

ETF3231/5231: Business forecasting

Week 1: Intro to forecasting and R
<https://bf.numbat.space/>



Outline

- 1 Teaching team and support
- 2 Teaching and learning approach
- 3 Unit outline
- 4 Individual Assignment 1
- 5 Chapter 1 - Getting started
- 6 Chapter 2 - Time series graphics

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George Athanasopoulos (Lecturer and Chief Examiner)

↙ yes extremely busy but you are my priority.

- **Professor and Head of Department** of Econometrics and Business Statistics, Monash Business School.
- Room H5.83, Building H, Caulfield.
- Past President / Director: [International Institute Forecasters](#)
 - ▶ Bridge the gap between theory and practice, with practice helping to set the research agenda and research providing useful results.
- Associate Editor: [International Journal Forecasting](#)
 - ▶ The leading academic journal in business forecasting.
- Editorial board: [Journal of Travel Research](#)

My methodology is used for forecasting:

- Australian Retail Sector *you will also do in your assignments*
- Australian Tourism (latest is post-Covid19) *funded by Tourism Australia*
- Hospital Admissions (UK and Mornington Peninsula) *through Covid for Mornington Peninsula.*
- Monash Student Enrollment Numbers *approx 86,000 students (a very large hierarchy)*
- Australian Prison Populations *BOCSA2*
- Macroeconomic Variables *Australian Treasury*
- Restaurant Bookings *Taiwan*
- Time series connected by aggregation constraints (very large data)

*Google, Walmart, Energy sector (AEMO), Tourism Australia,
UK emergency sector, Bank of New York Mellon, etc.*

Teaching Associates and Consultations

- Joan Tan (Head TA)
- Ari Handayani
- Weiben Zhang
- Sombut Jaidee

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** Lots of consultation so no excuses*

- Monday 12-1pm, **Joan Tan**, Room H4.68 and **zoom**. Online booking available upon request.
- Tuesday, 11-12.30pm, **Ari Handayani**, Room H4.63 and **zoom**.
- Tuesday, 4-5pm, **Weiben Zhang**, **zoom**.
- Thursday, 11.00-11.30pm, **Ari Handayani**, **zoom**.
- Thursday, 2-3pm, George Athanasopoulos, **zoom**.^{*}
- Friday 1-2pm, **Ari Handayani**, **zoom**.
- Friday 5-6pm, **Sombut Jaidee**, H4.69 and **zoom**.

** (may not always be available - will let you know).*

Further support

- Speak to your tutor if you would prefer a face-to-face consultation to see whether that can be arranged.

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- Ask the bot to get clarifications (not how to do your assignment).
- Assignment consultations - please see our teaching associates.

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x 300 students in ETF3231 /5231 in S1

* Over 400 students in ETC3550 /5550 in S2

I will not consult via email.

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- **Pre-class preparation.** Watch recorded lectures embedded in the textbook at <http://OTexts.org/fpp3/> and read the book sections. Allow 60 minutes to watch these. ** Please try and complete these.*

Seminars, Workshops, Tutorials

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- **Wednesday 15:00-15:50. In person seminar.** Review the important aspects of theory and enhance with deeper explanations or proofs when required and examples with coding. Aim: as interactive as possible.

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- **Wednesday 16:00-16:50. In person workshop.** Complete online quiz covering materials from your pre-class preparation and the seminar. We will be going through example exercises and exam questions. You will be practicing with me.

Between pre- & in-class you should be done!

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- **Thursday - Friday. In person tutorials.** Try and prepare questions before you go to the tute (a much more enjoyable experience).

Tutorials will help you with assignments. Workshops will help with exam preparation. → we will do multiple exams → keep attending.

Tutorials start tomorrow.

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Pre-class tutorial activity

- Install R, RStudio and required packages in your own laptops and have them ready to go.
- See <https://otexts.com/fpp3/appendix-using-r.html>
- `install.packages(c("tidyverse", "fpp3", "GGally"), dependencies = TRUE)`

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- If you already have it update everything: R, RStudio, packages.
- Note: we will be using R in seminars and workshops. **Bring your laptops with you.**

Complete pre- or in-tutorials

- Work through **Getting started** (5 modules) and **Writing Documents** of StartR at <https://starttr.numbat.space/>

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- Make sure you can successfully knit a Qmd file to Pdf. You will have to do this for your assignments.

Aim: install and become familiar with R, RStudio and the tidyverse packages. Get help in this week's tutorials if you need to.

Week 1 homework (continued)

Complete pre- or in-tutorials

- Work through **Getting started** (5 modules) and **Writing Documents** of StartR at <https://starttr.numbat.space/>
- Make sure you can successfully knit a Qmd file to Pdf. You will have to do this for your assignments.

Aim: install and become familiar with R, RStudio and the tidyverse packages. Get help in this week's tutorials if you need to.

Complete ~~pre- or post-~~ seminar

- Read Chapter 1 of the textbook and watch all embedded videos. Pay particular attention to [Section 1.7](#).
- Read [Section 2.1](#) of the textbook and watch the embedded video.

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Unit objectives

- Obtain an understanding of common statistical methods used in business and economic forecasting.
- Learn how to build accurate and robust models for forecasting.
- Acquire computer skills vital for forecasting business and economic data. ** not a coding course*
- To gain insights into the problems of implementing and operating large scale forecasting systems for use in business.

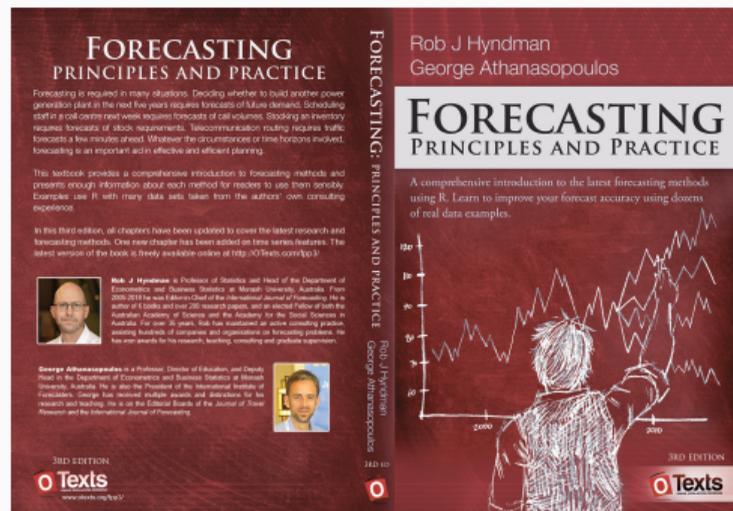
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We'll use R to do all this - so the course is about learning good forecasting practices using a very powerful tool.

