

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
- 4 Forecasting process
- 5 What can be forecasted?
- 6 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?

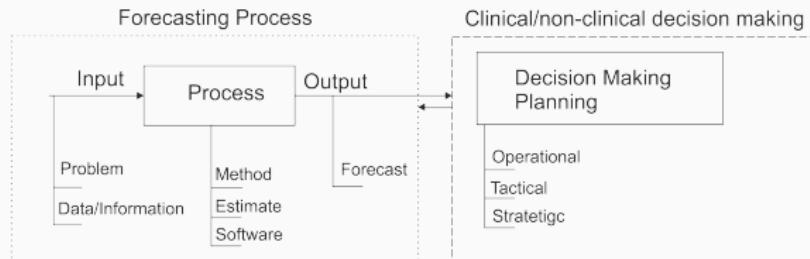
Why do you use forecast?

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

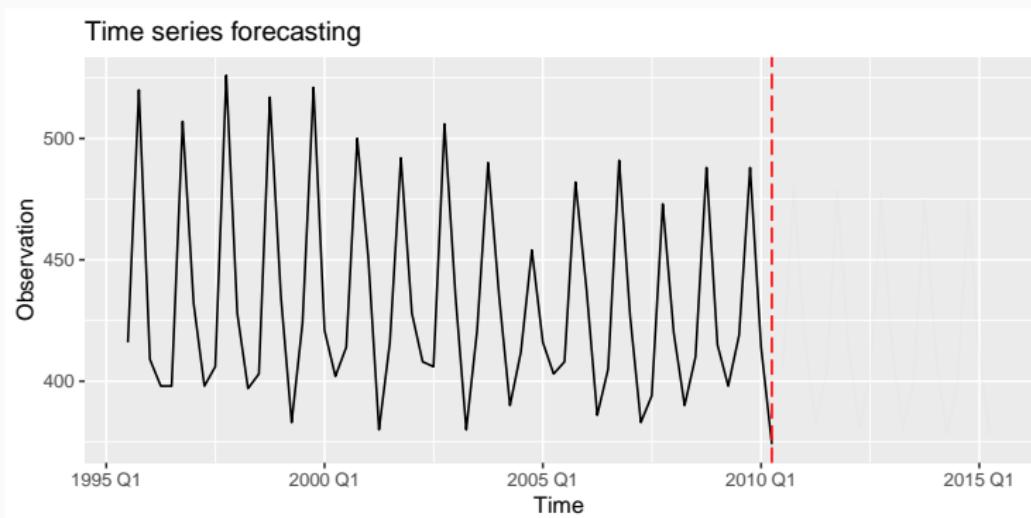


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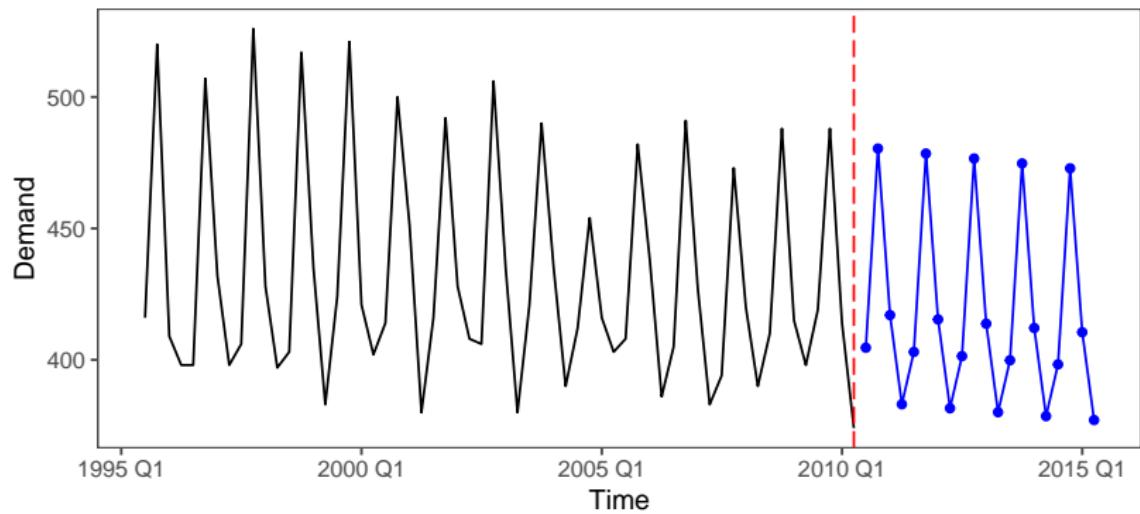
What is a forecast?

