Chapter 18
Functions

R is a functional programming language, meaning that everything you do is basically built on functions. However, moving beyond simply *using* pre-built functions to *writing* your own functions is when your capabilities really start to take off and your code development/writing takes on a new level of efficiency. Functions allow you to reduce code duplication by automating a generalized task to be applied recursively. Whenever you catch yourself repeating a function or copy-and-pasting code there is a good change that you should write a function to eliminate the redundancies.

Unfortunately, due to their abstractness, grasping the idea of writing functions (let alone writing them well) can take some time. However, in this chapter I will provide you with the basic knowledge of how functions operate in R to get you started on the right path. To do this, I cover the general components of functions, specifying function arguments, scoping and evaluation rules, managing function outputs, handling invalid parameters, and saving and sourcing functions for reuse. This will provide you with the required knowledge to start building your own functions. Lastly, I offer some additional resources that will help you learn more about functions in R.

18.1 Function Components

With the exception of primitive functions all R functions have three parts:

- `body()`: the code inside the function
- `formals()`: the list of arguments used to call the function
- `environment()`: the mapping of the location(s) of the function's variables

For example, let's build a function that calculates the present value (PV) of a single future sum. The equation for a single sum PV is:

$$PV = FV / (1 + r)^n$$

B.C. Boehmke, *Data Wrangling with R*, Use R!, DOI 10.1007/978-3-319-45599-0_18

where FV is future value, r is the interest rate, and n is the number of periods. In the function that follows the `body` of the function includes the equation

$$FV/(1+r)^n$$

and then rounding the output to two decimals. The `formals` (or arguments) required for the function include `FV`, `r`, and `n`. And the `environment` shows that function operates in the global environment.

```
PV <- function(FV, r, n) {
        PV <- FV / (1 + r)^n
        round(PV, 2)
}

body(PV)
## {
##     PV <- FV / (1 + r)^n
##     round(PV, 2)
## }

formals(PV)
## $FV
##
##
## $r
##
##
## $n

environment(PV)
## <environment: R_GlobalEnv>
```

18.2 Arguments

To perform the `PV()` function we can call the arguments in different ways.

```
# using argument names
PV(FV = 1000, r = .08, n = 5)
## [1] 680.58

# same as above but without using names (aka "positional matching")
PV(1000, .08, 5)
## [1] 680.58

# if using names you can change the order
PV(r = .08, FV = 1000, n = 5)
## [1] 680.58

# if not using names you must insert arguments in proper order
# in this e.g. the function assumes FV = .08, r = 1000, and n = 5
PV(.08, 1000, 5)
## [1] 0
```

Note that when building a function you can also set default values for arguments. In our original `PV()` we did not provide any default values so if we do not supply all the argument parameters an error will be returned. However, if we set default values then the function will use the stated default if any parameters are missing:

```
# missing the n argument
PV(1000, .08)
## Error in PV(1000, 0.08): argument "n" is missing, with no default

# creating default argument values
PV <- function(FV = 1000, r = .08, n = 5) {
        PV <- FV / (1 + r)^n
        round(PV, 2)
}

# function will use default n value
PV(1000, .08)
## [1] 680.58

# specifying a different n value
PV(1000, .08, 3)
## [1] 793.83
```

18.3 Scoping Rules

Scoping refers to the set of rules a programming language uses to lookup the value for variables and/or symbols. The following illustrates the basic concept behind the lexical scoping rules that R follows.

A function will first look inside the function to identify all the variables being called. If all variables exist then their is no additional search required to identify variables.

```
PV1 <- function() {
        FV <- 1000
        r <- .08
        n <- 5
        FV / (1 + r)^n
}

PV1()
## [1] 680.5832
```

However, if a variable does not exist within the function, R will look one level up to see if the variable exists.

```
# the FV variable is outside the function environment
FV <- 1000
```

```
PV2 <- function() {
        r <- .08
        n <- 5
        FV / (1 + r)^n
}

PV2()
## [1] 680.5832
```

This same concept applies if you have functions embedded within functions:

```
FV <- 1000


PV3 <- function() {
        r <- .08
        n <- 5
        denominator <- function() {
                (1 + r)^n
        }
        FV/denominator()
}

PV3()
## [1] 680.5832
```

This also applies for functions in which some arguments are called but not all variables used in the body are identified as arguments:

```
# n is specified within the function
PV4 <- function(FV, r) {
        n <- 5
        FV / (1 + r)^n
}

PV4(1000, .08)
## [1] 680.5832

# n is specified within the function and
# r is specified outside the function
r <- 0.08

PV5 <- function(FV) {
        n <- 5
        FV / (1 + r)^n
}

PV5(1000)
## [1] 680.5832
```

18.4 Lazy Evaluation

R functions perform “lazy” evaluation in which arguments are only evaluated if required in the body of the function.

```
# the y argument is not used so not including it causes
# no harm
lazy <- function(x, y){
        x * 2
}
lazy(4)
## [1] 8

# however, if both arguments are required in the body
# an error will result if an argument is missing
lazy2 <- function(x, y){
        (x + y) * 2
}
lazy2(4)
## Error in lazy2(4): argument "y" is missing, with no default
```

