Financial Trading in R

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The mechanics of trading usually come in one of two forms:

- Trend trading (also divergence or momentum), which is a bet that a quantity, such as a price, will keep moving in its current direction.
- Reversion trading (also convergence, cycle, or oscillation), which is a bet that a quantity, such as a price, will reverse.

How to prevent overfitting

When developing a trading system, a major pitfall that can creep into system development is the desire to find a strategy that worked phenomenally in the past. This is known as overfitting. Research by leading authors in the quantitative field has shown that not only is an overfitted system unlikely to generate profits in the future, but also that its performance can lead to losses. Some steps can be done to prevent overfitting:

- Examining the robustness of system performance.
- Reducing the number of parameters in the trading system.
- Conducting tests to determine statistical significance of a strategy.

Getting financial data

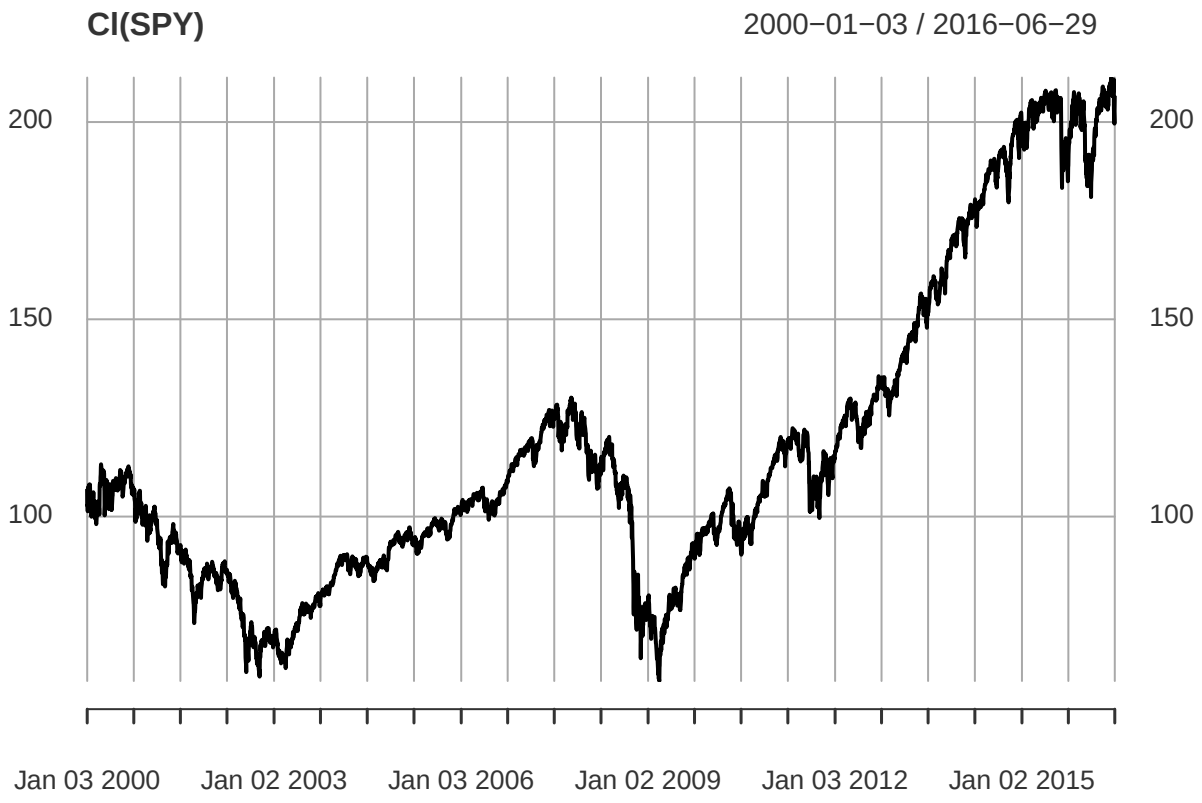
2 Types important ETF: LQD and SPY.

```
# Get SPY from yahoo
getSymbols("SPY",
           from = "2000-01-01",
           to = "2016-06-30",
           src =  "yahoo",
           adjust =  TRUE)
```

```
## 'getSymbols' currently uses auto.assign=TRUE by default, but will
## use auto.assign=FALSE in 0.5-0. You will still be able to use
## 'loadSymbols' to automatically load data. getOption("getSymbols.env")
## and getOption("getSymbols.auto.assign") will still be checked for
## alternate defaults.
##
## This message is shown once per session and may be disabled by setting
## options("getSymbols.warning4.0"=FALSE). See ?getSymbols for details.
```

```
## Warning in read.table(file = file, header = header, sep = sep,
## quote = quote, : incomplete final line found by readTableHeader
## on 'https://query2.finance.yahoo.com/v7/finance/download/SPY?
## period1=-2208988800&period2=1599436800&interval=1d&events=split&crumb=oeQ7r3fqEpH'

## Warning in read.table(file = file, header = header, sep = sep,
## quote = quote, : incomplete final line found by readTableHeader
## on 'https://query2.finance.yahoo.com/v7/finance/download/SPY?
## period1=-2208988800&period2=1599436800&interval=1d&events=split&crumb=oeQ7r3fqEpH'

## [1] "SPY"
```

```
# Plot the closing price of SPY
plot(Cl(SPY))
```