- Forecasting is estimating how the sequence of observations will continue into the future.

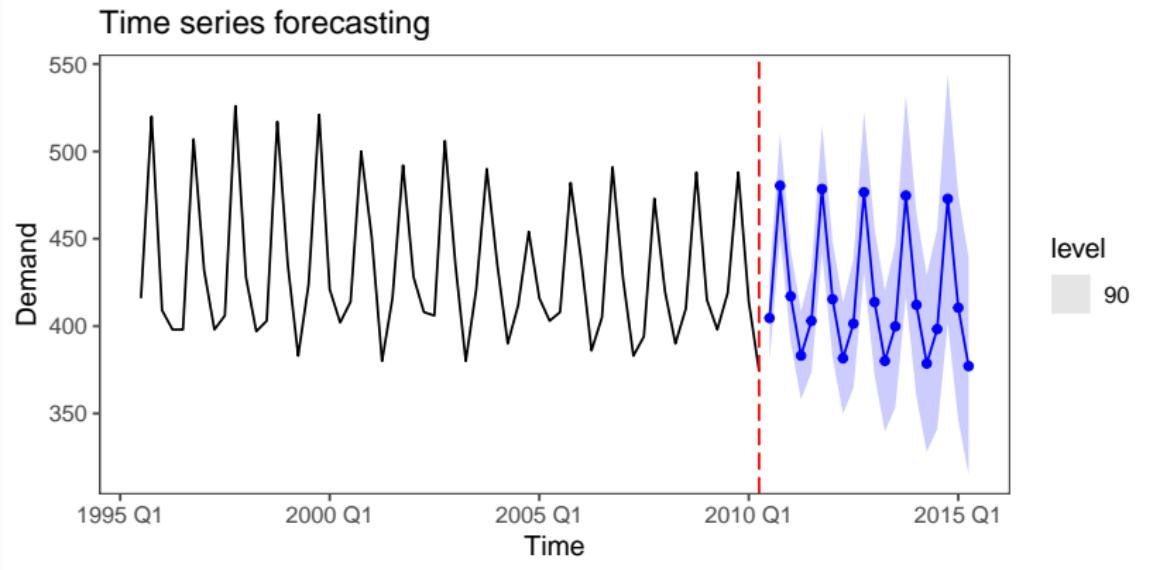


Point forecasts

Time series forecasting

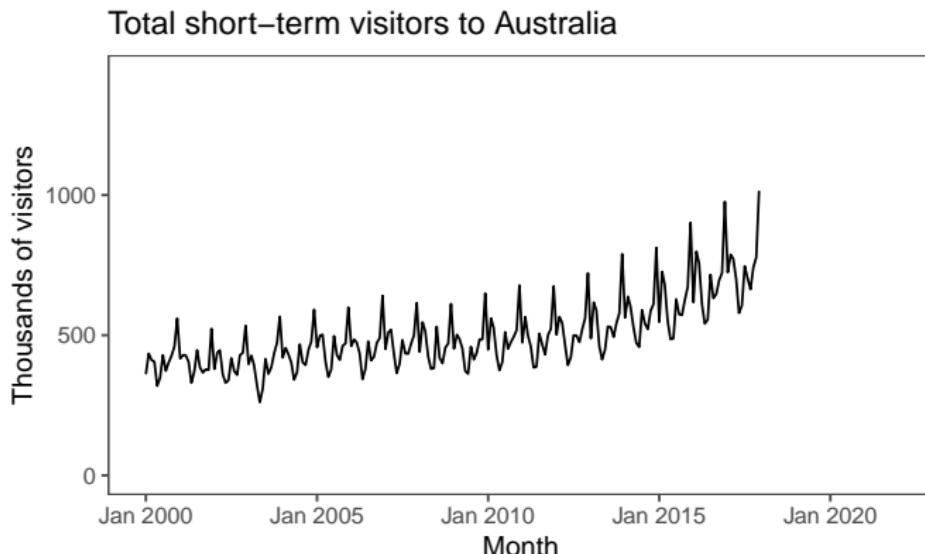


Prediction interval forecasts



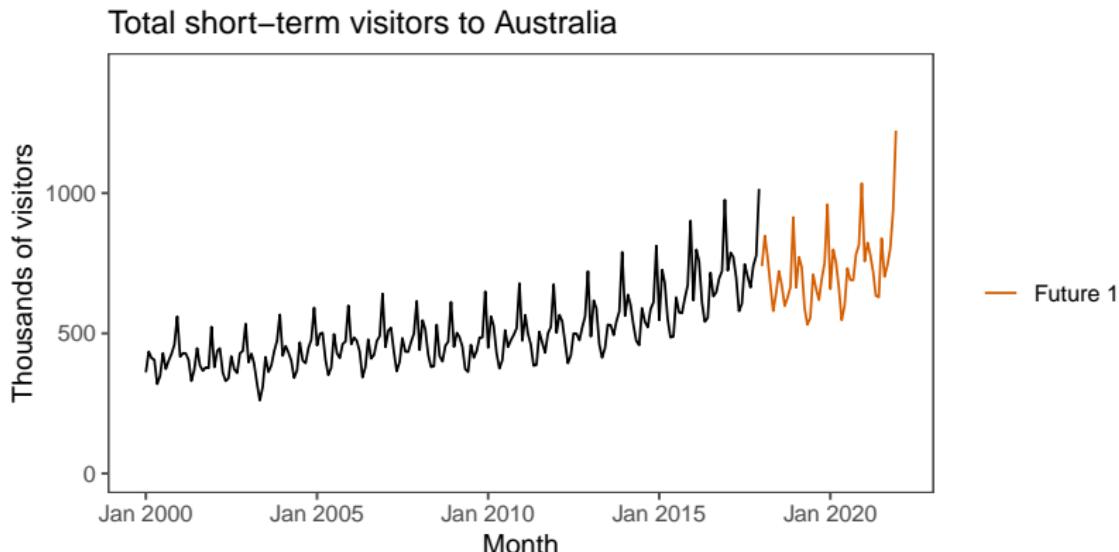
What is a forecast?

A forecast is an estimate of the probability distribution of a variable to be observed in the future