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

- <http://OTexts.org/fpp3/>
- Free online → show translations (if you read and find any errors let us know).
- Printed version available [here](#)
- Data sets in associated package.
- Pre-recorded videos (beginning of each section).





Available for download from CRAN:

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



Available for download from RStudio:

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



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

<https://PollEv.com/georgeathana023>

How familiar are you with R, RStudio?



Main packages



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# Install required packages (do once)
install.packages(c("tidyverse", "fpp3", "GGally"))
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```
# Data manipulation and plotting functions
library(tidyverse)
# Time series manipulation
library(tsibble)
# Tidy time series data
library(tsibbledata)
# Time series graphics and statistics
library(feasts)
# Forecasting functions
library(fable)
```

** We'll demonstrate
this soon*

Week	Topic	Chapter
1	Introduction to forecasting and R	1, App
2	Time series graphics	2
3	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

- All students: In-class weekly quiz (Weeks 2-12, 8%).

Assessment

- All students: In-class weekly quiz (Weeks 2-12, 8%).
 - All students: Forecasting Competition (IA1, 2%).
 - All students: Individual Assignments (IA2, IA3, IA4) (5%, 10%, 15%).
- Aim to get you started. Expectation full marks.*

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- ETF5231: Extra Group Assignments (GA2, GA3, GA4).

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- In-semester Assessments: Total Weight 40%.

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- Invigilated Exam (2 hours): Weight 60% (hurdle requirement 45%).

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See assignment schedule on [moodle](#) and [bf.numbat.space](#)

- Assignment submission dates are to be confirmed as we go along.
- Forecasting Competition IA1 already posted. Will announce shortly.

- Includes all lecture note handouts, R code, assignments, past exams, etc.