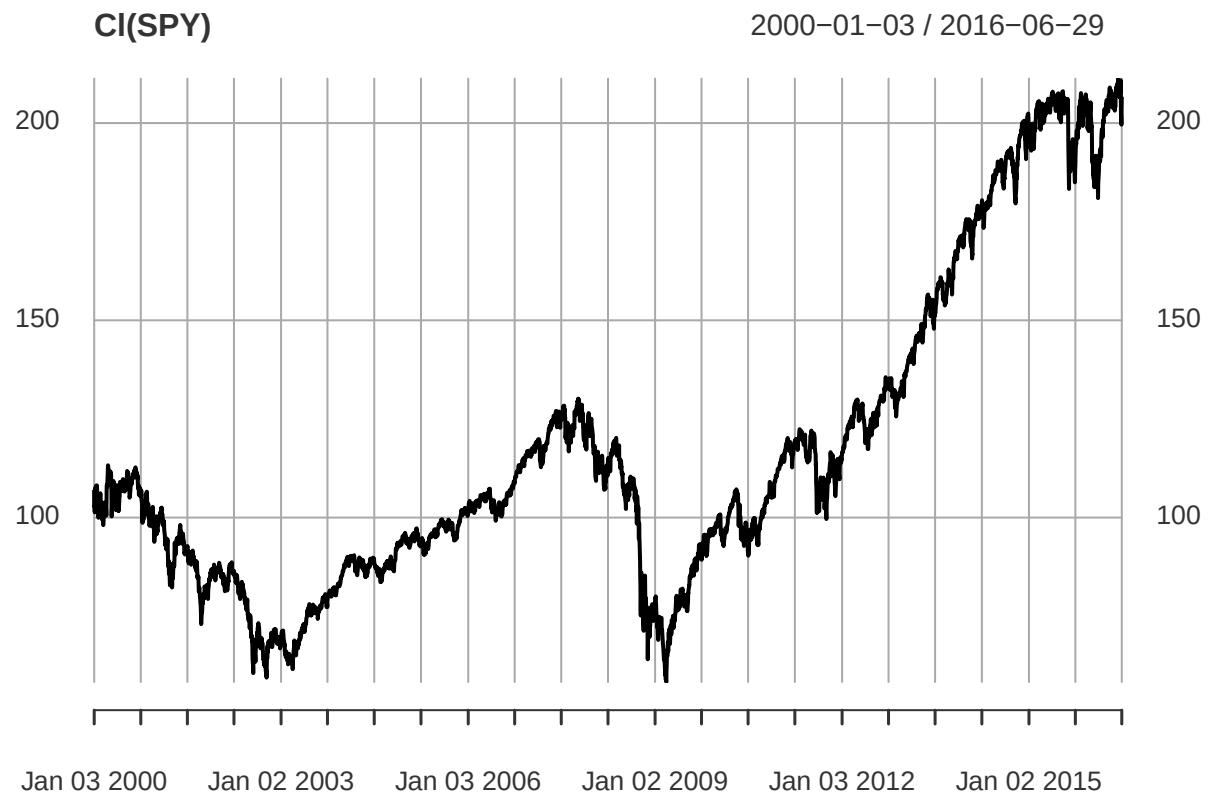
Adding a moving average to financial data

One of the most popular indicators to add to a trading strategy is the 200-day simple moving average (SMA). This is a technical indicator of the average closing price of a stock over the past 200 days. Other moving averages can be of varying length, such as 50-day, 100-day, etc.