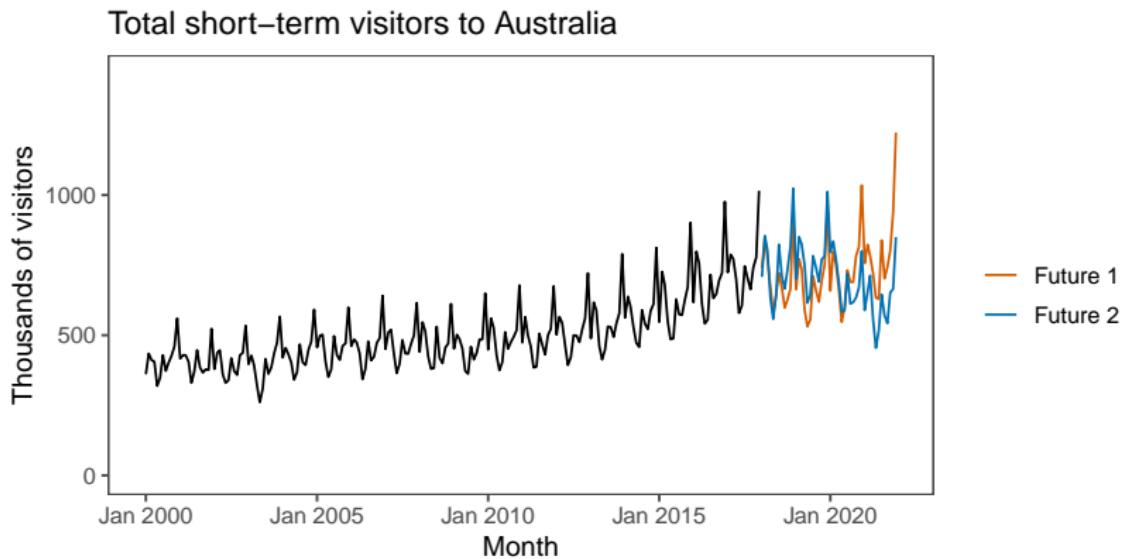
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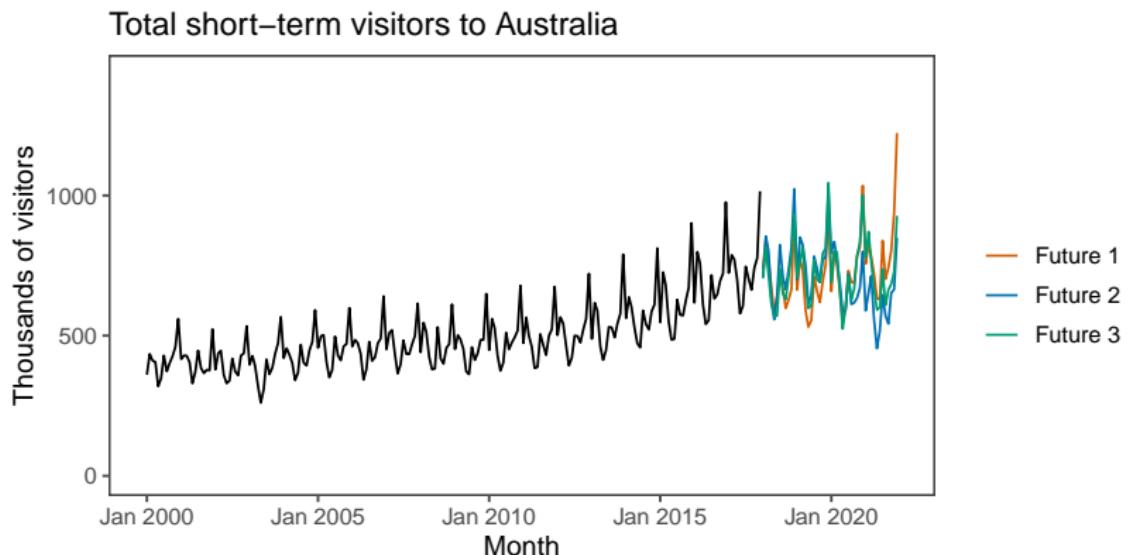
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