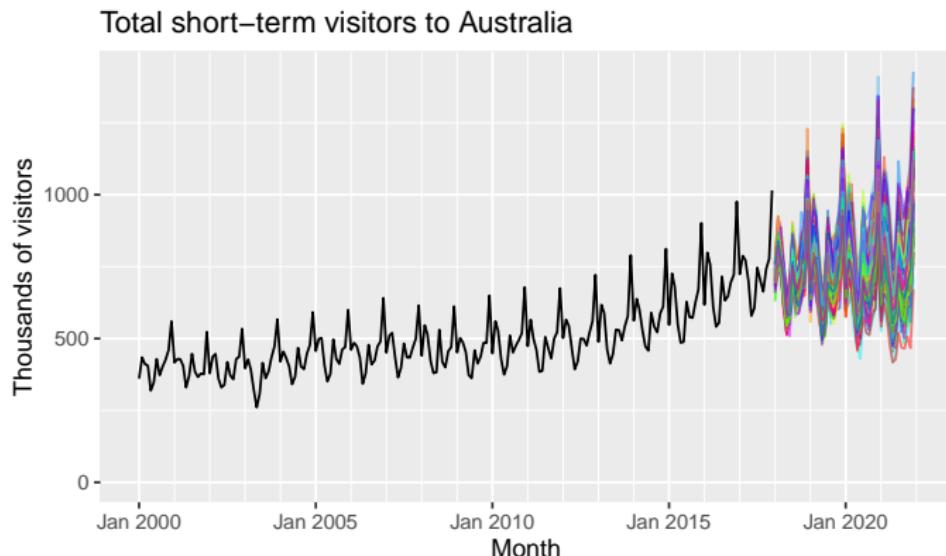
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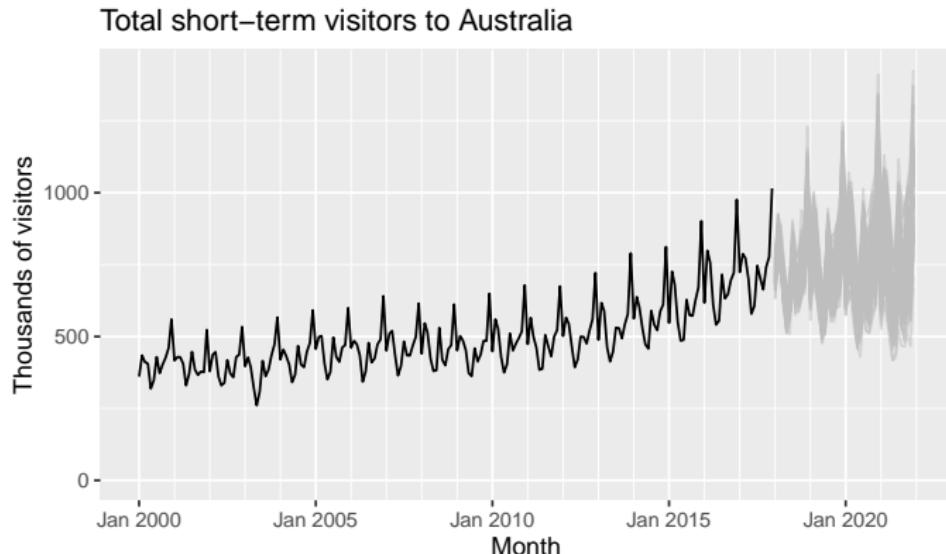
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