Rotman

INTRO TO R – TIME SERIES & FINANCE PACKAGES

R Workshop – 4 (Part 2)

April 2, 2022 Prepared by Jay Cao / TDMDAL

Website: https://tdmdal.github.io/r-tutorial-202122-winter/

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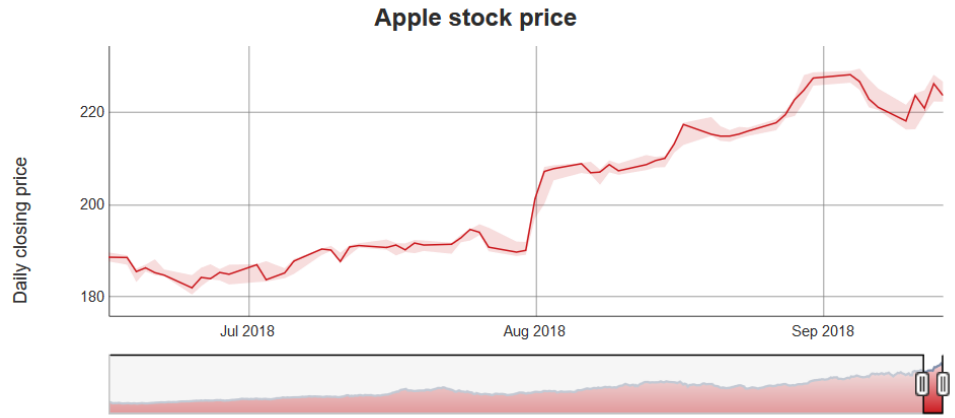
What's Time Series (TS)

- A series of values obtained at successive times
  - A series of numerical values
  - With associated timestamps (or start, end, and frequency if equi-interval)

- Typical operations on a time series
  - lead, lag, difference, rolling window aggregation, etc.
  - time-aware subsetting

- Typical statistics
  - moving average, returns, etc.
  - trend, seasonality, stationarity, etc.