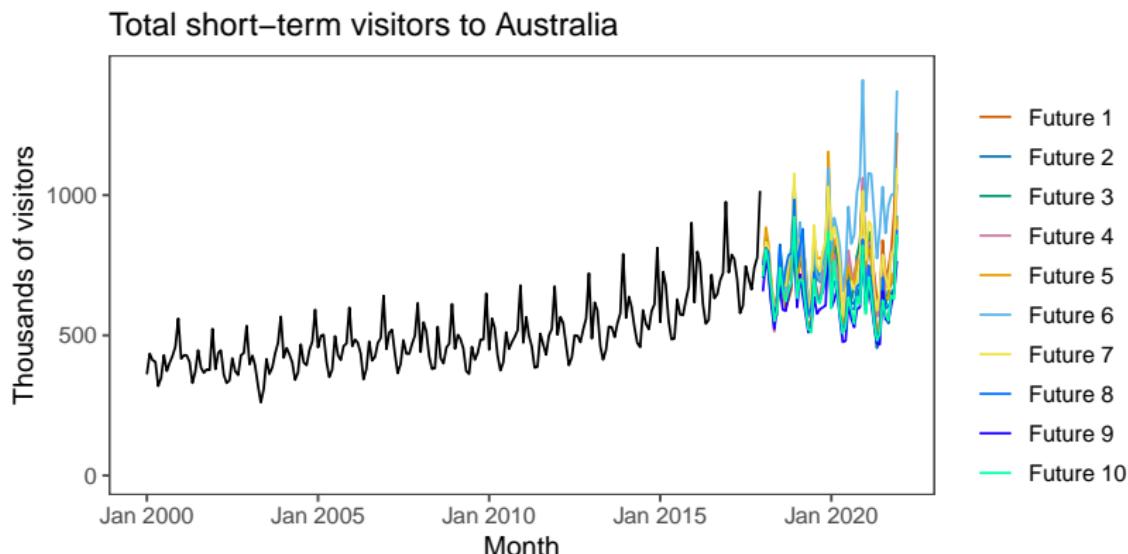
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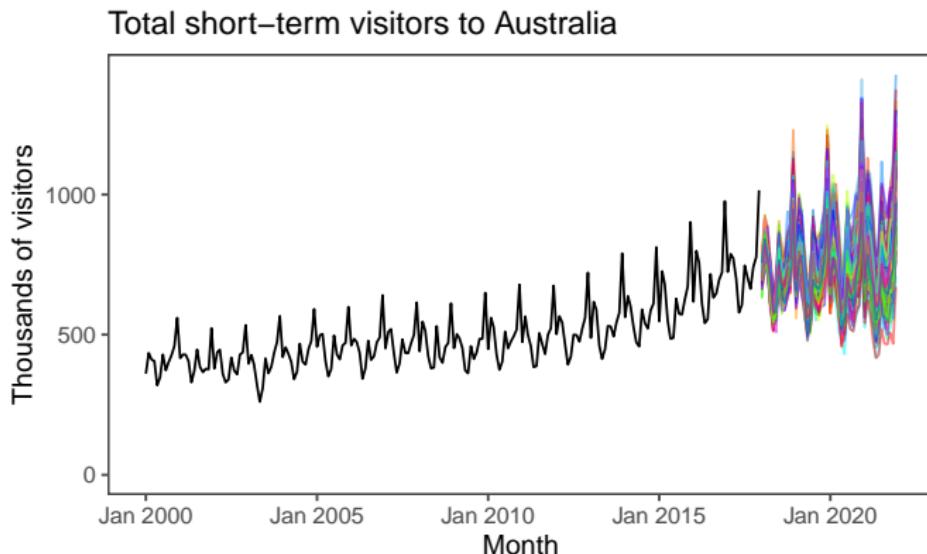
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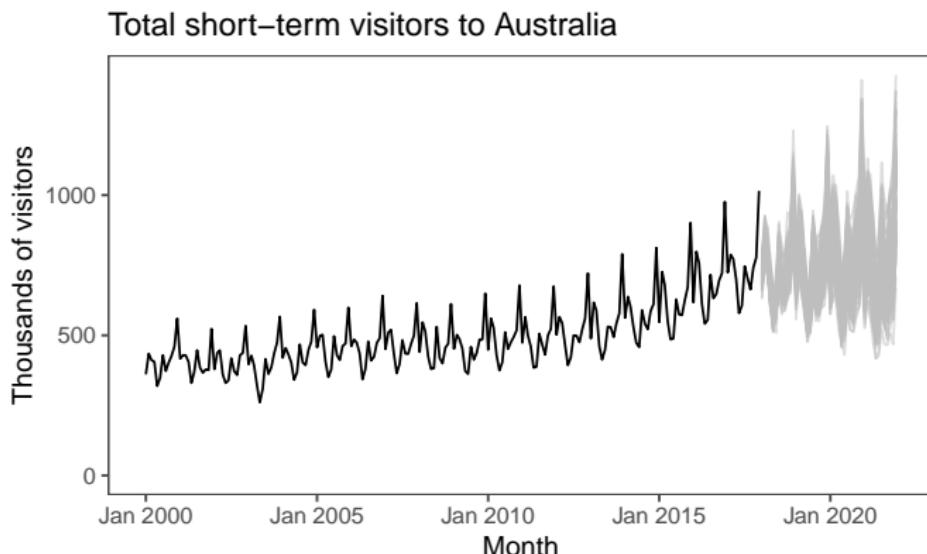