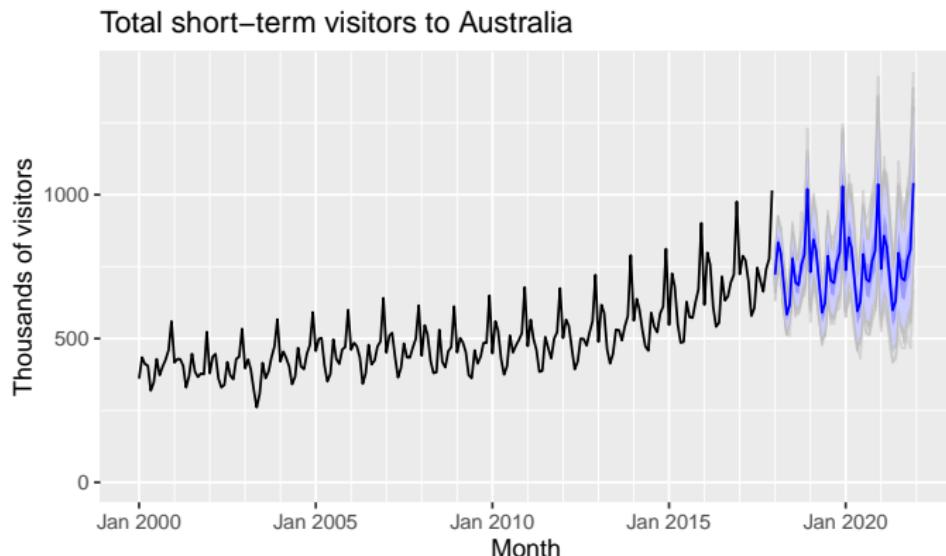
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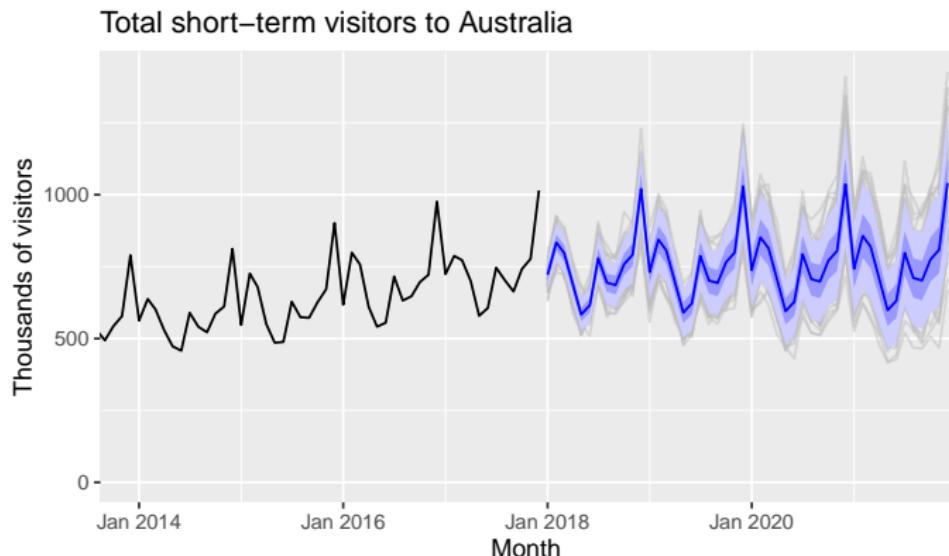