18.5 Returning Multiple Outputs from a Function

If a function performs multiple tasks and therefore has multiple results to report then we have to include the `c()` function inside the function to display all the results. If you do not include the `c()` function then the function output will only return the last expression:

```
bad <- function(x, y) {
        2 * x + y
        x + 2 * y
        2 * x + 2 * y
        x / y
}
bad(1, 2)
## [1] 0.5

good <- function(x, y) {
        output1 <- 2 * x + y
        output2 <- x + 2 * y
        output3 <- 2 * x + 2 * y
        output4 <- x / y
        c(output1, output2, output3, output4)
}
good(1, 2)
## [1] 4.0 5.0 6.0 0.5
```

Furthermore, when we have a function which performs multiple tasks (i.e. computes multiple computations) then it is often useful to save the results in a list.

```
good_list <- function(x, y) {
        output1 <- 2 * x + y
        output2 <- x + 2 * y
        output3 <- 2 * x + 2 * y
        output4 <- x / y
        c(list(Output1 = output1, Output2 = output2,
               Output3 = output3, Output4 = output4))
}
good_list(1, 2)
## $Output1
## [1] 4
##
## $Output2
## [1] 5
##
## $Output3
## [1] 6
##
## $Output4
## [1] 0.5
```

18.6 Dealing with Invalid Parameters

For functions that will be used again, and especially for those used by someone other than the creator of the function, it is good to check the validity of arguments within the function. One way to do this is to use the `stop()` function. The following uses an `if()` statement to check if the class of each argument is numeric. If one or more arguments are not numeric then the `stop()` function will be triggered to provide a meaningful message to the user.

```
PV <- function(FV, r, n) {
        if(!is.numeric(FV) | !is.numeric(r) | !is.numeric(n)){
                stop('This function only works for numeric inputs!\n',
                     'You have provided objects of the following classes:\n',
                     'FV: ', class(FV), '\n',
                     'r: ', class(r), '\n',
                     'n: ', class(n))
        }
        PV <- FV / (1 + r)^n
        round(PV, 2)
}
```

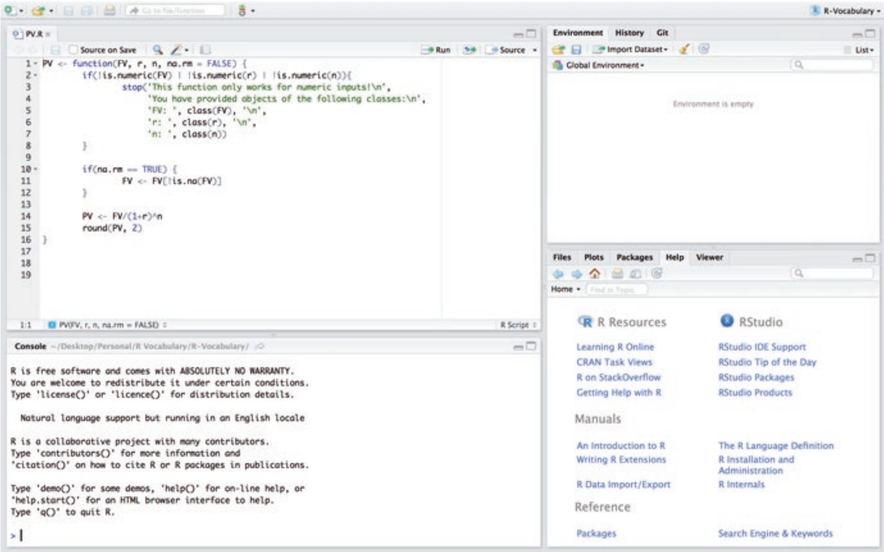
```
PV("1000", 0.08, "5")
## Error in PV("1000", 0.08, "5"): This function only works for numeric inputs!
## You have provided objects of the following classes:
## FV: character
## r: numeric
## n: character
```

Another concern is dealing with missing or `NA` values. Lets say you wanted to perform the `PV()` function on a vector of potential future values. The function as is will output `NA` in place of any missing values in the FV input vector. If you want to remove the missing values then you can incorporate the `na.rm` parameter in the function arguments along with an `if` statement to remove missing values if `na.rm = TRUE`.