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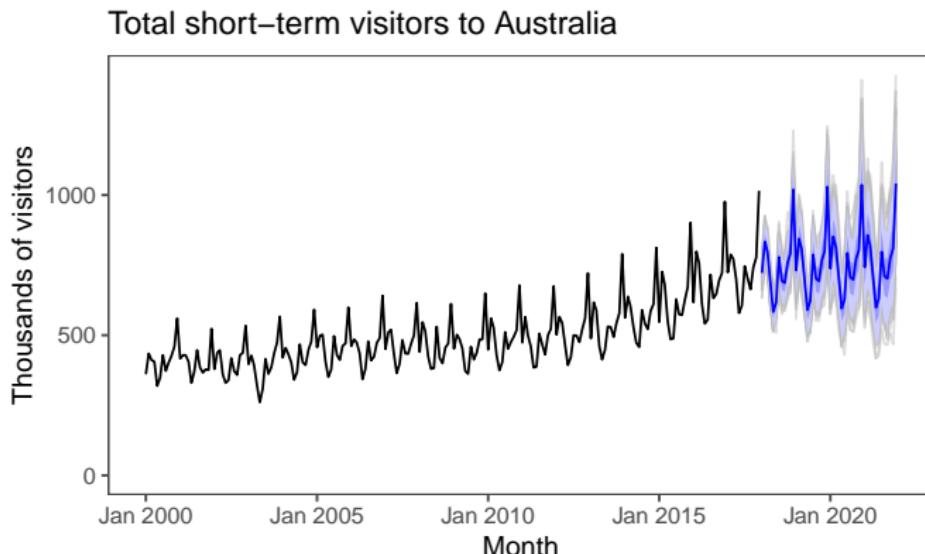
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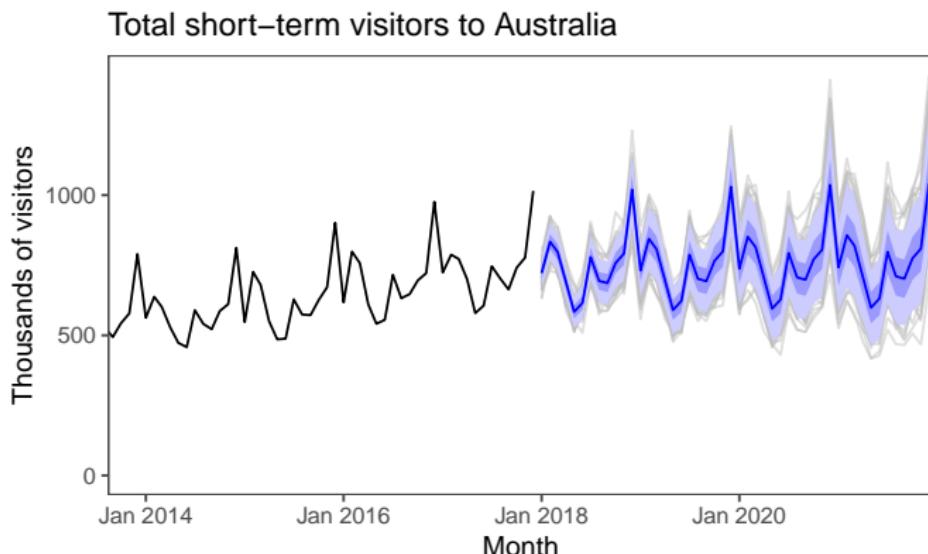