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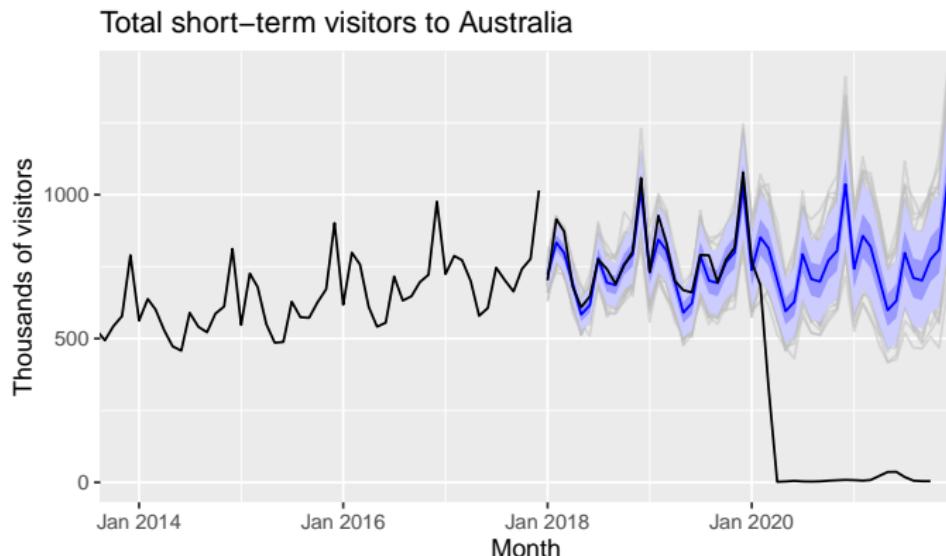
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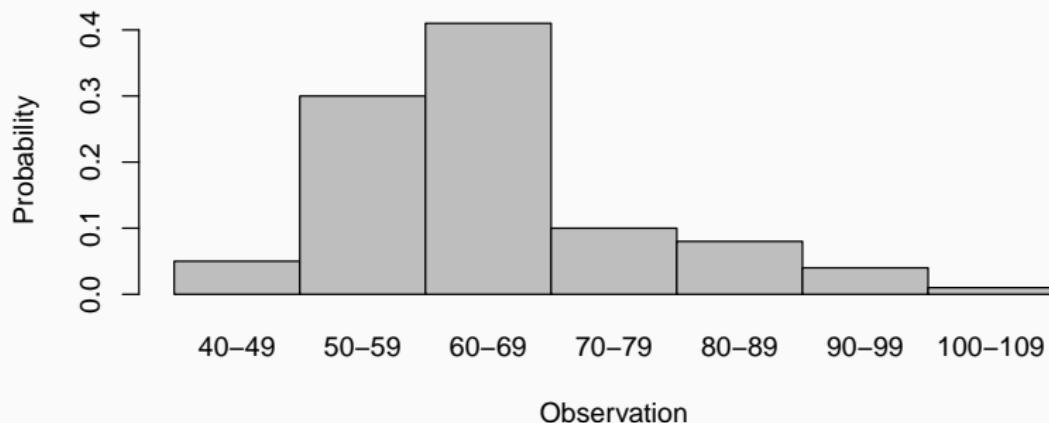