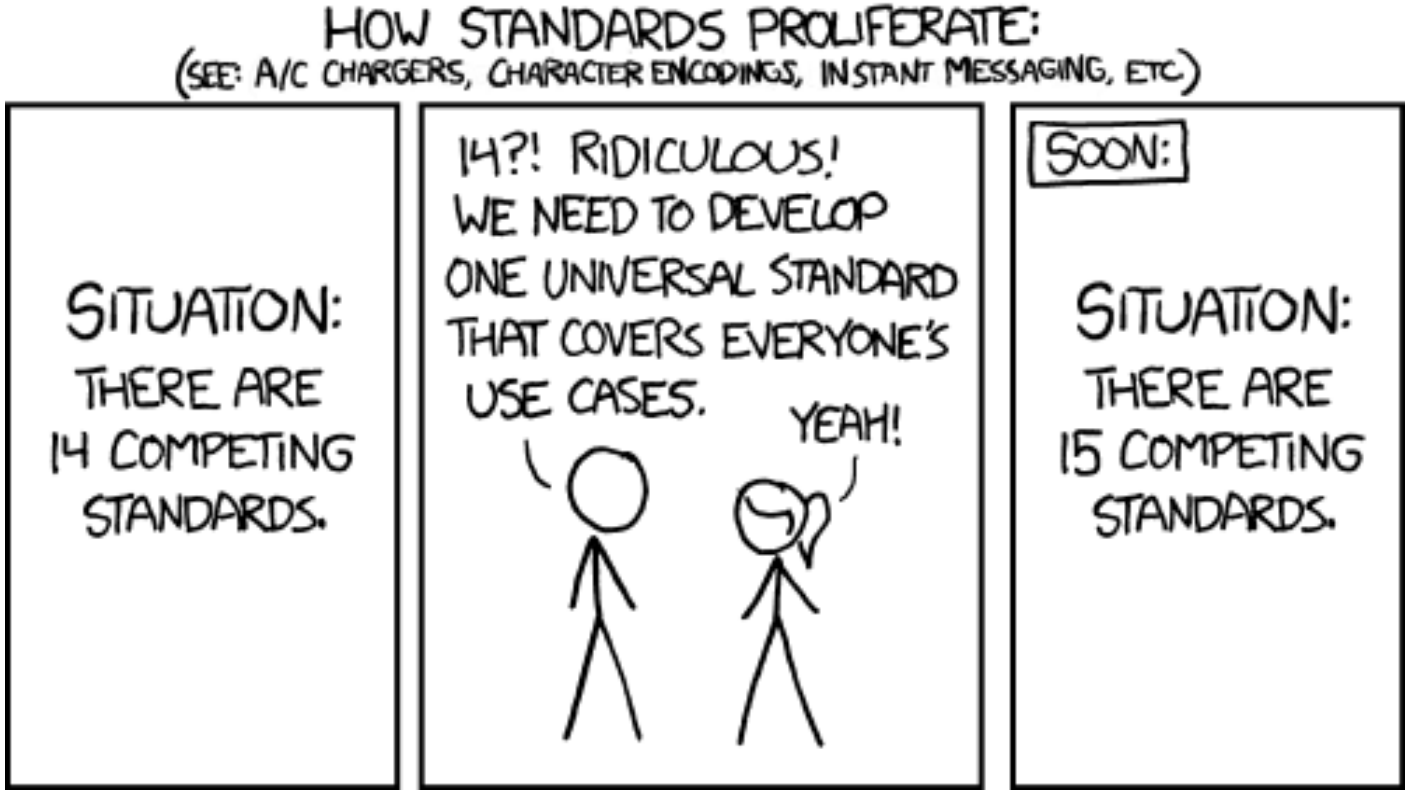
How to Store Time Series (TS) in R

- From what we have seen so far
  - Vectors (with names as timestamps)
  - Matrices (with row names as timestamps)
  - **Dataframes/tibbles** with a timestamp column

- What we really need
  - Store time series efficiently
  - More importantly, be able to manipulate time series efficiently
    - i.e. need associated functions/packages that can efficiently operate on stored time series (lead, lag, smooth, moving average, etc.)

Current Status of R TS Data Structures

- A vast number of Time Series Data Structures
- Each has associated packages
  - for TS manipulation
  - for TS analysis/modeling



https://www.tsbox.help/; https://xkcd.com/927/

Oldies but Goodies

- **`ts`** class: a class for equi-spaced time series
  - what's a "class": a data structure with associated operations (methods)
- `zoo` class
  - can handle regular- and irregular-spaced time series
  - can use arbitrary classes for the timestamps
- **`xts`** class
  - built on `zoo` with more functions for data processing
  - uniform handling of R's time-based data classes (e.g.`zoo`, `timeSeries`, etc.)
- Many more
  - `timeSeries` class in `timeSeries` package
  - `tis` class from `tis` package

https://cran.r-project.org/web/views/TimeSeries.html

New Kids in Town – Tidy Data Convert

- `tsibble`, a new time series class (`tbl_ts`) built on `tibble`
  - from tsibble package: time-based dataframe/tibble
  - Part of tidyverts ecosystem (not tidyverse) for time series

- `tibble`, but make it "time-aware" whenever needed
  - tidyquant
    - e.g., convert `tibble` to `xts` when interfacing with other packages that operates on `xts`
  - modeltime and its ecosystem
    - a consistent way to do time series analysis using many other time series packages
    - same team behind tidyquant
  - `prophet`
    - time series forecast (from Facebook) based on addictive model
    - work directly with `tibble` from tidyverse