- [Ed discussion forum](#) for asking questions, getting help from teaching team and the bot, etc.
- Assignment submissions through moodle (links in the bf webpage).
- A common question: are the lectures recorded? Yes but. . .

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Let's explore the website: <https://bf.numbat.space/>



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

<https://forecasters.org/programs/research-awards/students>

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SKIP - come back after Section 5

Go to <https://bf.numbat.space/assignments/A1.html>.

Comments:

- Forecasting competition **bragging rights** and **official recognition** (top three will be recognised but there will be only one winner). → certificates to top 3
- Should not take you longer than an **hour or two**.
- If you submit something sensible you will get **full marks** (2%).

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Absolute error = $|y - \hat{y}|$ *(the lower the better)*

Interval score = $(\hat{u} - \hat{L}) + 10 (\hat{L} - y)_+ + 10 (y - \hat{u})_+$ $u_+ = \max(u, 0)$

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Eg $y = 90$

$$(100 - 80) = 20 \quad 10(80 - 90)_+ = 0 \quad 10(90 - 100)_+ = 0 \quad IS = 20$$

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$$(120 - 100) = 20 \quad 10(100 - 90)_+ = 100 \quad 10(90 - 120) = 0 \quad IS = 120$$

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$$(92 - 82) = 10 \quad 10(82 - 90)_+ = 0 \quad 10(90 - 92)_+ = 0 \quad IS = 10$$

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What can we forecast?



Which is easiest to forecast?

- 1 Google stock price tomorrow
- 2 Tourism demand next summer
- 3 Google stock price in 6 months time
- 4 Exchange rate of \$US/AUS next week
- 5 Prison population in 2 years
- 6 Time of sunrise this day next year
- 7 Maximum temperature tomorrow
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<https://PollEv.com/georgeathana023>

Which one is easiest to forecast?

* rank from most difficult to easiest.

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H

- Lot of data



M

- Lots of data

- We understand factors

- Usually no significant breaks

- forecast don't affect future



E

- no uncertainty (mathematical rules)

