Adil-Gokturk_HW7.R

HAG

2020-03-29

```r
# Adil Gokturk
# FIN 659

# HW7: BASICS OF OPTIONS
# set working directory
setwd("~/Desktop/Spring2020/FIN659/Assignments/hw7")
getwd()
```

```
## [1] "/Users/HAG/Desktop/Spring2020/FIN659/Assignments/hw7"
```

```r
# Load the libraries
library(tidyverse)
```

```
## ── Attaching packages ─────────────────────────────────────────────────── tidyverse 1.3.0 ──

## ✓ ggplot2 3.3.0     ✓ purrr   0.3.3
## ✓ tibble  2.1.3     ✓ dplyr   0.8.5
## ✓ tidyr   1.0.2     ✓ stringr 1.4.0
## ✓ readr   1.3.1     ✓ forcats 0.5.0

## ── Conflicts ──────────────────────────────────────────────────────── tidyverse_conflicts() ──
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```r
library(quantmod)
```

```
## Loading required package: xts

## Loading required package: zoo

##
## Attaching package: 'zoo'

## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric

##
## Attaching package: 'xts'
```

```
## The following objects are masked from 'package:dplyr':
##
##     first, last

## Loading required package: TTR

## Registered S3 method overwritten by 'quantmod':
##   method            from
##   as.zoo.data.frame zoo

## Version 0.4-0 included new data defaults. See ?getSymbols.

library(optiRum)
library(jrvFinance)
library(knitr)

options(scipen = 20) # adjust scientific numbers

# Textbook Reference:Section 1.8, pp. 14-16;
# Section 10.4, pp. 215-219; Section 10.7, pp. 221-222;
# Section 11.4, pp. 238-241, Equation 11.10

###############
## Problem 1 ##
###############
# The key principle to take away from this problem is
# that leverage can have significant effects when it comes to investing.
# Leverage allows relatively small amounts of capital
# to generate large profits - a magnification effect.
# The danger of leverage is that losses are also magnified.
# Options contracts are a leverage tool
# as they allow investors to multiply the power of their starting capital.

# The current price of DISH Network stock is $31.50 per share,
# and six-month European call options on the stock with a strike price of
$32.50
# are currently trading at $3.60.
# An investor, who has $10,000 of capital to invest,
# believes that the price of the stock will increase by 20% over the next six
months.
# The investor is trying to decide between two strategies -
# (A) buying shares or
# (B) buying call options.
# What return will each strategy produce after six months,
# if the investor is correct in their assessment of the stock?
# Assume that either a whole number of shares can be bought OR
# a whole number of option contracts cane be bought
# (representing the right to buy 100 shares per option contract).
```

```r
# This information is summarized in the tables below.

# Hint: The price for the call option is for an option on 1 share;
# each option contract is for options on 100 shares.

# Price of security
(price.of.security <- c(31.50, 3.60)) # US$

## [1] 31.5  3.6

# Strike price of the call options
(strike.price.of.the.call.options <- c("NA", 32.50)) # US$

## [1] "NA"   "32.5"

# let's put it in a table and convert to df
(df1 <- rbind(price.of.security, strike.price.of.the.call.options))

##                                  [,1]   [,2]
## price.of.security                "31.5" "3.6"
## strike.price.of.the.call.options "NA"   "32.5"

(df1 <- as.data.frame(df1))

##                                    V1   V2
## price.of.security                31.5  3.6
## strike.price.of.the.call.options   NA 32.5

# rename column names
c("Strategy A:Buy shares",
  "Strategy B:Buy call options") -> colnames(df1)
kable(df1, align = "c")
```

	Strategy A:Buy shares	Strategy B:Buy call options
price.of.security	31.5	3.6
strike.price.of.the.call.options	NA	32.5

```r
# Amount available for investment
(amount.available.for.investment <- 10000) # US$

## [1] 10000

# Anticipated change in stock price
(Anticipated.change.in.stock.price <- 0.2)

## [1] 0.2