Which One Should You Use

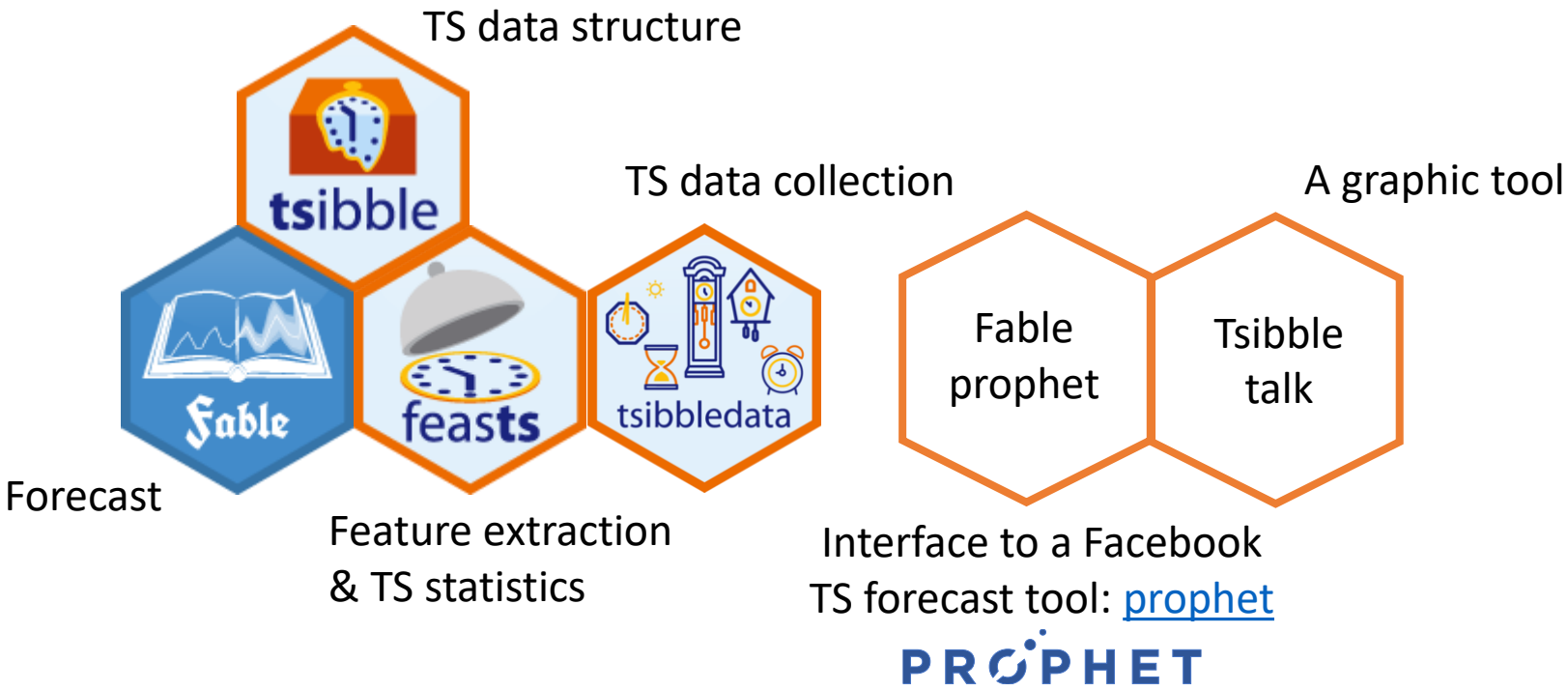
- Try “New Kids” and their eco-system first
  - They mostly follow the tidy data & tidyverse framework for data wrangling, something you are familiar with from tabular data
  - Not our focus today, but we will mention a few packages

- If “New Kids” can’t do the job, fall back to “Oldies but Goodies”
  - Many old but potentially useful TS packages still uses traditional TS DS
  - We will focus on `ts` and `xts` and a few related TS and finance packages today

- Use both (“hybrid-mode”)
  - convert between time series data structures (e.g. using tsbox, etc.)

