Stat4DS / Homework 03 - Notes

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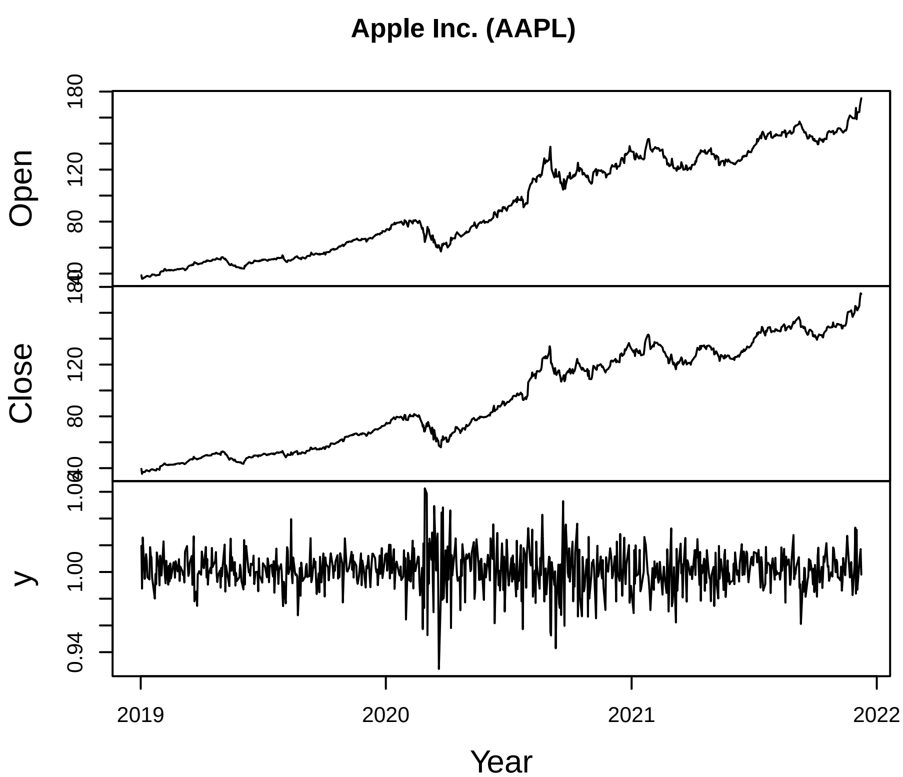
Appendix (A) - Financial data & `R`

As you can imagine, we can pull financial data into `R` in many different ways. For a general overview of the available tools, there are always the two `Task View` on Empirical Finance and Web Technologies and Services.
For specific suggestions I tried in the past, I would say:

- the `get.hist.quote()` function in the tseries package, or
- the `getSymbols()` function in the quantmod package – more info – or
- the `yahooImport()` function in the fImport package.

For general time series handling, I would suggest to explore a little bit the zoo package.
To get the stocks info you need, you have to know (in advance) the **symbol** associated to that stock (e.g. `Apple Inc.`, `IBM`, etc.) in a particular market (e.g. `NYSE`, `NASDAQ`, etc.). You can obtain this from portals like Yahoo! Finance. So, for example:

```r
suppressMessages( require(tseries, quietly = TRUE) )  # Load the package
options("getSymbols.warning4.0" = FALSE)              # Stop info-messages to show up
?get.hist.quote

# Get Apple Inc. from NYSE
aapl <- get.hist.quote(instrument="AAPL", start="2019-01-01", end="2021-12-10",
                       quote= c("Open","Close"), provider="yahoo", drop=TRUE)
# Take a look
class(aapl); names(aapl); head(aapl)
# Build some relative performance measure like <Close/Open> and plot
aapl$y <- aapl$Close/aapl$Open
plot(aapl, main = "Apple Inc. (AAPL)", xlab = "Year")
```



```
## time series starts 2019-01-02
## time series ends   2021-12-09
## [1] "zoo"
## [1] "Open"  "Close"
##               Open   Close
## 2019-01-02 38.7225 39.4800
## 2019-01-03 35.9950 35.5475
## 2019-01-04 36.1325 37.0650
## 2019-01-07 37.1750 36.9825
## 2019-01-08 37.3900 37.6875
## 2019-01-09 37.8225 38.3275
```

Appendix (B) - Returns & Price relatives of a stock.