## How many shares can be purchased under Strategy A?
## How many option contracts can be purchased under Strategy B?
# (Round your answers to the nearest whole number.)
```

```r
# Strategy A
(Strategy.A <- amount.available.for.investment/price.of.security[1])

## [1] 317.4603

(Strategy.A <- floor(Strategy.A) ) # nearest integer

## [1] 317

print("Strategy A: 317 shares can be purchased")

## [1] "Strategy A: 317 shares can be purchased"

# Strategy B
(Strategy.B <- (amount.available.for.investment/(100*price.of.security[2])))

## [1] 27.77778

(Strategy.B <- floor(Strategy.B))# nearest integer

## [1] 27

print("Strategy A: 27 options contracts can be purchased")

## [1] "Strategy A: 27 options contracts can be purchased"

## How much uninvested cash does the investor still have?
# (Assume that this cash remains in a non-interest-bearing account.)

# Strategy A
(Strategy.A <- amount.available.for.investment - (price.of.security[1] *
Strategy.A))

## [1] 14.5

print("Strategy A: $14.50")

## [1] "Strategy A: $14.50"

# Strategy B
(Strategy.B <- amount.available.for.investment - (Strategy.B * 100 *
price.of.security[2]))

## [1] 280

print("Strategy B: $280.00")

## [1] "Strategy B: $280.00"

## Assume that the anticipated change in stock price is
## realized over the next six months.
## What is the price of a share of the stock?
(price.of.security[1] * (1 + Anticipated.change.in.stock.price))
```

```r
## [1] 37.8

print("The price of a share of the stock is $37.80")

## [1] "The price of a share of the stock is $37.80"

## What is the value of all of the shares purchased
## if the anticipated change in stock price is realized?
## What is the intrinsic value of the options purchased,
## assuming they are all exercised at maturity
## if the anticipated change in stock price is realized?

# Strategy A
(Strategy.A <- floor(amount.available.for.investment/price.of.security[1])*
    (price.of.security[1] * (1 + Anticipated.change.in.stock.price)))

## [1] 11982.6

print("Strategy A: the intrinsic value of the options = $11,982.6")

## [1] "Strategy A: the intrinsic value of the options = $11,982.6"

# Strategy B
(Strategy.B <- (max(37.80-32.50,0)*27*100))

## [1] 14310

print("Strategy B: $14,310.00")

## [1] "Strategy B: $14,310.00"

## What is the total profit made in dollar terms?
# Hint: Remember to add back the uninvested cash
# before subtracting the initial investment

# Strategy A
(Strategy.A <-11982.60 + 14.50 - amount.available.for.investment)

## [1] 1997.1

print("Strategy A: $1,997.10")

## [1] "Strategy A: $1,997.10"

# Strategy B
(Strategy.B <- 14310 + 280 - amount.available.for.investment)

## [1] 4590

print("Strategy B: $4,590.00")

## [1] "Strategy B: $4,590.00"
```

```r
## What is the total profit made (in percentage terms)?
##In other words, express the answers above
## as a percentage of the initial capital available for investment.

# Strategy A
(Strategy.A <-1997.10/amount.available.for.investment*100)

## [1] 19.971

print("Strategy A: 19.97%")

## [1] "Strategy A: 19.97%"

# Strategy B
(Strategy.B <- (14310 + 280 -
amount.available.for.investment)/amount.available.for.investment * 100)

## [1] 45.9

print("Strategy B: 45.90%")

## [1] "Strategy B: 45.90%"

## Now consider the outcome to the two strategies
## if the stock price were to decrease by 20%.

# Anticipated change in stock price 20%

(anticipated.change.in.stock.price <- 0.20)

## [1] 0.2

## What is the price of a share of the stock in this second scenario?
(price.of.security[1] * (1 + anticipated.change.in.stock.price))

## [1] 37.8

print("The price of a share of the stock in this second scenario = $37.80")

## [1] "The price of a share of the stock in this second scenario = $37.80"