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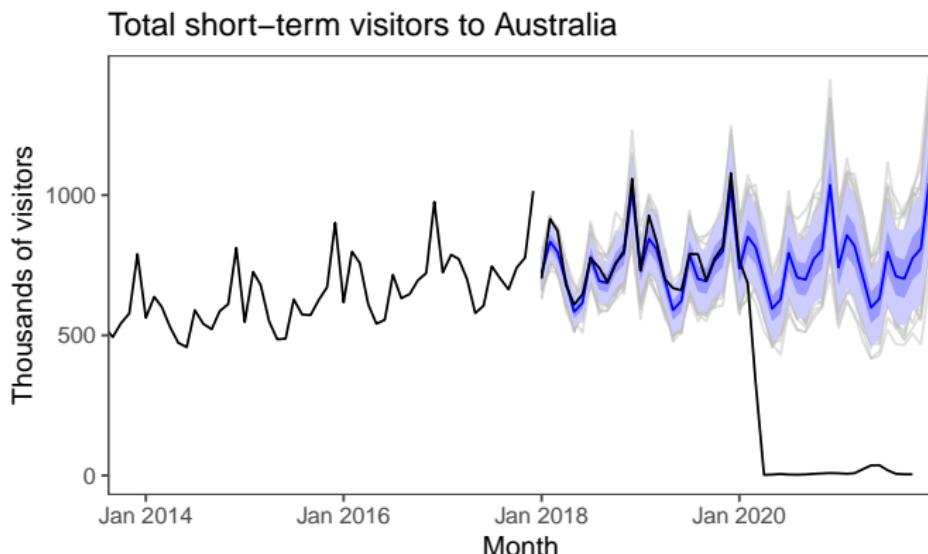
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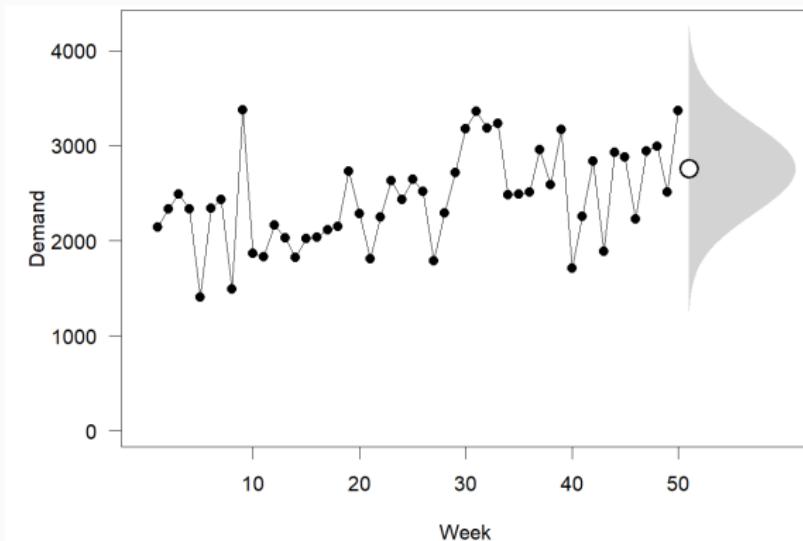


