MONASH University

MONASH BUSINESS SCHOOL

ETC3550/ETC5550
Applied forecasting

Ch2. Time series graphics

OTexts.org/fpp3/

`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
   1960 Afghanistan  537777811.    7.02    4.13    8996351
   1961 Afghanistan  548888896.    8.10    4.45    9166764
   1962 Afghanistan  546666678.    9.35    4.88    9345868
   1963 Afghanistan  751111191.   16.9     9.17    9533954
   1964 Afghanistan  800000044.   18.1     8.89    9731361
   1965 Afghanistan 1006666638.   21.4    11.3     9938414
   1966 Afghanistan 1399999967.   18.6     8.57   10152331
   1967 Afghanistan 1673333418.   14.2     6.77   10372630
   1968 Afghanistan 1373333367.   15.2     8.90   10604346
   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

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()`

Seasonal or cyclic?

Differences between seasonal and cyclic patterns:

- seasonal pattern constant length; cyclic pattern variable length
- average length of cycle longer than length of seasonal pattern
- magnitude of cycle more variable than magnitude of seasonal pattern

Seasonal or cyclic?

Differences between seasonal and cyclic patterns:

- seasonal pattern constant length; cyclic pattern variable length
- average length of cycle longer than length of seasonal pattern
- magnitude of cycle more variable than magnitude of seasonal pattern

The timing of peaks and troughs is predictable with seasonal data, but unpredictable in the long term with cyclic data.

Trend and seasonality in ACF plots

- When data have a trend, the autocorrelations for small lags tend to be large and positive.
- When data are seasonal, the autocorrelations will be larger at the seasonal lags (i.e., at multiples of the seasonal frequency)
- When data are trended and seasonal, you see a combination of these effects.

Which is which?