## What is the value of all of the shares purchased
## if the anticipated change in stock price is realized?
## What is the intrinsic value of the options purchased,
## assuming they are all exercised at maturity
## if the anticipated change in stock price is realized?

# Strategy A
(Strategy.A <-25.20*317)

## [1] 7988.4

print("Strategy A: $7,988.40")
```

```r
## [1] "Strategy A: $7,988.40"

# strike.price.of.the.call.options[2]
# Strategy B
(Strategy.B <- max(25.20 - 32.50,0)* 27 *100)

## [1] 0

print("Strategy B: $0.00")

## [1] "Strategy B: $0.00"

## What is the total loss made in dollar terms?

# Strategy A
(Strategy.A <-7988.4 + 14.50 - amount.available.for.investment)

## [1] -1997.1

print("Strategy A: -$1,997.10")

## [1] "Strategy A: -$1,997.10"

# Strategy B
(Strategy.B <- (max(25.20 - 32.50,0)* 27 *100)+280 -
amount.available.for.investment)

## [1] -9720

print("Strategy B: -$9,720.00")

## [1] "Strategy B: -$9,720.00"

## What is the total profit made (in percentage terms)?
## In other words, express the answers above
## as a percentage of the initial capital available for investment.
# Strategy A
(Strategy.A <-(7988.4 + 14.50 -
amount.available.for.investment)/amount.available.for.investment *100)

## [1] -19.971

round(Strategy.A,2)

## [1] -19.97

print("Strategy A: -19.97%")

## [1] "Strategy A: -19.97%"

# Strategy B
(Strategy.B <- ((max(25.20 - 32.50,0)* 27 *100)+280 -
amount.available.for.investment)/
    amount.available.for.investment *100)
```

```
## [1] -97.2

print("Strategy B: -97.20%")

## [1] "Strategy B: -97.20%"

## Which strategy has a higher standard deviation of returns?
## In other words, which investment strategy is riskier?
print("Strategy B: Buying call option has  a higher standard deviation of
returns")

## [1] "Strategy B: Buying call option has  a higher standard deviation of
returns"

###############
## Problem 2 ##
###############

## The main concept to remember from this question is that
## an exchange will alter the terms of options contracts
## if a company decides to significantly change the number of shares it has
outstanding.
## Assuming the market capitalization of the company remains constant,
## an increase in the number of shares outstanding
## will automatically result in a decrease in the price per share.
## The terms of an options contract usually do not change when a cash
dividend is
## paid by the company (although a large special dividend would be an
exception to this).

## Consider a call option to buy 100 shares of a company for $60 per share.
## How do the terms of the option contract change in each of the following
cases?
## (If there is no change in the terms, write in the original terms of the
contract.)

# Original terms of the option contract:
(original.terms.of.the.option.contract <- c(100, 60))

## [1] 100  60

# A cash dividend:      Dividend amount     $5.00
(cash.divident <- c(original.terms.of.the.option.contract[1],
original.terms.of.the.option.contract[2]))

## [1] 100  60

# A stock split:        Split ratio     4/1
(split.ratio <- 4/1)

## [1] 4
```

```r
(stok.split <- c(original.terms.of.the.option.contract[1]* split.ratio,
original.terms.of.the.option.contract[2]/split.ratio))
```

```
## [1] 400  15
```

```r
# A stock dividend:     Dividend percentage     10%
(divident.percentage <- 0.1)
```

```
## [1] 0.1
```

```r
(stock.divident <-
c(original.terms.of.the.option.contract[1]*(1+divident.percentage),

original.terms.of.the.option.contract[2]/(1+divident.percentage)))
```

```
## [1] 110.00000  54.54545
```

```r
round(stock.divident,2)
```

```
## [1] 110.00  54.55
```

```r
# lets put it in a table

(df2 <- rbind(original.terms.of.the.option.contract,
              cash.divident,
              stok.split,
              stock.divident))
```

```
##                                        [,1]     [,2]
## original.terms.of.the.option.contract  100 60.00000
## cash.divident                          100 60.00000
## stok.split                             400 15.00000
## stock.divident                         110 54.54545
```

```r
(df2 <- round(df2, 2))
```

```
##                                        [,1]  [,2]
## original.terms.of.the.option.contract  100 60.00
## cash.divident                          100 60.00
## stok.split                             400 15.00
## stock.divident                         110 54.55
```

```r
# # rename column names
c("No. of shares to buy",
  "Strike price $") -> colnames(df2)

# Visualize it
kable(df2, align = "c")
```

	No. of shares to buy	Strike price $
original.terms.of.the.option.contract	100	60.00

cash.divident	100	60.00
stok.split	400	15.00
stock.divident	110	54.55

```
###############
## Problem 3 ##
###############