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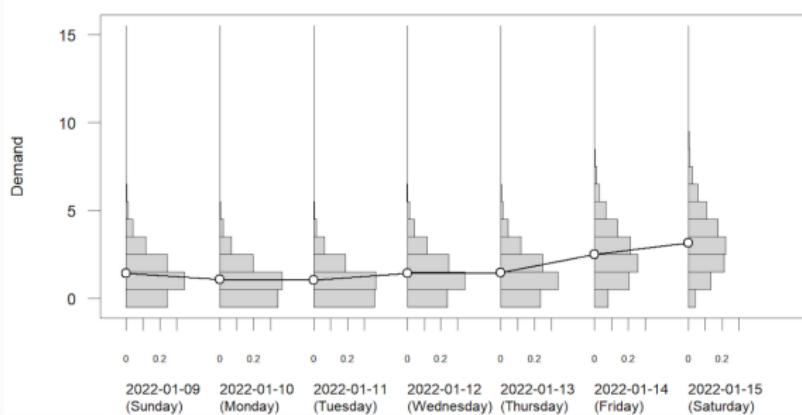
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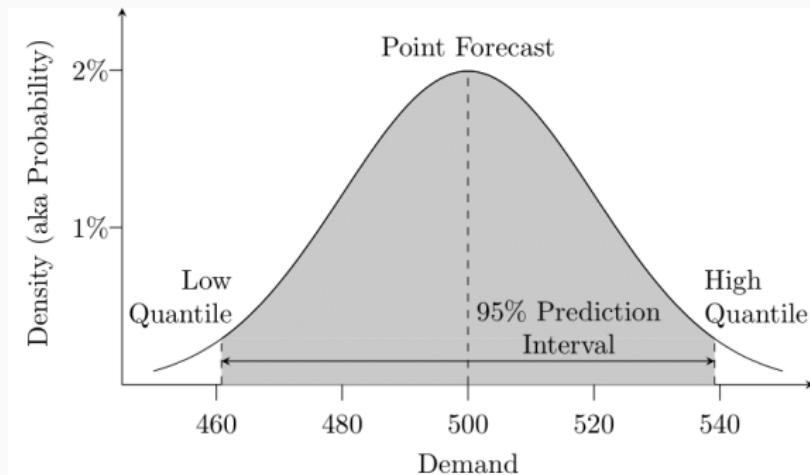
Forecast as probability distribution