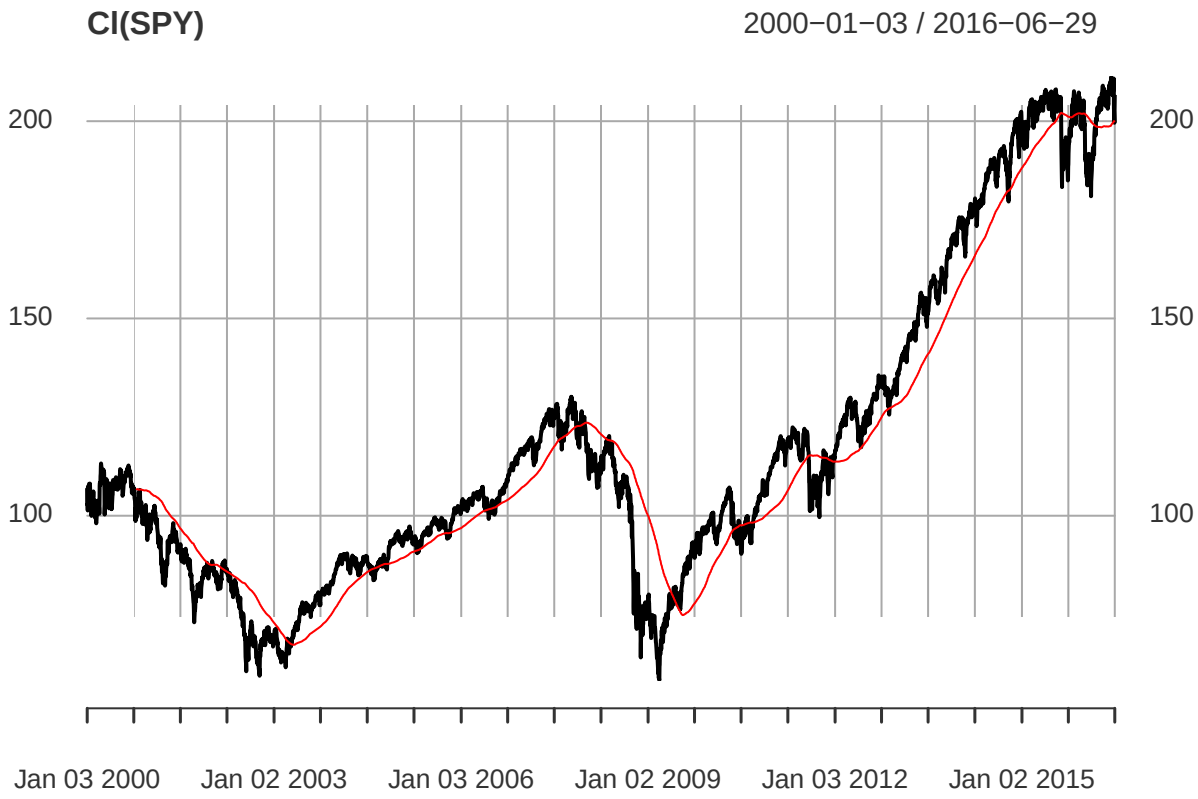
Whenever the price is above the 200-day moving average, a whole assortment of good things usually happen, such as the asset appreciating in price, low volatility, and so on. Getting a long-lasting visual might shed light on why this indicator is mentioned so often.

The TTR package has a function that calculates moving averages, SMA(), which takes in a price series x and computes the arithmetic mean over n days. A call of SMA() with a lookback window of 50 days could look like the following: SMA(Cl(GDX), n = 50)

```
# Plot the closing prices of SPY
plot(Cl(SPY))
```




```
# Add a 200-day SMA using lines()
lines(SMA(Cl(SPY), n = 200), col = "red")
```



Initializing setting quanstrat

Define boilerplate code

Let's get started with creating our first strategy in quantstrat. In this exercise, you will need to fill in three dates:

An initialization date for your backtest. The start of your data. The end of your data. The initialization date must always come before the start of the data, otherwise there will be serious errors in the output of your backtest.

You should also specify what time zone and currency you will be working with with the functions Sys.setenv() and currency(), respectively. An example is here:

Sys.setenv(TZ = "Europe/London") currency("EUR")

```
# Load the quantstrat package
library(quantstrat)
```

```
## Loading required package: blotter
```

```
## Loading required package: FinancialInstrument
```

```
## Loading required package: PerformanceAnalytics
```

```
##
## Attaching package: 'PerformanceAnalytics'

## The following object is masked from 'package:graphics':
##
##     legend

## Loading required package: foreach
```

```
# Create initdate, from, and to strings
initdate <- "1999-01-01"
from <- "2003-01-01"
to <- "2015-12-31"

# Set the timezone to UTC
Sys.setenv(TZ = "UTC")

# Set the currency to USD
currency("USD")
```

```
## [1] "USD"
```

```
# Load the quantmod package
library(quantmod)

# Retrieve SPY from yahoo
getSymbols("SPY", src = "yahoo", from = from, to = to, adjust = TRUE)
```

```
## Warning in read.table(file = file, header = header, sep = sep,
## quote = quote, : incomplete final line found by readTableHeader
## on 'https://query2.finance.yahoo.com/v7/finance/download/SPY?
## period1=-2208988800&period2=1599436800&interval=1d&events=split&crumb=oeQ7r3fqEpH'

## Warning in read.table(file = file, header = header, sep = sep,
## quote = quote, : incomplete final line found by readTableHeader
## on 'https://query2.finance.yahoo.com/v7/finance/download/SPY?
## period1=-2208988800&period2=1599436800&interval=1d&events=split&crumb=oeQ7r3fqEpH'

## [1] "SPY"
```

```
# Use stock() to initialize SPY and set currency to USD
stock("SPY", currency = "USD")
```

```
## [1] "SPY"
```

Understanding initialization settings - III

Let's continue the setup of your strategy. First, you will set a trade size of 100,000 USD in an object called tradesize which determines the amount you wager on each trade. Second, you will set your initial equity to 100,000 USD in an object called initeq.