New Kids TS Ecosystem (1)

- `tsibble`, a new time series class (`tbl_ts`) built on `tibble`
  - from tsibble package: time-based dataframe/tibble
  - Part of tidyverts ecosystem (not tidyverse) for time series



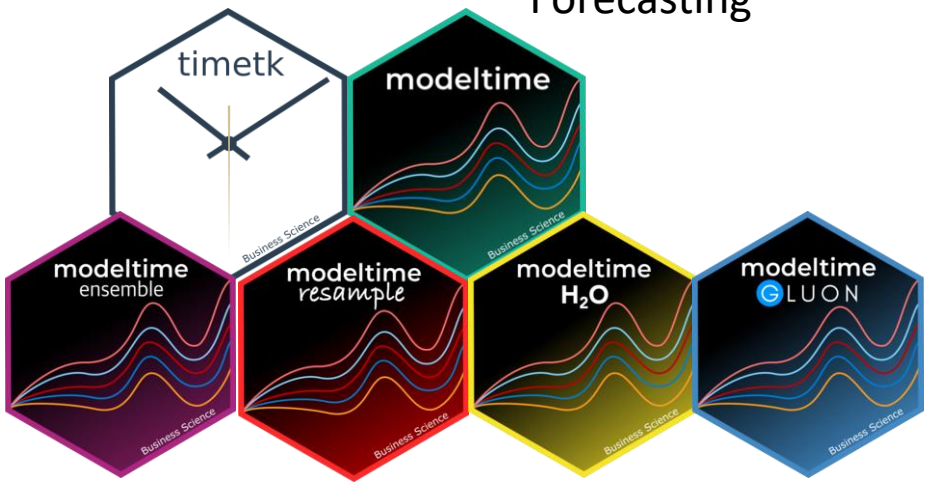
New Kids TS Ecosystem (2)

- modeltime and its ecosystem
  - a consistent way to do time series analysis
  - build on many other time series packages
    - i.e., a super "wrapper" of other R packages
  - very new so…

- tidyquant
  - integrates resources for collecting and analyzing financial data (`xts`, `quantmod`, `TTR`(`Technical Trading Rule`) and `PerformanceAnalytics`)
    - i.e., a super "wrapper" too
  - work with `tibble` from `tidyverse`

Time series
data wrangling

Forecasting



Modelling
related tasks

Interface to big data
And deep learning tool

New Kids TS Ecosystem (3)

- `prophet`
  - a specific time series forecast procedure based on addictive model
    - robust to outliers, missing data, and dramatic changes in your time series
    - tunable
  - work directly with `tibble` from tidyverse
  - built by Facebook (Facebook Open Source)

`ts` class

- A class for equi-spaced time series supported by base R

- Data is stored as
  - a vector (univariate) or matrix (multi-variate) with attributes…
  - “class”: ts
  - “tsp” (time series parameters): a numerical vector recording (start, end, freq)

- Many functions/packages work well with ts object
  - e.g., `forecast` package

`ts` class – how are data stored / 1

```
> ts_obj <- ts(1:10, frequency = 4, start = c(2017, 2)) # 2nd Quarter of 2017
> ts_obj
     Qtr1 Qtr2 Qtr3 Qtr4
2017         1    2    3
2018    4    5    6    7
2019    8    9   10
>
> typeof(ts_obj)
[1] "integer"
>
> class(ts_obj)
[1] "ts"
```

`ts` class – how are data stored / 2

```
> attributes(ts_obj)
$tsp
[1] 2017.25 2019.50    4.00

$class
[1] "ts"
```

`ts` class – associated time-aware operations

```
> cycle(ts_obj)
     Qtr1 Qtr2 Qtr3 Qtr4
2017         2    3    4
2018    1    2    3    4
2019    1    2    3
>
> diff(ts_obj, 4)
     Qtr1 Qtr2 Qtr3 Qtr4
2018         4    4    4
2019    4    4    4
>
# see notebook for more, and the "forecast" packages intro
```

```
> ts_obj
     Qtr1 Qtr2 Qtr3 Qtr4
2017         1    2    3
2018    4    5    6    7
2019    8    9   10
```

xts class

- xts extends zoo
  - zoo can handle regular- and irregular-spaced time series; so does xts
- xts can use arbitrary classes for timestamps
- Compatible with zoo and other time-series classes in other packages
- Many functions/packages work well with xts object
  - e.g., forecast, quantmod, and PerformanceAnalytics