- how do we measure "easiest"?
- what makes something easy/difficult to forecast?

Factors affecting forecastability

Something is **easier to forecast** if:

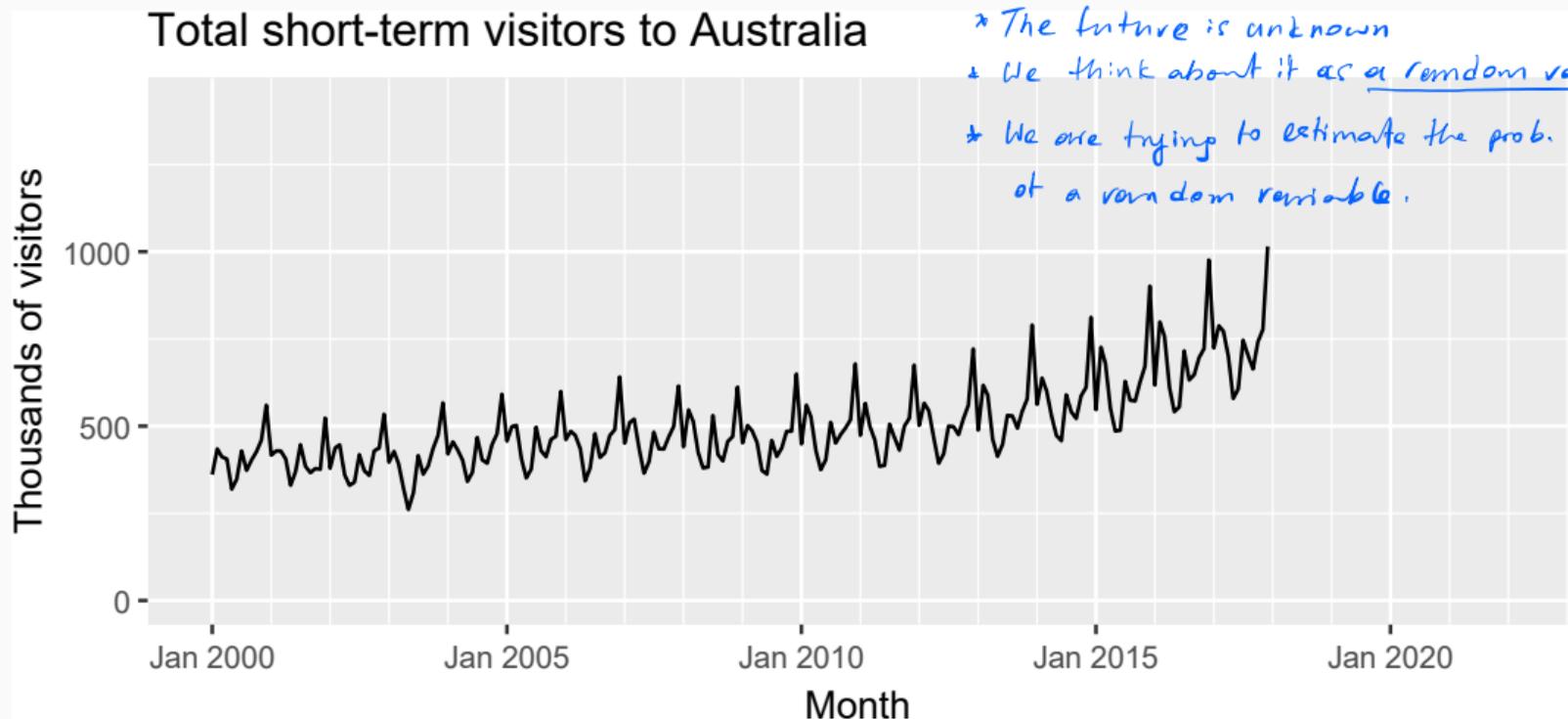
- 1 we have a good understanding of the **factors that contribute** to it;
- 2 there is **lots of data** available;
- 3 the **future is somewhat similar to the past**;
- 4 the **forecasts cannot affect** the thing we are trying to forecast.

What is a forecast?

A forecast is an estimate of the probabilities of possible futures.

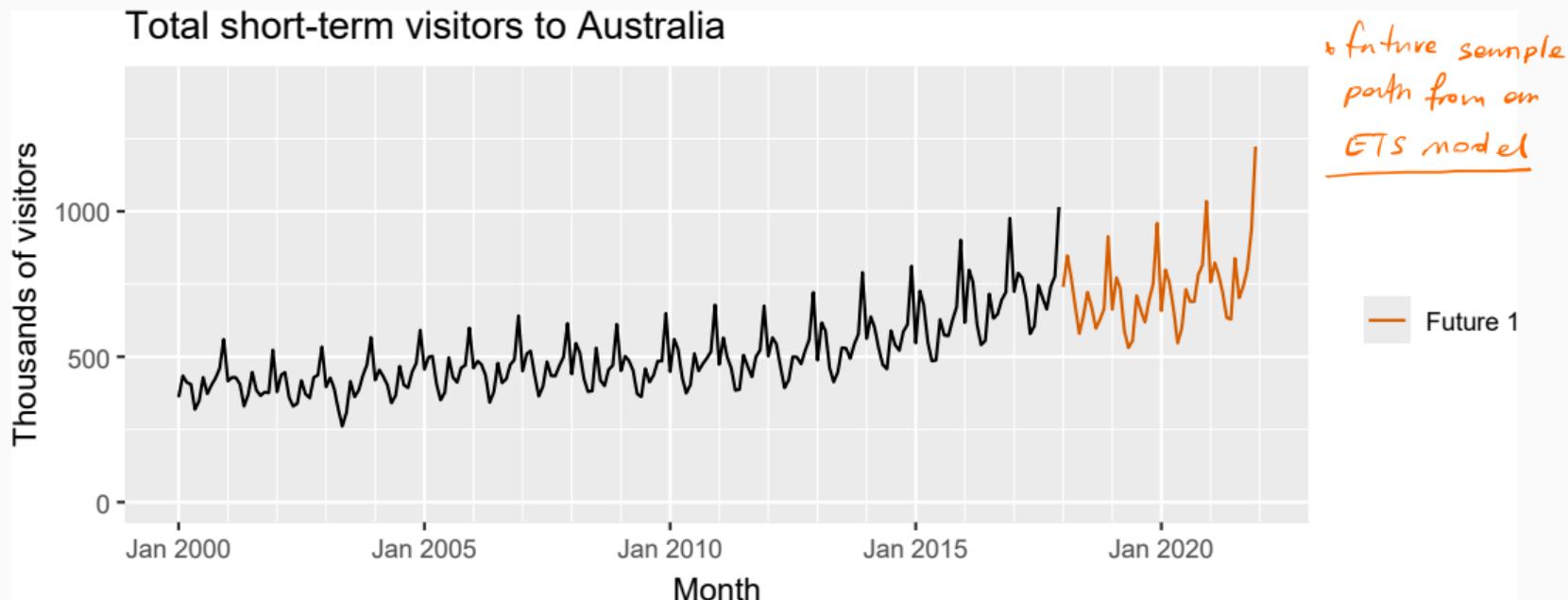
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Random futures

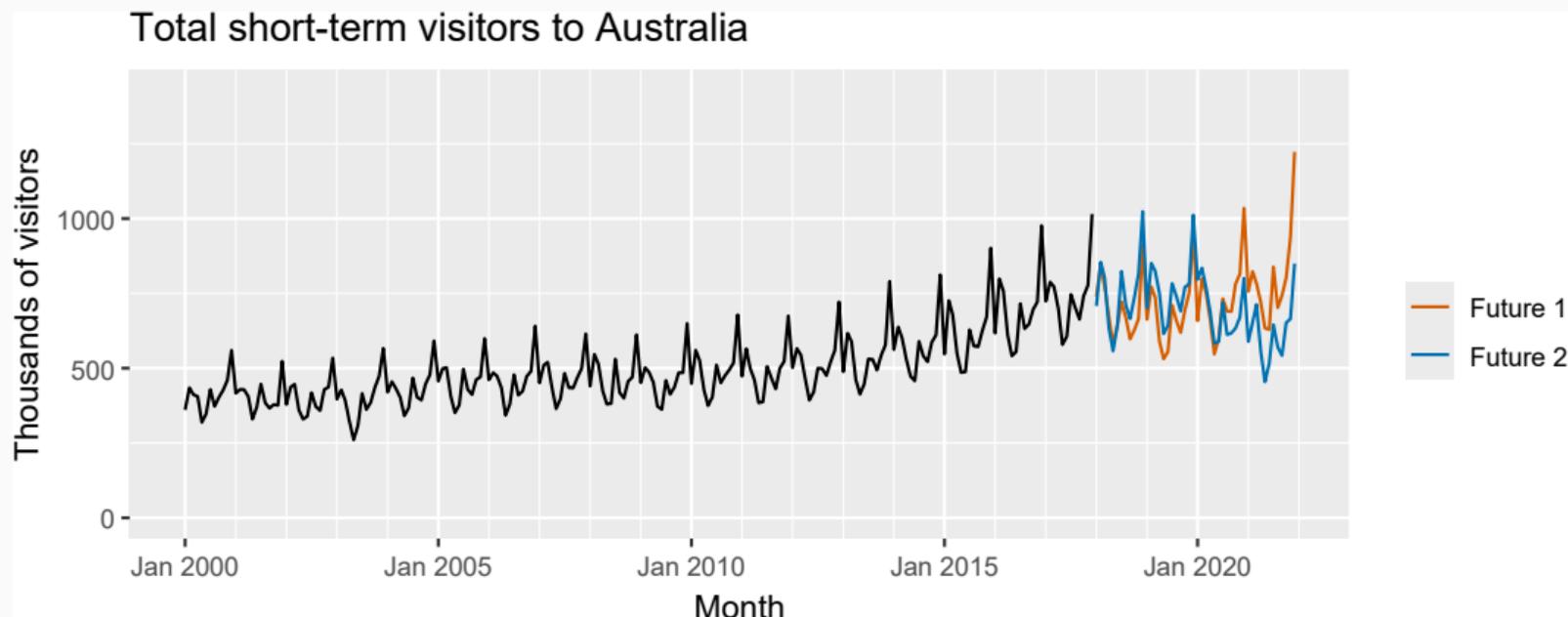
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Simulated futures
from an ETS model

Random futures

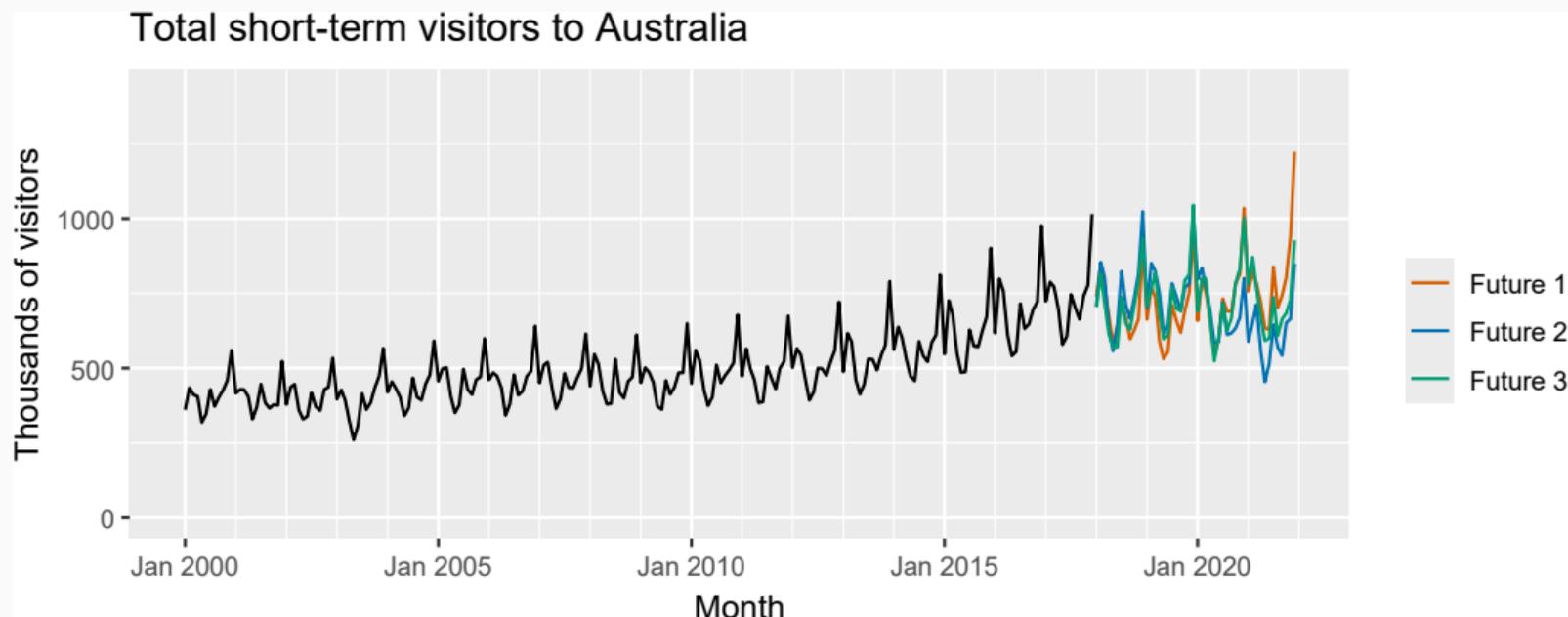
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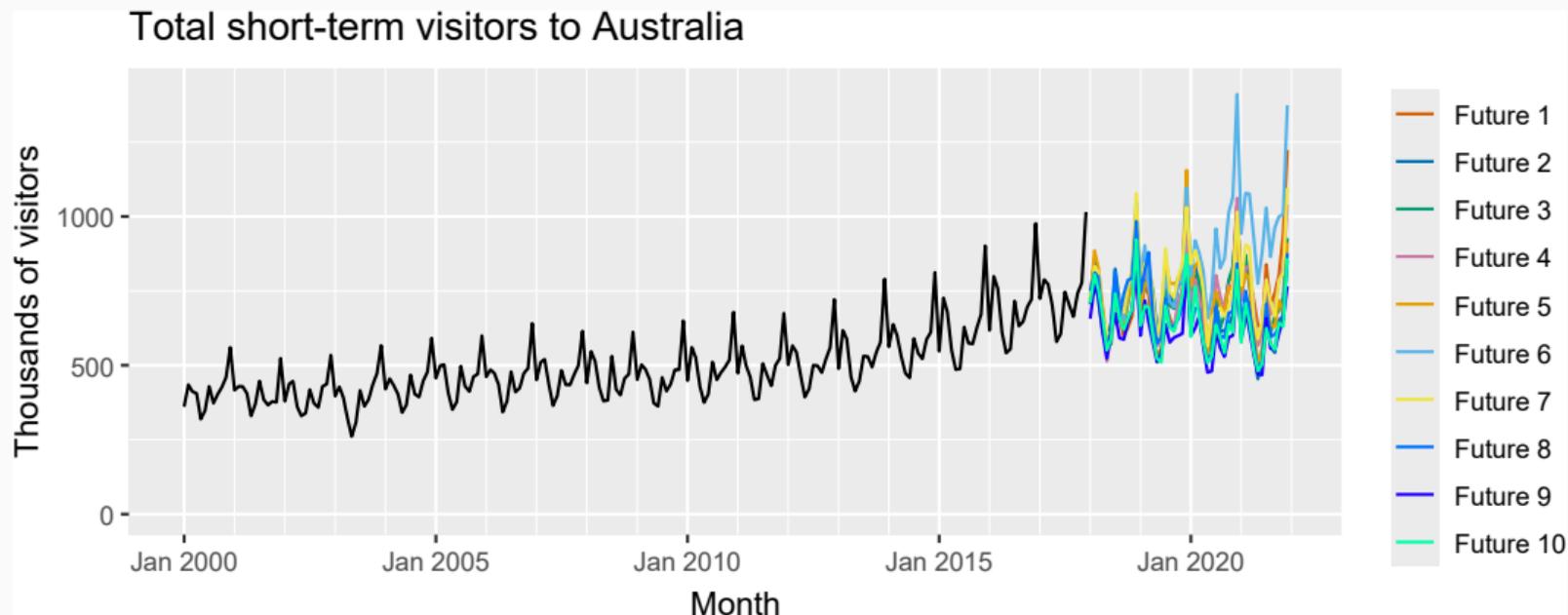
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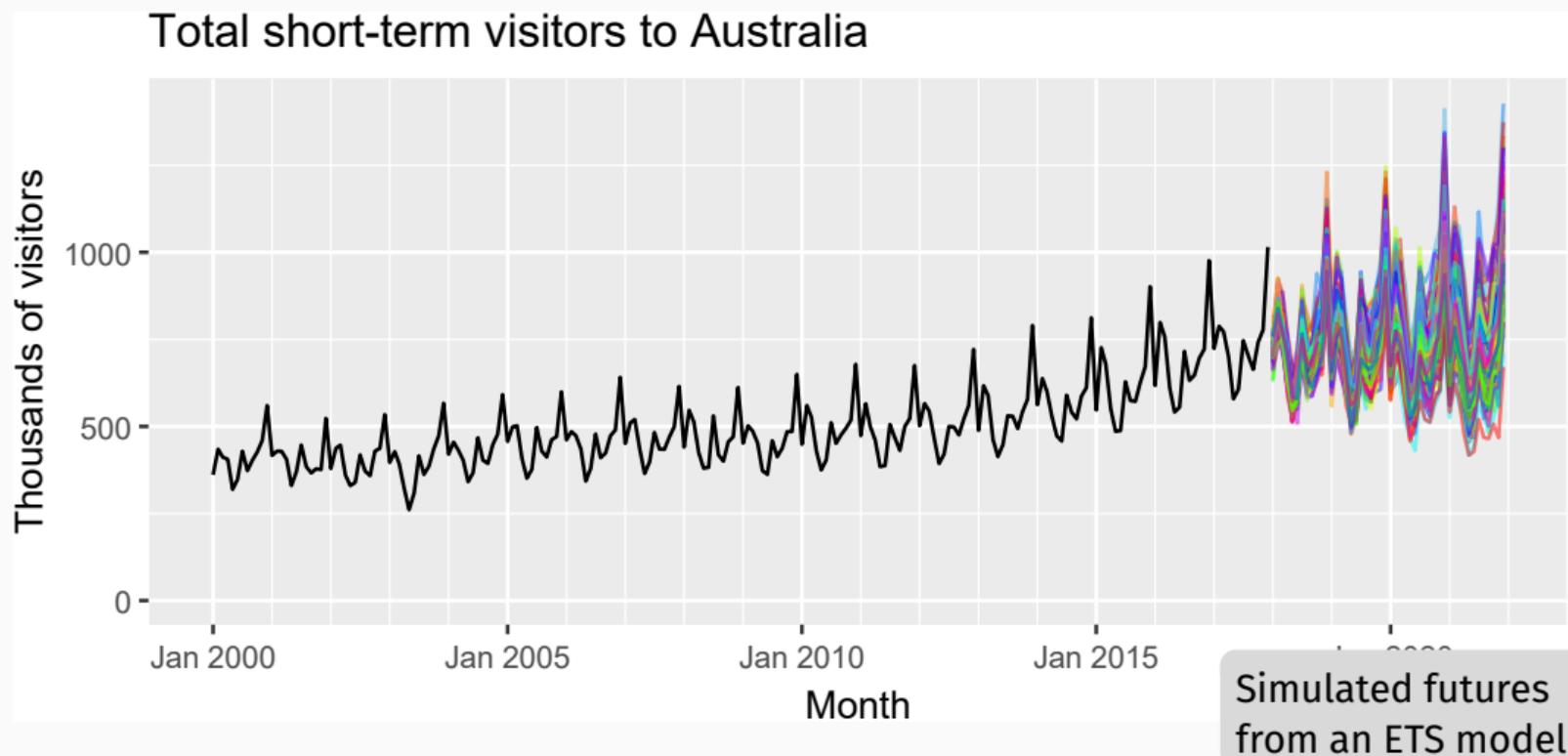
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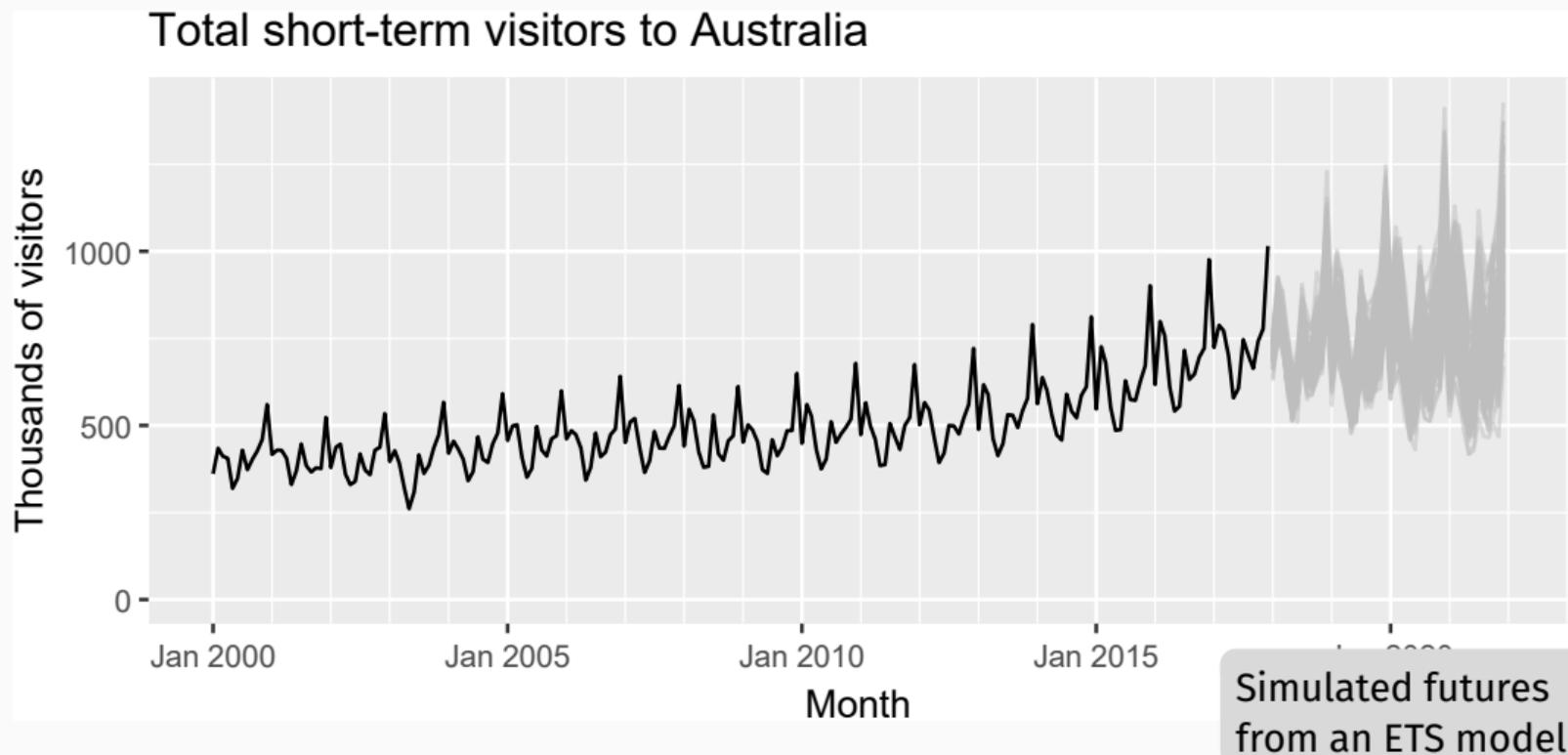