Quantstrat requires three different objects to work: an account, a portfolio, and a strategy. An account is comprised of portfolios, and a portfolio is comprised of strategies. For your first strategy, there will only be one account, one portfolio, and one strategy. Let's call them "firststrat" for "first strategy".

Finally, before proceeding, you must remove any existing strategies using the strategy removal command rm.strat() which takes in a string of the name of a strategy.

```
# Define your trade size and initial equity
tradesize <- 100000
initeq <- 100000

# Define the names of your strategy, portfolio and account
strategy.st <- "firststrat"
portfolio.st <- "firststrat"
account.st <- "firststrat"

# Remove the existing strategy if it exists
rm.strat(strategy.st)
```

Understanding initialization settings - IV

Now that everything has been named, you must initialize the portfolio, the account, the orders, and the strategy to produce results.

The portfolio initialization initPortf() needs a portfolio string name, a vector for symbols used in the backtest, an initialization date initDate, and a currency. The account initialization call initAcct() is identical to the portfolio initialization call except it takes an account string name instead of a new portfolio name, an existing portfolios name, and an initial equity initEq. The orders initialization initOrders() needs a portfolio string portfolio and an initialization date initDate. The strategy initialization strategy() needs a name of this new strategy and must have store set to TRUE.

```
# Initialize the portfolio
initPortf(portfolio.st, symbols = "SPY", initDate = initdate, currency = "USD")
```

```
## [1] "firststrat"
```

```
# Initialize the account
initAcct(account.st, portfolios = portfolio.st, initDate = initdate, currency = "USD", initEq = initeq)
```

```
## [1] "firststrat"
```

```
# Initialize the orders
initOrders(portfolio.st, initDate = initdate)

# Store the strategy
strategy(strategy.st, store = TRUE)

# Everything up and running now.
```

Introduction to indicators

The SMA and RSI functions

An indicator is a transformation of market data that is used to generate signals or filter noise. Indicators form the backbone of many trading systems, and the system you will build in this course uses several of them.

The simple moving average (SMA) and relative strength index (RSI) are two classic indicators. As you saw in Chapter 1, the SMA is an arithmetic moving average of past prices, while the RSI is a bounded oscillating indicator that ranges from 0 to 100. Their respective functions SMA() and RSI() both take in a series of prices, denoted by x and price respectively, and a lookback period n, for example:

SMA(x = Cl(GDX), n = 50) RSI(price = Cl(GDX), n = 50)

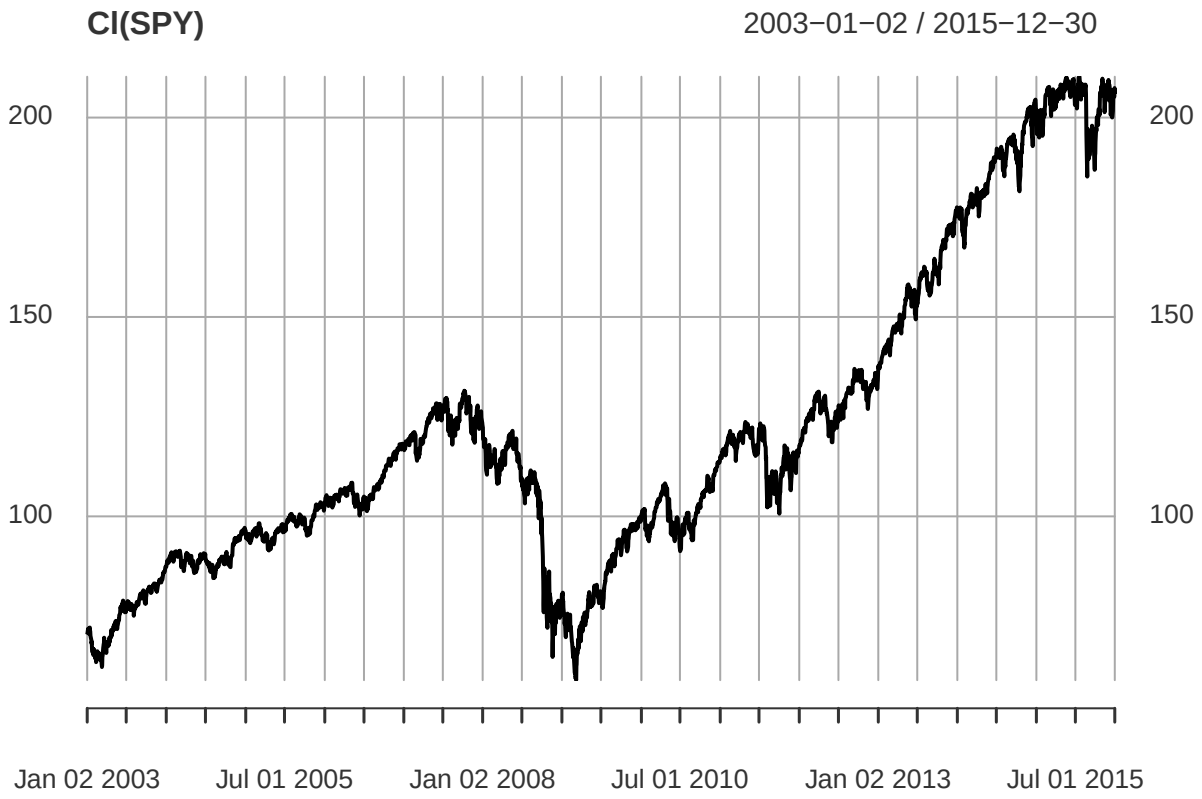
```
# Create a 200-day SMA
spy_sma <- SMA(x = Cl(SPY), n = 200)

# Create an RSI with a 3-day lookback period
spy_rsi <- RSI(price = Cl(SPY), n = 3)
```