## The central idea to recognize in this example is that
## writing options (that is, selling them) involves risk for the party
## that is doing the selling.
## An exchange will require that margin be put up by the option writer
## to mitigate the possibility that they will default on a loss-making
position.
## An investor buying an option does not have a margin requirement,
## as the maximum loss is the cost of the option and this is paid up front.

## A United States investor writes eight naked call option contracts and
## eleven naked put option contracts (each contract is for options on 100
shares).
## The call option price is $5.00,
## the put option price is $10.55,
## the strike price for both calls and puts is $90.00,
## and the stock price is $84.00.
## What is the initial margin requirement for the investor?

# This information is summarized in the table below.

# No. of call option contracts sold         8
(number.of.call.option.contracts.sold <- 8)

## [1] 8

# Call option price         $5.00
(call.option.price <- 5.00)

## [1] 5

# No. of put option contracts sold          11
(number.of.put.option.contracts.sold <- 11)

## [1] 11

# Put option price          $10.55
(put.option.price <- 10.55)

## [1] 10.55

# Strike price          $90.00
(strike.price <- 90.00)
```

```
## [1] 90

# Stock price           $84.00
(stock.price <- 84.00   )

## [1] 84

# let's put it in a df
(df3 <- rbind(number.of.call.option.contracts.sold,
          call.option.price,
          number.of.put.option.contracts.sold,
          put.option.price,
          strike.price,
          stock.price))

##                                       [,1]
## number.of.call.option.contracts.sold  8.00
## call.option.price                     5.00
## number.of.put.option.contracts.sold  11.00
## put.option.price                     10.55
## strike.price                         90.00
## stock.price                          84.00

# rename column name
c("Values") -> colnames(df3)

# Visualize it
kable(df3, align = "c")
```

	Values
number.of.call.option.contracts.sold	8.00
call.option.price	5.00
number.of.put.option.contracts.sold	11.00
put.option.price	10.55
strike.price	90.00
stock.price	84.00

```
## The initial and maintenance margin for a written naked call option
# is the greater of the following two calculations:

# Calculation 1:
# A total of 100% of the proceeds of
# the sale plus 20% of the underlying share price
# less the amount if any by which the option is out of the money

## Margin requirement for all written call option contracts

# Hint: Remember to multiply the margin requirement for one option
# by the number of option contracts times 100
```

```
(number.of.call.option.contracts.sold*100*(call.option.price + 0.2*
                                             stock.price -(strike.price -
stock.price)))

## [1] 12640

print("Margin requirement for all written call option contracts =
$12,640.00")

## [1] "Margin requirement for all written call option contracts =
$12,640.00"

# Calculation 2:
# A total of 100% of the option proceeds plus 10% of the underlying share
price
## Margin requirement for all written call option contracts

# Hint: Remember to multiply the margin requirement for one option
#by the number of option contracts times 100
(number.of.call.option.contracts.sold * 100 *
    (call.option.price+ 0.1 * stock.price))

## [1] 10720

print("Margin requirement for all written call option contracts =
$10,720.00")

## [1] "Margin requirement for all written call option contracts =
$10,720.00"

## Therefore, the initial and maintenance margin for all written naked call
options is:
(max(12640, 10720))

## [1] 12640

print("Therefore, the initial and maintenance margin for all written naked
call options is: $12,640")

## [1] "Therefore, the initial and maintenance margin for all written naked
call options is: $12,640"

## The initial and maintenance margin for a written naked put option is the
greater of:

# Calculation 1:
# A total of 100% of the proceeds of the sale
# plus 20% of the underlying share price
# less the amount if any by which the option is out of the money

## Margin requirement for all written put option contracts
# Hint: Remember to multiply the margin requirement for
```