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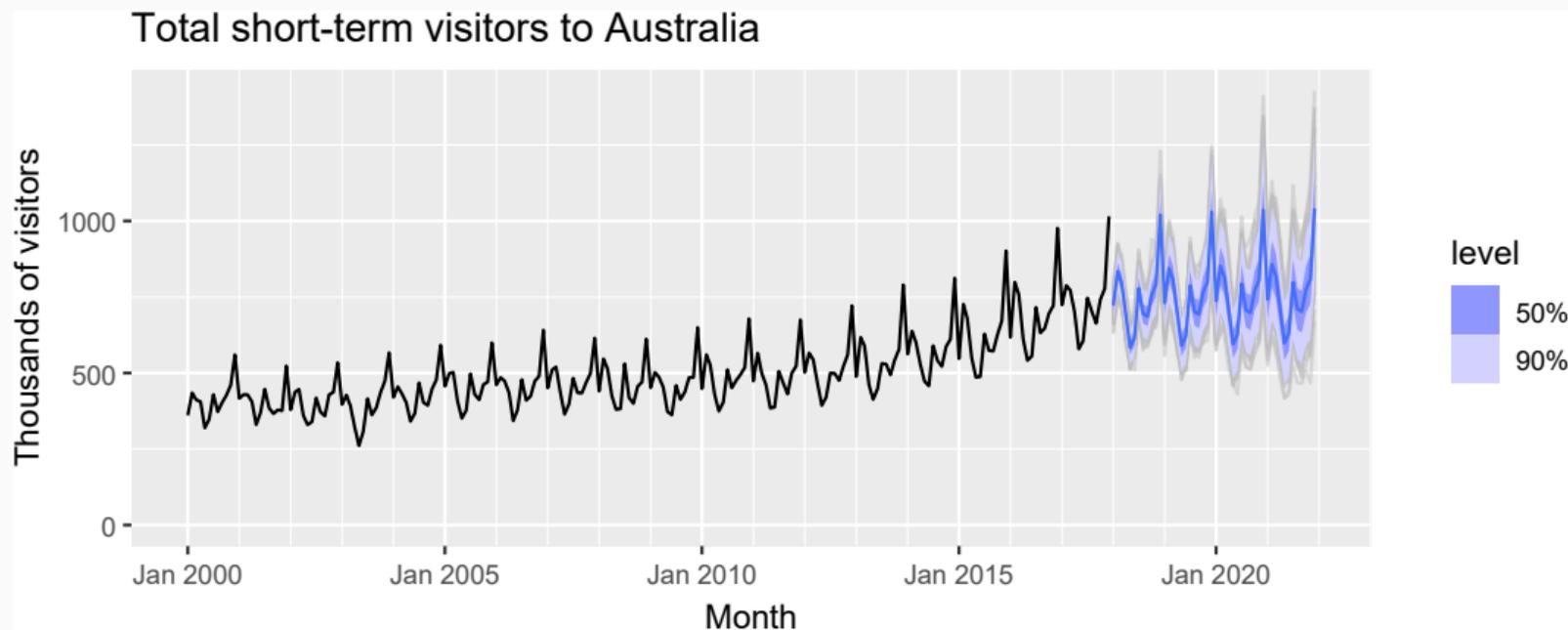
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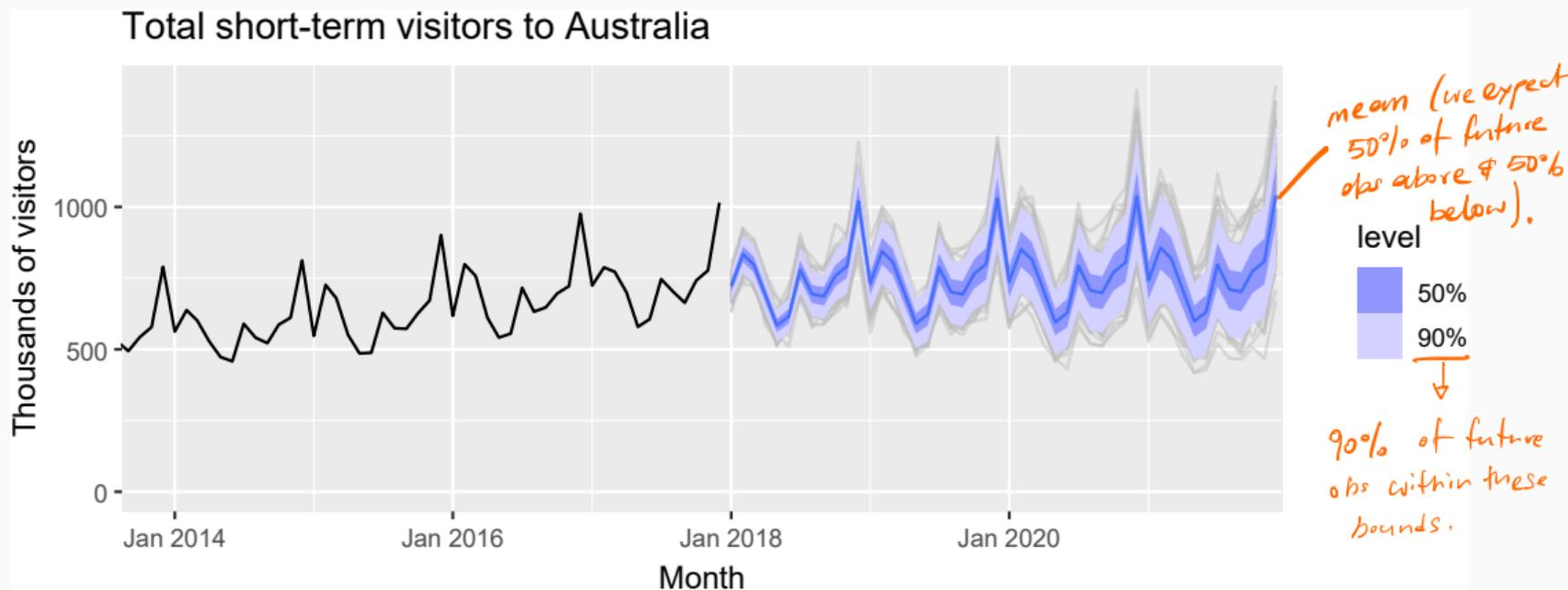
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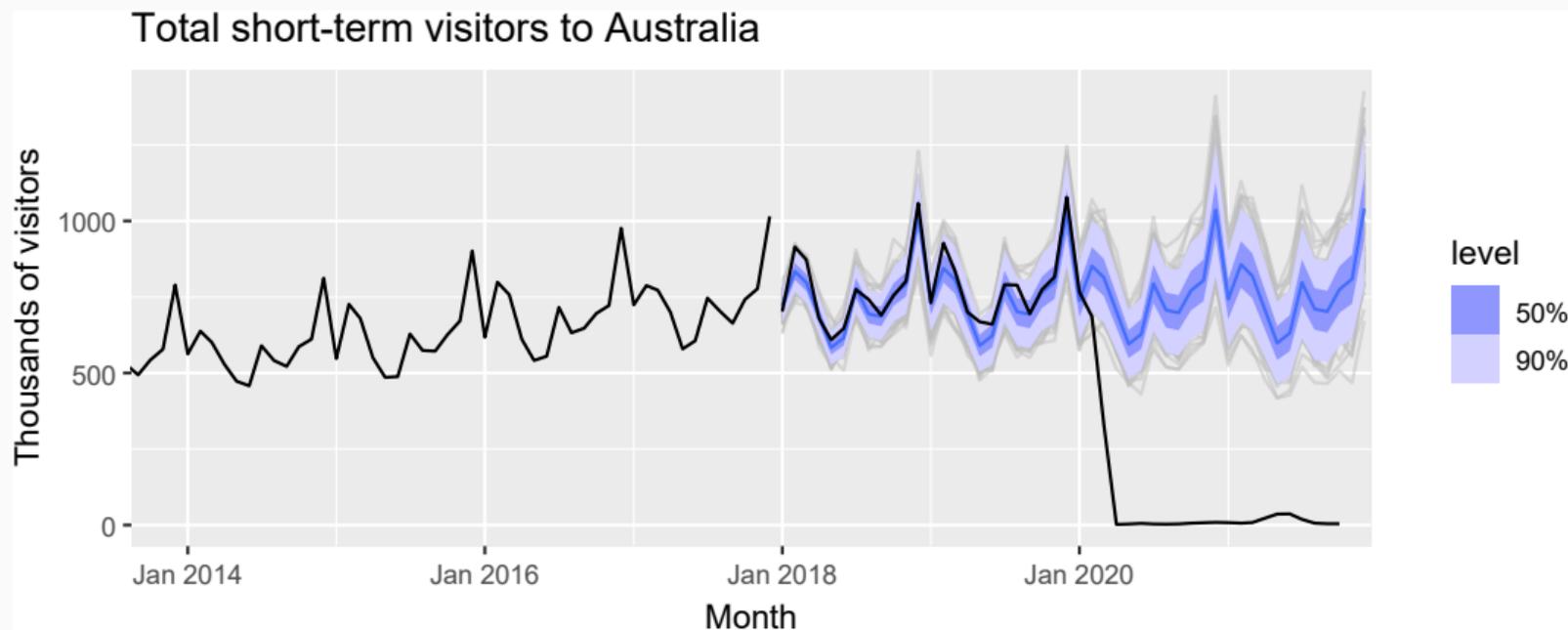


Question - if I was generating 90% intervals for 5 things how many should fall within the bounds?

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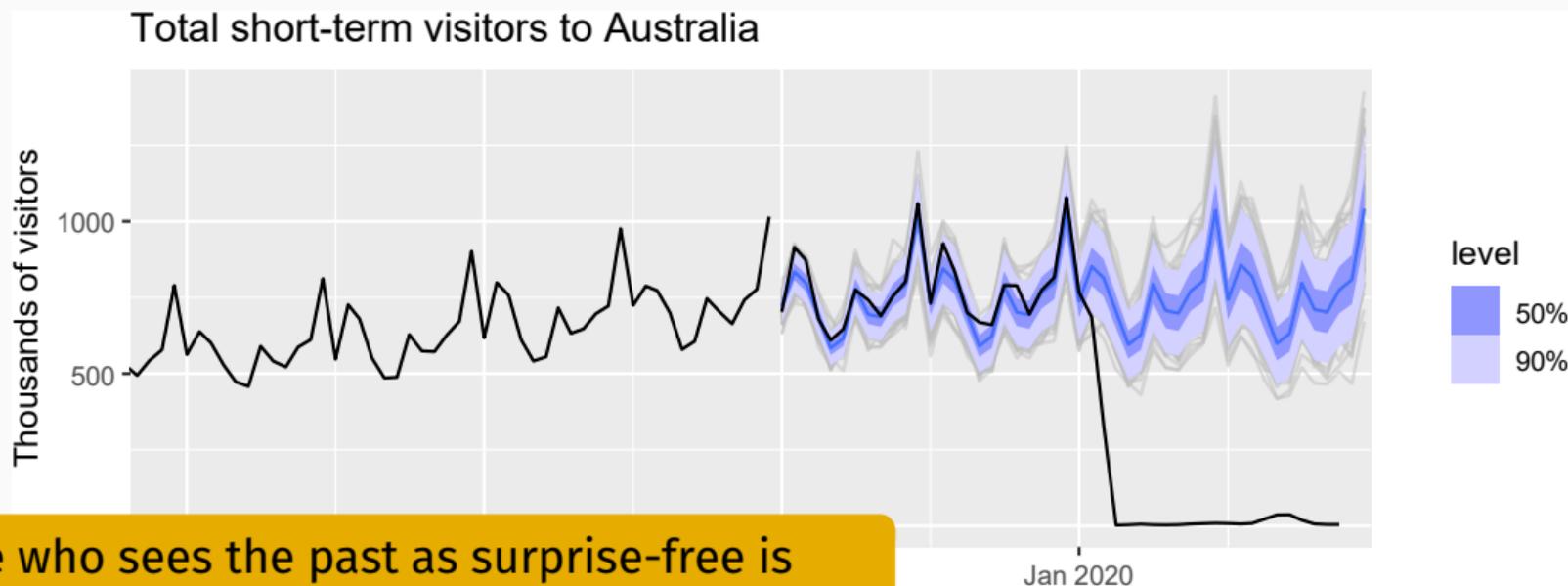
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Random futures

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“He who sees the past as surprise-free is bound to have a future full of surprises.”

(Amos Tversky)

Simulated futures
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What is a forecast

A whole probability distribution, we call this a **forecast distribution**, which we summarise with the mean, we call this a **point forecast** and some other quantiles, we call these **prediction intervals**.

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2.1 tsibble objects

This is how we deal with time series in R (tidyverse tibble - Hadley Wickham)