Forecast as probability distribution



Probabilistic forecast perspective



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.

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 Past/historical time series data on the variable we intend to forecast
- 2 Past and future data about deterministic predictors
- 3 Past and future data about stochastic predictors
- 4 Expertise of individuals in an organization and any contextual information that may affect the forecast variable
 - ▶ New information

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	

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

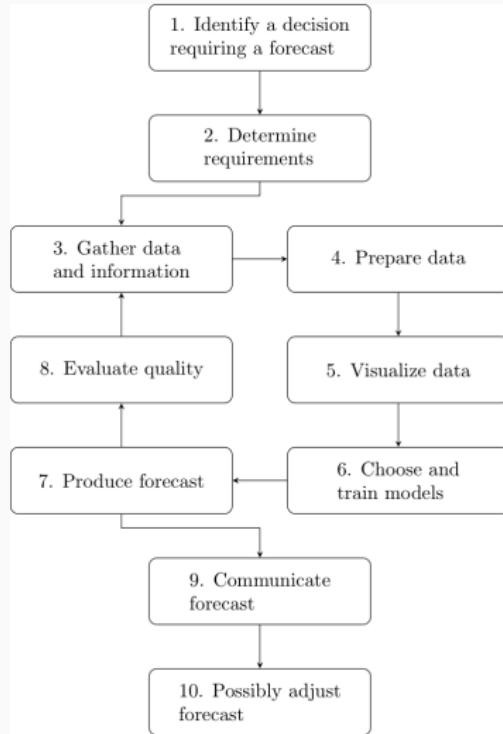
Time Series forecasting models

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

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Forecasting process



Determine forecasting requirement

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

Gathering data/information

- Historical data/ time series
- Past and future values of predictors
 - ▶ Deterministic, e.g. holidays
 - ▶ Stochastic, 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, ...

The statistical forecasting workflow

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

- 1 Prepare data
- 2 Visualise data
- 3 Specify/choose models
- 4 Train models
- 5 Produce forecasts
- 6 Evaluate quality

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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 systematic patterns and relationships which exist in the historical data, but do not replicate past events that will not occur again.

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Current situation in your organisation

Think about the forecasting process in your organisation:

- Identify one decision that requires a forecast
- Determine forecasting requirements?
 - ▶ variable
 - ▶ granularity
 - ▶ frequency
 - ▶ horizon
- How do you produce and communicate forecasts?