Let's start from the basics: what is a **return**? The goal of investing is, of course, to make a profit. The revenue from investing, or the loss in the case of a negative revenue, depends upon both the change in prices and the amounts of the assets/stocks being held. Investors are interested in revenues that are high relative to the size of the initial investments. Returns measure this, because returns on an asset, e.g., a stock, a bond, a portfolio of stocks and bonds, are changes in price expressed as a fraction of the initial price.

There are many variants of the definition of returns, according to whether we allow some extra parameters to be considered in their calculation, like dividends or costs of transactions. Here we just look at the most simple definition of returns where only the price is considered.

1. Simple Return

Let P_t be the price of an asset at time t. Given a time scale τ, the τ–period simple return at time t, $R_t(\tau)$ is the rate of change in the price obtained from holding the asset from time $t-\tau$ to time t:

$$R_t(\tau) = \frac{P_t - P_{t-\tau}}{P_{t-\tau}} = \frac{P_t}{P_{t-\tau}} - 1.$$

The τ–period *simple gross return* at time t is $R_t(\tau)+1$. If $\tau = 1$ we have a 1–period simple return (respectively, a *simple gross return*), and denote it R_t (resp., $R_t + 1$). Notice that if $\{P_t\}_t$ represents the series of *closing price* of a stock, the 1–period simple gross return gives essentially the price relatives used in `Borodin et al.(2004)` and mentioned in the very first section of this appendix.

There is a practical reason for defining returns backwards, and it is that more often than not we want to know the return obtained today for an asset bought some time in the past. Note that return values range from -1 to ∞; so, in principle, you can not lose more than what you have invested, but you can have unlimited profits.

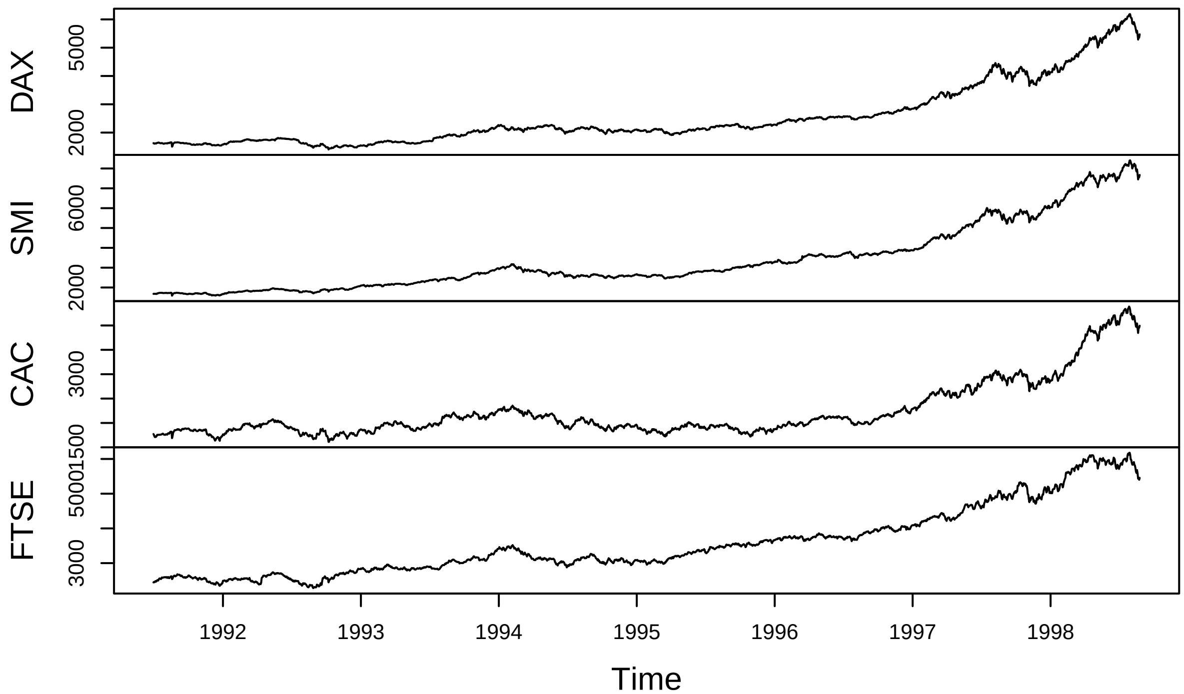
Notice also that the τ–period *simple gross return* at time t equals the product of τ one–period simple gross returns at times $t-\tau+1$ to t; that is,