Visualize an indicator and guess its purpose - I

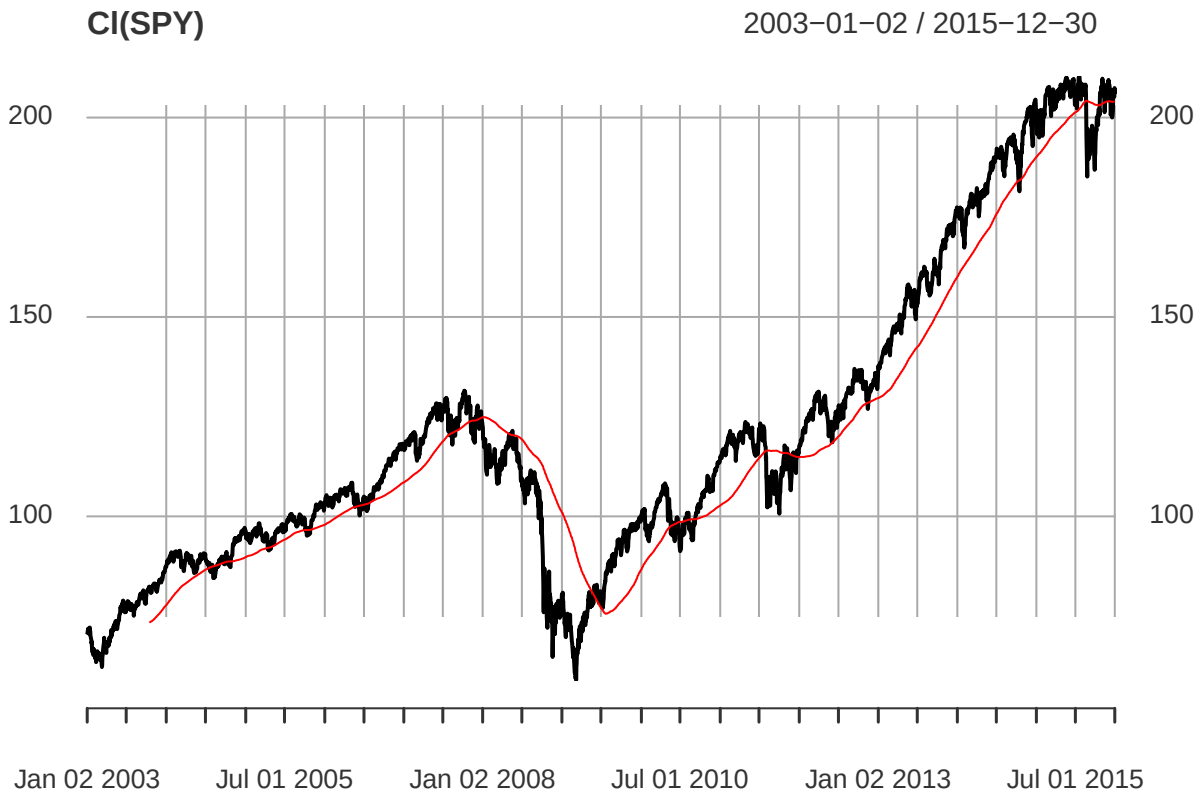
Now you will visualize these indicators to understand why you might want to use the indicator and what it may represent. Recall that a trend indicator attempts to predict whether a price will continue in its current direction, whereas a reversion indicator attempts to predict whether an increasing price will soon decrease, or the opposite.