`xts` class – how are data stored / 1

```
> x <- matrix(1:6, ncol = 2)
> print(x)
     [,1] [,2]
[1,]    1    4
[2,]    2    5
[3,]    3    6
>
> idx <- as.Date(c("2019-01-01", "2019-01-02", "2019-01-05"))
> print(idx)
[1] "2019-01-01" "2019-01-02" "2019-01-05"
```

`xts` class – how are data stored / 2

```
> xts_obj <- xts(x, order.by = idx)
> xts_obj
           [,1] [,2]
2019-01-01    1    4
2019-01-02    2    5
2019-01-05    3    6

> typeof(xts_obj)
[1] "integer“

> class(xts_obj)
[1] "xts" "zoo"
```

`xts` class – how are data stored / 3

```
> str(attributes(xts_obj))
List of 3
 $ dim  : int [1:2] 3 2
 $ index: num [1:3] 1.55e+09 1.55e+09 1.55e+09
  ..- attr(*, "tzone")= chr "UTC"
  ..- attr(*, "tclass")= chr "Date"
 $ class: chr [1:2] "xts" "zoo"
```

`xts` class – associated time-aware operations

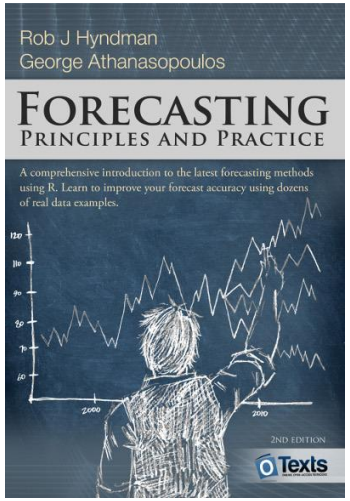
```
> # use quantmod package to get data from yahoo finance
> library(quantmod)
> msft <- getSymbols("MSFT",
                     from = "2018-12-31",
                     to = "2019-12-31",
                     auto.assign = FALSE)
>
> # msft_xts is an xts object
> class(msft_xts)
[1] "xts" "zoo"
```

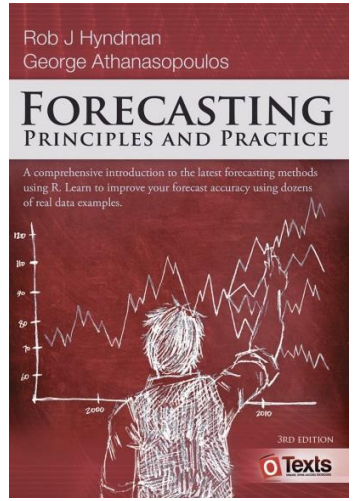
`xts` class – associated time-aware operations

```
> # get data for all Monday in 2019 (time-aware subsetting)
> msft[.indexyear(msft) == (2019 - 1900) & .indexwday(msft) == 1]

           MSFT.Open MSFT.High MSFT.Low MSFT.Close MSFT.Volume MSFT.Adjusted
2019-01-07    101.64    103.27   100.98     102.06    35656100        102.06
2019-01-14    101.90    102.87   101.26     102.05    28437100        102.05
2019-01-28    106.26    106.48   104.66     105.08    29476700        105.08
2019-02-04    102.87    105.80   102.77     105.74    31315100        105.74
…

# see notebook for more, and the "PerformanceAnalytics" package intro
```

Resources

- a Little book of R for Time Series
  - uses traditional time series data structures & related packages
- Forecasting: Principles and Practice (2nd ed)
  - uses forecast packages
- Forecasting: Principles and Practice (3rd ed.)
  - uses tsibble and fable packages
- Financial Engineering Analytics: A Practice Manual Using R





Too Many TS Data Structures!

- tsbox
  - provides conversion between many time series data structures
  - an attempt to unite time series data structure in R