```
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
```

rows *columns* *frequency*
categories in the key variable(s)

2.1 tsibble objects

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*Always
in a
tsibble* →

	Year	Country	GDP	Imports	Exports	Population
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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

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# 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
```

2.1 tsibble objects

```
global_economy
```

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

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

```
  Year Country      GDP Imports Exports Population
  <dbl> <chr>      <dbl> <dbl> <dbl> <dbl>
1  1960 Afghanistan 537777811.  7.02  4.15  8998351
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
```

2.1 tsibble objects

```
global_economy
```

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

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

A unique observation on each row for the combination of key & index.

```
  Year Country      GDP Imports Exports Population
  <dbl> <chr>      <dbl> <dbl> <dbl> <dbl>
1  1960 Afghanistan 537777811.  7.02  4.15  8998351
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
```

quarterly

combinations of key variables

→ each row is unique across index & keys

tsibble objects

```
tourism
```

```
# A tsibble: 24,320 x 5 [1Q]
# Key:           Region, State, Purpose [304]
  Quarter Region State Purpose Trips
  <chr>      <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
  <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
```

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 155.
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
  <dbl> <chr> <chr> <chr> <dbl>
1 1998 Q1 Adelaide SA Business 155.
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 of travel.

tibble objects

- A `tibble` is a `data.frame` that contains a rectangular set of data.
 - ▶ Each column contains a variable (can be of different type).
 - ▶ Each row contains an observation.

tsibble objects

- A `tsibble` is a `data.frame` that contains a rectangular set of data.
 - ▶ Each column contains a variable (can be of different type).
 - ▶ Each row contains an observation.
- A `tsibble` allows storage and manipulation of multiple time series in R.
 - ▶ **Index**: contains time information about the observation.
 - ▶ **Key variable(s)**: optional unique identifiers for each series.
 - ▶ **Measured variable(s)**: numbers of interest.
- It works with `tidyverse` functions.

Common 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()

very useful for reading data from excel or csv files

Attendance