$$R_t(\tau) + 1 = \frac{P_t}{P_{t-\tau}} = \frac{P_t}{P_{t-1}} \cdot \frac{P_{t-1}}{P_{t-2}} \cdots \frac{P_{t-\tau+1}}{P_{t-\tau}} = (R_t+1)\cdot(R_{t-1}+1)\cdots(R_{t-\tau+1}+1).$$

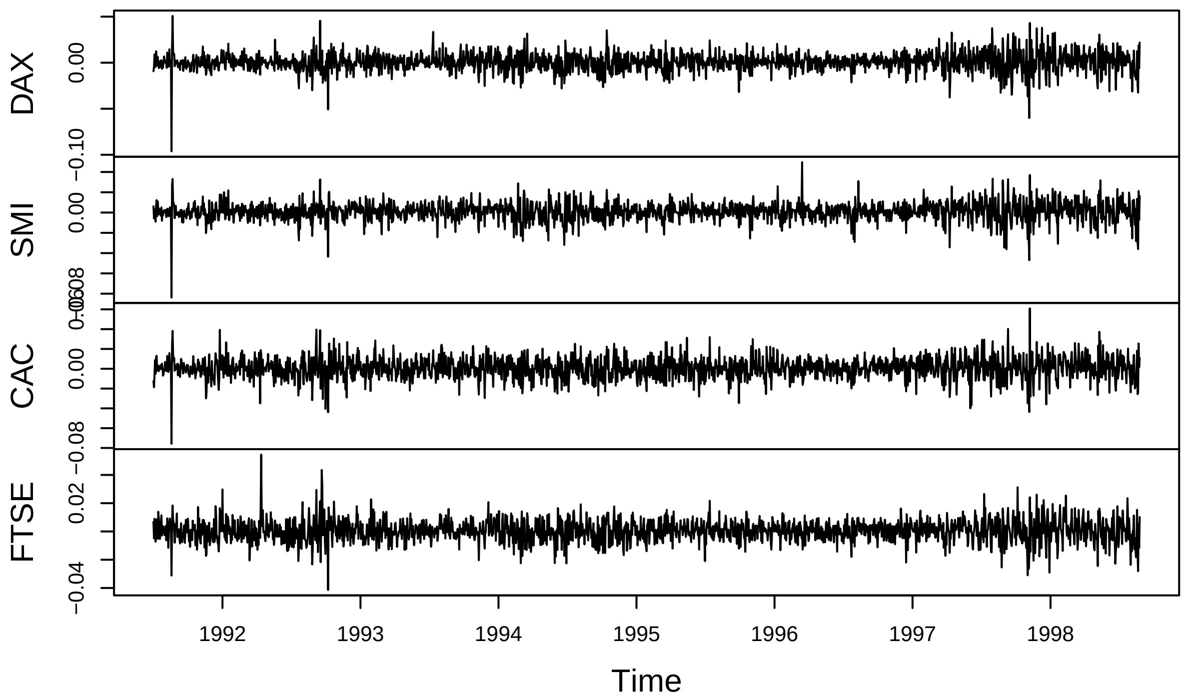
For this reason these *multiperiod* returns are known also as **compounded returns**. Returns are independent from the magnitude of the price, but they depend on the time period τ. For this reason one must always add to the numerical information the time span considered, if daily, weekly, monthly and so on. An example:

```r
# Daily closing prices of major European stock indices
data(EuStockMarkets)
?EuStockMarkets

# mode(EuStockMarkets)
# class(EuStockMarkets)

# Daily closing prices
plot(EuStockMarkets, main = "Daily closing prices of major European stock indices")

# Log-returns
logR = diff(log(EuStockMarkets))
plot(logR, main = "Log-returns of daily closing prices")
```