In this exercise, you will revisit the 200-day SMA. As a refresher, this indicator attempts to smooth out prices, but comes with a tradeoff - a lag. You will plot the prices of SPY and plot a 200-day SMA on top of the price series. Using this information, you will determine if it is a trend indicator or reversion indicator.

```
# Plot the closing prices of SPY
plot(Cl(SPY))
```




```
# Overlay a 200-day SMA
lines(SMA(Cl(SPY), n = 200), col = "red")
```




```
# What kind of indicator?
"trend"
```

```
## [1] "trend"
```

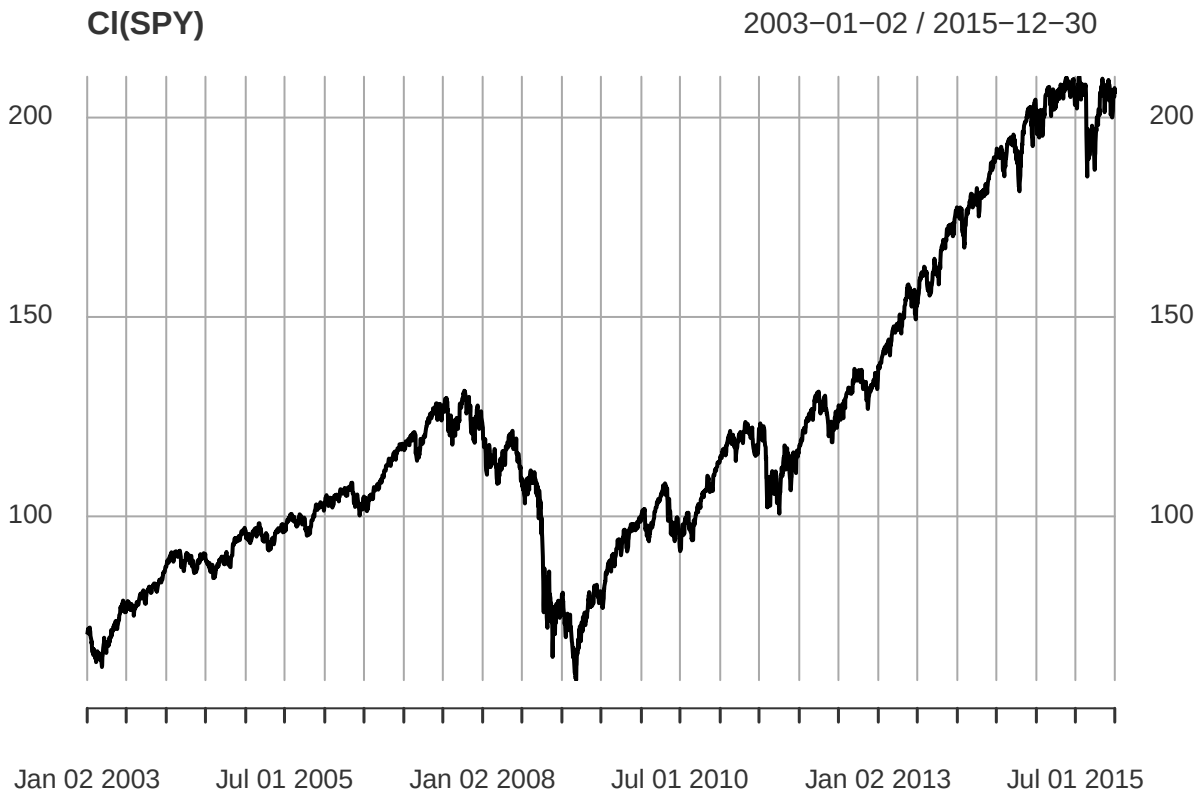
```
# SMA is a trend indicator rather than reversion.
```