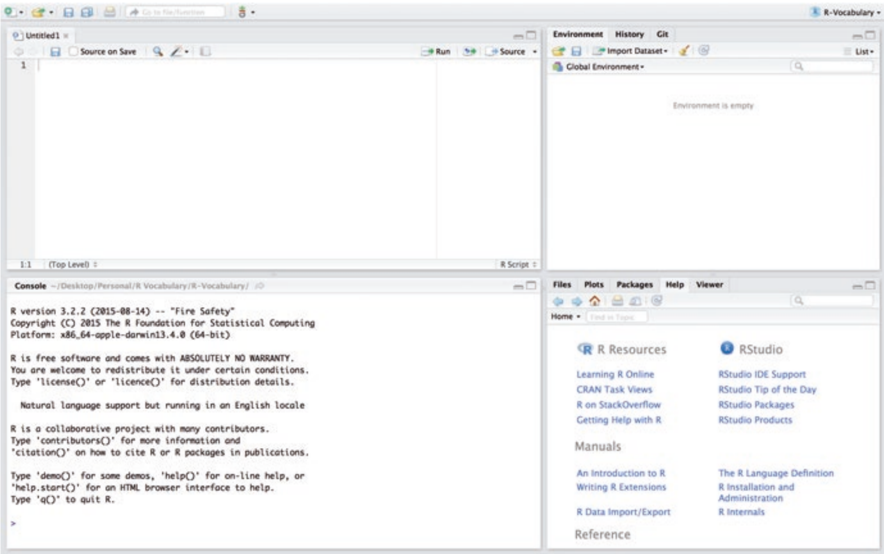
```
# vector of future value inputs
fv <- c(800, 900, NA, 1100, NA)

# original PV() function will return NAs
PV(fv, .08, 5)
## [1] 544.47 612.52     NA 748.64     NA

# add na.rm argument
PV <- function(FV, r, n, na.rm = FALSE) {
        if(!is.numeric(FV) | !is.numeric(r) | !is.numeric(n)){
                stop('This function only works for numeric inputs!\n',
                 'You have provided objects of the following classes:\n',
                     'FV: ', class(FV), '\n',
                     'r: ', class(r), '\n',
                     'n: ', class(n))
        }
        if(na.rm == TRUE) {
                FV <- FV[!is.na(FV)]
        }
        PV <- FV / (1 + r)^n
        round(PV, 2)
}

# setting na.rm = TRUE argument eliminates NA outputs
PV(fv, 0.08, 5, na.rm = TRUE)
## [1] 544.47 612.52 748.64
```

18.7 Saving and Sourcing Functions

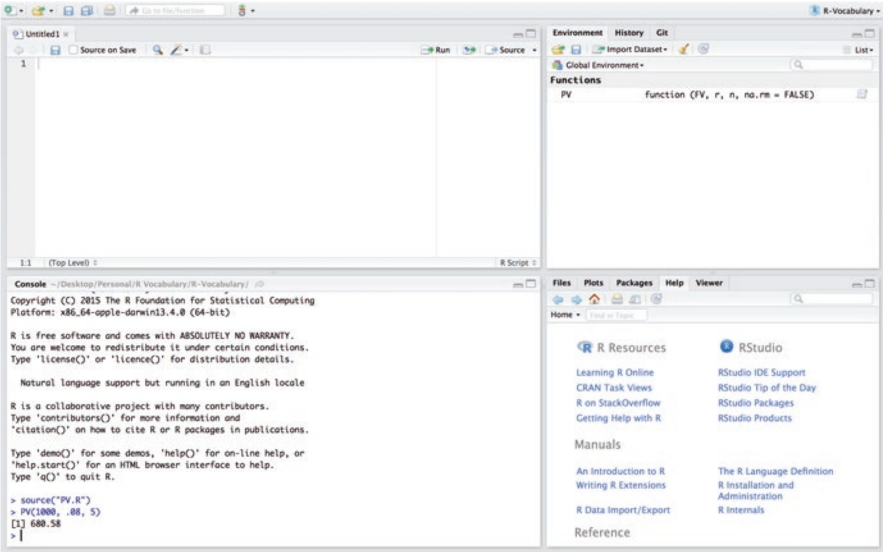
If you want to save a function to be used at other times and within other scripts there are two main ways to do this. One way is to build a package which I do not cover in this book but is discussed in more details in Hadley Wickhams R Packages book, which is openly available at http://r-pkgs.had.co.nz/. Another option, and the one discussed here, is to save the function in a script. For example, we can save a script that contains the `PV()` function and save this script as `PV.R`.



Now, if we are working in a fresh script you'll see that we have no objects and functions in our working environment:



If we want to use the PV function in this new script we can simply read in the function by sourcing the script using `source("PV.R")`. Now, you'll notice that we have the `PV()` function in our global environment and can use it as normal. Note that if you are working in a different directory then where the `PV.R` file is located you'll need to include the proper path to access the relevant directory.



18.8 Additional Resources

Functions are a fundamental building block of R and writing functions is a core activity of an R programmer. It represents the key step of the transition from a mere "user" to a developer who creates new functionality for R. As a result, its important to turn your existing, informal knowledge of functions into a rigorous understanding of what functions are and how they work. A few additional resources that can help you get to the next step of understanding functions include:

- Hadley Wickham's Advanced R book
- Roger Peng's R Programming for Data Science book
- DataCamp's Intermediate R course
- Coursera's R Programming course