Daily closing prices of major European stock indices



Log−returns of daily closing prices



Finally, one of the most important features of financial assets, and possibly the most relevant for professional investors, is the asset **volatility**: in practice **volatility refers to a degree of fluctuation of the asset returns**.
However it is **not** something that can be directly observed. One can observe the return of a stock every day, by comparing the change of price from the previous to the current day, but one can not observe how the return fluctuates in a specific day. We need to make further observations of returns (and of the price) at different times on the same day to make an estimate of the way returns vary daily (so that we can talk about daily volatility), but these might not be sufficient to know precisely how returns will fluctuate. Therefore volatility can not be observed but only estimated from some model of the asset returns.
A general perspective, useful as a framework for volatility models, is to consider volatility as the **conditional standard deviation** of the asset returns. But better if we stop here!

2. Price relatives

Now, consider a portfolio containing p stocks quoted on some market, NYSE say. Each trading day $t \in \{1, \ldots, T\}$ we observe the opening price $o_{j,t}$ and the closing[1] price $c_{j,t}$ of each stock $j \in \{1, \ldots, p\}$.

To evaluate the performance of a stock, it is more convenient to work with some sort of **relative price** that, broadly speaking, should represent the *factor* by which the wealth/money invested in the j^{th} stock increases during the t^{th} period. In the literature we see different options. Here's some examples:

1. In Borodin et al.(2004), the Authors consider (possibly on a log-scale)

$$x_{t,j} = \frac{c_{t,j}}{c_{t-1,j}},$$

so that an investment of d€ in the j^{th} stock just **before** the t^{th} day yields $(d \cdot x_{j,t})$ dollars. But notice that there is nothing special about "daily closing prices" and the problem can be defined with respect to **any** (sub)sequence of the (intra-day) sequence of all price offers which appear in the stock market. In fact…

2. …in Cover (1991), they consider the ratio between opening and closing prices

$$x_{t,j} = \frac{c_{t,j}}{o_{t,j}},$$

3. …but *today* closing price does not necessarily match *tomorrow* opening price. For this reason in Helmbold et al.(1998), they use

$$x_{t,j} = \frac{o_{t+1,j}}{o_{t,j}},$$

so that moving from one morning to the next, the value of a stock increases or falls to $x_{t,j}$ times its previous value.

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[1] These are usually **adjusted closing prices**. The price that is quoted at the end of the trading day is the price of the last lot of stock that was traded for the day. This is called a stock's **closing price** and can be used by investors to compare a stock's performance over a period of time (usually from one trading day to another). During the course of a trading day, many things can happen to affect a stock's price: good and bad news relating to the operations of a company, any sort of *distribution* that is made to investors such as *cash dividends*, *stock dividends* and *stock splits*. When any these things happen, the closing prince has to be appropriately **adjusted**. Fortunately, historical price services provided by financial sites such as Yahoo! Finance eliminate the confusion by directly calculating **adjusted closing prices** for investors.