Visualize an indicator and guess its purpose - II

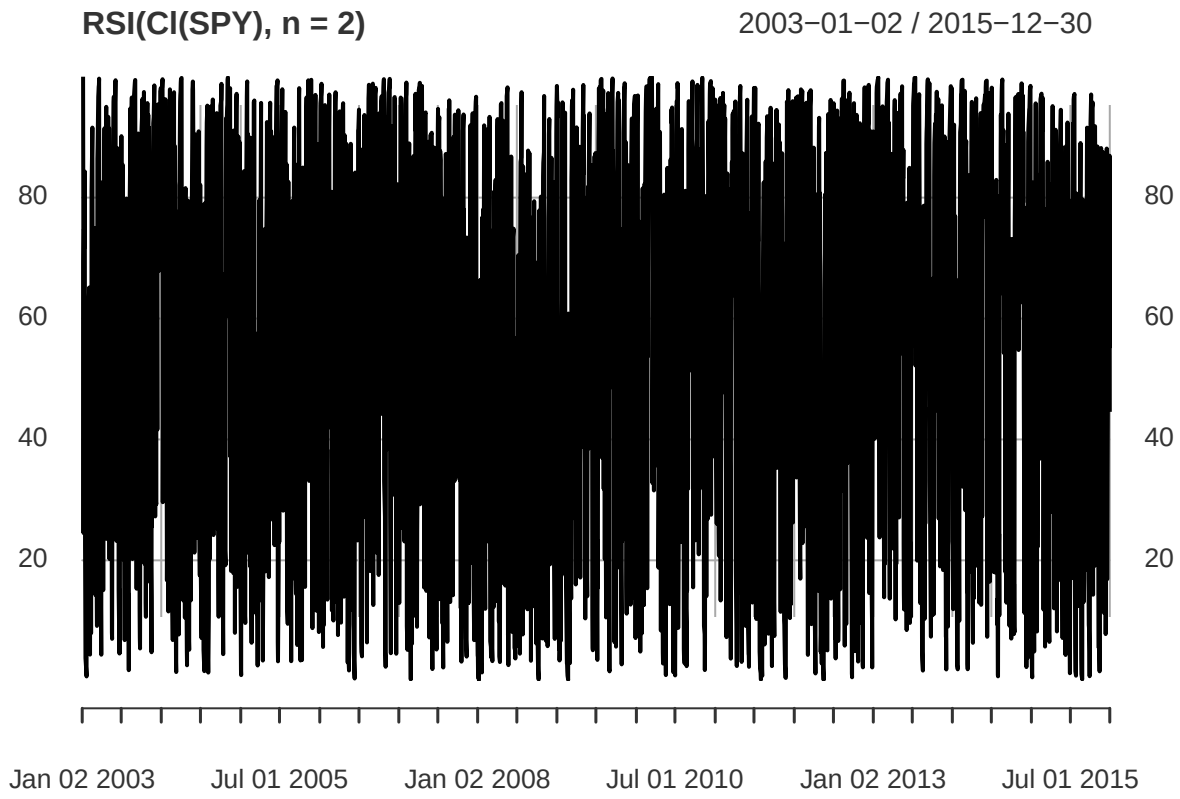
The Relative Strength Index (RSI) is another indicator that rises with positive price changes and falls with negative price changes. It is equal to 100 - 100/(1 + RS), where RS is the average gain over average loss over the lookback period. At various lengths, this indicator can range from a reversion indicator, to a trend filter, or anywhere in between. There are various ways of computing the RSI.

As you already know, RSI() takes in a price series price and a number of periods n which has a default value of 14. Some traders believe that the 2-period RSI, also known as the RSI 2, has even more important properties than the 14-period RSI.

```
# Plot the closing price of SPY
plot(Cl(SPY))
```




```
# Plot the RSI 2
plot(RSI(Cl(SPY), n = 2))
```




```
# What kind of indicator?
"reversion"
```

```
## [1] "reversion"
```

Indicator mechanics

Implementing an indicator - I

At this point, it's time to start getting into the mechanics of implementing an indicator within the scope of the quantstrat library. In this exercise you will learn how to add an indicator to your strategy. For this exercise you will use the strategy you created in earlier exercises, strategy.st. For your first indicator, you will add a 200-day simple moving average.

To add an indicator to your strategy, you will use the add.indicator(). Set strategy equal to the name of your strategy, name to the name of a function in quotes, and arguments to the arguments of the named function in the form of a list. For instance, if your function name was SMA, the arguments argument will contain the arguments to the SMA function:

add.indicator(strategy = strategy.st, name = "SMA", arguments = list(x = quote(Cl(mktdata)), n = 500), label = "SMA500") When referencing dynamic market data in your add.indicator() call, include mktdata inside the quote() function because it is created inside quantstrat and will change depending on whichever instrument the package is using at the time. quote() ensures that the data can dynamically change over the course of running your strategy.

```
# Add a 200-day SMA indicator to strategy.st
add.indicator(strategy = strategy.st,

              # Add the SMA function
              name = "SMA",

              # Create a lookback period
              arguments = list(x = quote(Cl(mktdata)), n = 200),

              # Label your indicator SMA200
              label = "SMA200")
```

```
## [1] "firststrat"
```

Implementing an indicator - II

Great job implementing your first indicator! Now, you'll make your strategy even more robust by adding a 50-day SMA. A fast moving average with a slower moving average is a simple and standard way to predict when prices in an asset are expected to rise in the future. While a single indicator can provide a lot of information, a truly robust trading system requires multiple indicators to operate effectively.

```
# Add a 50-day SMA indicator to strategy.st
add.indicator(strategy = strategy.st,

              # Add the SMA function
              name = "SMA",

              # Create a lookback period
              arguments = list(x = quote(Cl(mktdata)), n = 50),

              # Label your indicator SMA50
              label = "SMA50")
```

```
## [1] "firststrat"
```

Implementing an indicator - III

In financial markets, the goal is to buy low and sell high. The RSI can predict when a price has sufficiently pulled back, especially with a short period such as 2 or 3.

Here, you'll create a 3-period RSI, or RSI 3, to give you more practice in implementing pre-coded indicators. The quantstrat and quantmod packages are loaded for you.

```
# Add an RSI 3 indicator to strategy.st
add.indicator(strategy = strategy.st,

              # Add the RSI 3 function
              name = "RSI",

              # Create a lookback period
              arguments = list(price = quote(Cl(mktdata)), n = 3),
```

```
              # Label your indicator RSI_3
              label = "RSI_3")
```

```
## [1] "firststrat"
```

Code your own indicator - I

So far, you've used indicators that have been completely pre-written for you by using the add.indicator() function. Now it's time for you to write and apply your own indicator.