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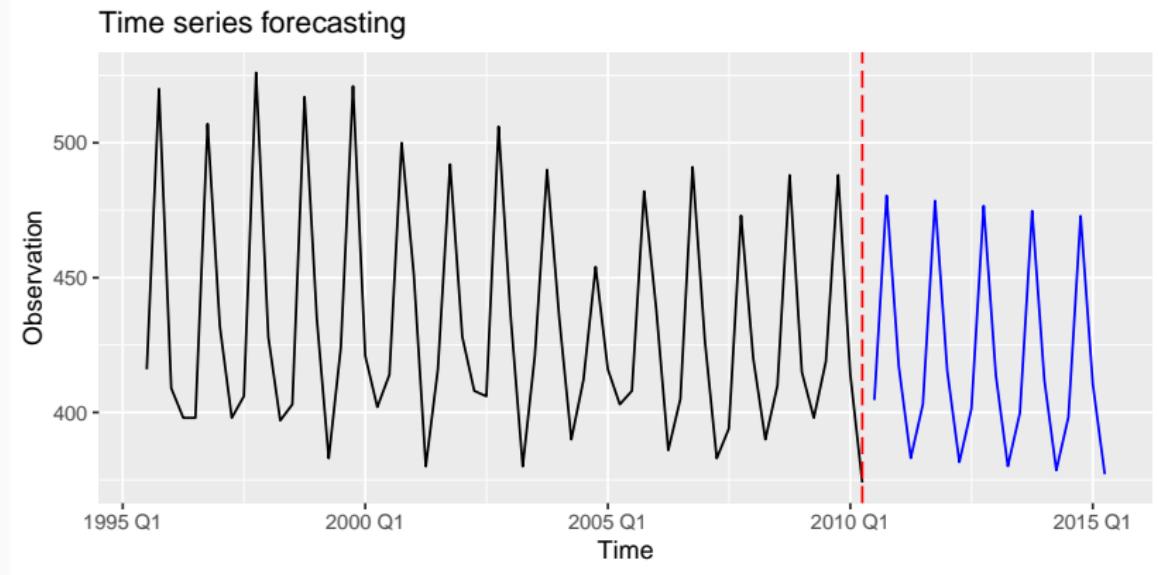
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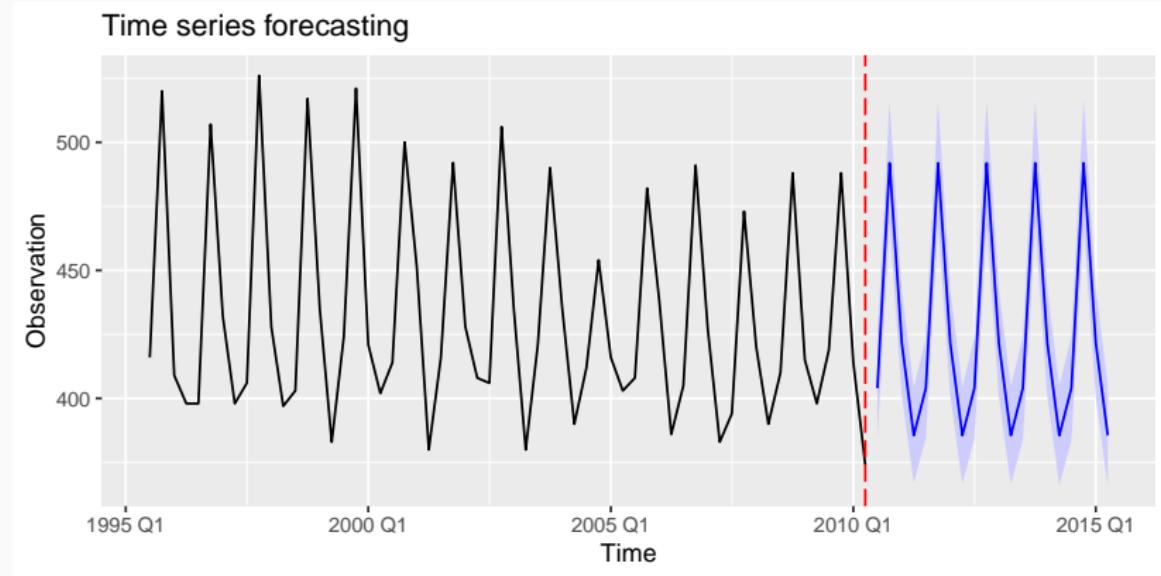
Forecast as probability distribution



Point forecasts



Prediction interval forecasts



Statistical forecasting

- Thing to be forecast: y_{T+h} .
- What we know: y_1, \dots, y_T .
- Forecast distribution:
 $y_{T+h|t} = y_{T+h} \mid \{y_1, y_2, \dots, y_T\}$.
- Point forecast: $\hat{y}_{T+h|T} = E[y_{T+h} \mid y_1, \dots, y_T]$.
- Forecast variance: $\text{Var}[y_t \mid y_1, \dots, y_T]$
- Prediction interval is a range of values of y_{T+h} with high probability.

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Current situation in your organisation

Think about the forecasting process in your organisation:

- What do you forecast?
 - ▶ variable
 - ▶ granularity
 - ▶ frequency
 - ▶ horizon
- How do you present forecasts?
- Do you need to adjuste statistical forecasts?
 - ▶ When and How you do it?