Your indicator function will calculate the average of two different indicators to create an RSI of 3.5. Here's how:

Take in a price series. Calculate RSI 3. Calculate RSI 4. Return the average of RSI 3 and RSI 4. This RSI can be thought of as an RSI 3.5, because it's longer than an RSI 3 and shorter than an RSI 4. By averaging, this indicator takes into account the impact of four days ago while still being faster than a simple RSI 4, and also removes the noise of both RSI 3 and RSI 4.

In this exercise, you will create a function for this indicator called calc_RSI_avg() and add it to your strategy strategy.st. All relevant packages are also loaded for you.

```
# Write the calc_RSI_avg function
calc_RSI_avg <- function(price, n1, n2) {

  # RSI 1 takes an input of the price and n1
  RSI_1 <- RSI(price = price, n = n1)

  # RSI 2 takes an input of the price and n2
  RSI_2 <- RSI(price = price, n = n2)

  # RSI_avg is the average of RSI_1 and RSI_2
  x <- (RSI_1 + RSI_2)/2

  # Your output of RSI_avg needs a column name of"RSI_avg"
  colnames(x) <- "RSI_avg"
  return(x)
}

# Add this function as RSI_3_4 to your strategy with n1 = 3 and n2 = 4
add.indicator(strategy.st, name = "calc_RSI_avg", arguments = list(price=quote(Cl(mktdata)), n1 = 3, n2
```

```
## [1] "firststrat"
```

Code your own indicator - II

While the RSI is decent, it is somewhat outdated as far as indicators go. In this exercise, you will code a simplified version of another indicator from scratch. The indicator is called the David Varadi Oscillator (DVO), originated by David Varadi, a quantitative research director.

The purpose of this oscillator is similar to something like the RSI in that it attempts to find opportunities to buy a temporary dip and sell in a temporary uptrend. In addition to obligatory market data, an oscillator function takes in two lookback periods.

First, the function computes a ratio between the closing price and average of high and low prices. Next, it applies an SMA to that quantity to smooth out noise, usually on a very small time frame, such as two days. Finally, it uses the runPercentRank() function to take a running percentage rank of this average ratio, and multiplies it by 100 to convert it to a 0-100 quantity.

Think about the way that students get percentile scores after taking a standardized test (that is, if a student got an 800 on her math section, she might be in the 95th percentile nationally). runPercentRank() does the same thing, except over time. This indicator provides the rank for the latest observation when taken in the context over some past period that the user specifies. For example, if something has a runPercentRank value of .90 when using a lookback period of 126, it means it's in the 90th percentile when compared to itself and the past 125 observations.

Your job is to implement this indicator and save it as DVO. Some of the necessary code has been provided, and the quantstrat, TTR, and quantmod packages are loaded into your workspace.

```
# Delare the DVO function
DVO <- function(HLC, navg = 2, percentlookback = 126) {

  # Compute the ratio between closing prices to the average of high and low
  ratio <- Cl(HLC)/((Hi(HLC) + Lo(HLC))/2)

  # Smooth out the ratio outputs using a moving average
  avgratio <- SMA(ratio, n = navg)

  # Convert ratio into a 0-100 value using runPercentRank()
  out <- runPercentRank(avgratio, n = percentlookback, exact.multiplier = 1) * 100
  colnames(out) <- "DVO"
  return(out)
}
```

Apply your own indicator

Great job! Now you have a better understanding of indicators as functions that anyone can write. It's time to apply the indicator you created in the previous exercise. To do so, you will make use of the applyIndicators() command.

From debugging to subsetting, knowing how to step inside your strategy is a valuable piece of knowledge. Every so often, you might have an error in your strategy, and will want to track it down. Knowing how to use the applyIndicators() command will help you identify your errors. Furthermore, sometimes you may want to look at a small chunk of time in your strategy. This exercise will help train you to do this as well.

In order to subset time series data, use brackets with the start date, forward slash symbol, and end date. Both dates are in the same format as the from and to arguments for getSymbols() that you used in the first chapter. The quantstrat, TTR, and quantmod packages have once again been loaded for you.

```
# Add the DVO indicator to your strategy
add.indicator(strategy = strategy.st, name = "DVO",
              arguments = list(HLC = quote(HLC(mktdata)), navg = 2, percentlookback = 126),
              label = "DVO_2_126")
```

```
## [1] "firststrat"
```

```
# Use applyIndicators to test out your indicators
test <- applyIndicators(strategy = strategy.st, mktdata = OHLC(SPY))
```

```
# Subset your data between Sep. 1 and Sep. 5 of 2013
test_subset <- test["2013-09-01/2013-09-05"]
```

Introduction to signals