```r
# one option by the number of option contracts times 100
(number.of.put.option.contracts.sold*100*
    (put.option.price+0.2 * stock.price))

## [1] 30085

print("Margin requirement for all written PUT option contracts = $30,085.00")

## [1] "Margin requirement for all written PUT option contracts = $30,085.00"

# Calculation 2:
# A total of 100% of the option proceeds plus 10% of the exercise price
# Margin requirement for all written put option contracts
# Hint: Remember to multiply the margin requirement for
# one option by the number of option contracts times 100
(number.of.put.option.contracts.sold*100*
    (put.option.price+0.1*strike.price))

## [1] 21505

print("Margin requirement for all written PUT option contracts = $21,505.00")

## [1] "Margin requirement for all written PUT option contracts = $21,505.00"

## Therefore, the initial and maintenance margin for all written naked call
options is:
(max(30085, 21505))

## [1] 30085

print("Therefore, the initial and maintenance margin for all written naked
put options is: $30,085")

## [1] "Therefore, the initial and maintenance margin for all written naked
put options is: $30,085"

## Hence, the total initial margin requirement for the investor is:
(total.initial.margin.requirement <- 30085 + 12640)

## [1] 42725

print("Hence, the total initial margin requirement for the investor is:
$42,725")

## [1] "Hence, the total initial margin requirement for the investor is:
$42,725"

###############
## Problem 4 ##
###############

# The key principle to take away from this problem is that
# arbitrage opportunities arise when securities are not trading at their
```

```
theoretical prices.
# If security A is overvalued relative to security B,
# then security A should be sold and security B should be bought ("buy low,
sell high").
# As more and more market participants observe the arbitrage opportunity,
# selling pressure will cause the price of security A to decrease and
# buying pressure will cause the price of security B to
# increase until an equilibrium is reached where the arbitrage opportunity no
longer exists.
# (Note that selling a zero-coupon bond is equivalent to borrowing money,
# and buying a zero-coupon bond is equivalent to investing.)

## A European call option and put option on a stock both have a strike price
of $20 and
## an expiration date in three months.
## Both sell for $3.
## The risk-free interest rate is 10% per annum,
## the current stock price is $19,
## and a $1 dividend is expected in one month.
## What is the arbitrage opportunity open to a trader?

# This information is summarized in the table below.

# Price of European call option         $3.00
(price.of.European.call.option <- 3)

## [1] 3

# Price of European put option          $3.00
(price.of.European.put.option <- 3)

## [1] 3

# Strike price of both options          $20.00
(strike.price <- 20)

## [1] 20

# Time to expiration (months)           3
(time.to.expiration <- 3)

## [1] 3

# Risk-free interest rate           10%
(risk.free.rate <- 0.1)

## [1] 0.1

# Current stock price           $19.00
(stock.price <- 19)

## [1] 19
```

```r
# Expected dividend        $1.00
(expected.dividend <- 1)
```

```
## [1] 1
```

```r
# Time until dividend received (months)        1
(time.until.dividend.received <- 1)
```

```
## [1] 1
```

```r
# let's put it in a table
(df4 <- rbind(price.of.European.call.option,
              price.of.European.put.option,
              strike.price,
              time.to.expiration,
              risk.free.rate,
              stock.price,
              expected.dividend,
              time.until.dividend.received))
```

```
##                                [,1]
## price.of.European.call.option   3.0
## price.of.European.put.option    3.0
## strike.price                   20.0
## time.to.expiration              3.0
## risk.free.rate                  0.1
## stock.price                    19.0
## expected.dividend               1.0
## time.until.dividend.received    1.0
```

```r
# rename column name
c("Values") -> colnames(df4)

# Visualize it
kable(df4, align = "c")
```

	Values
price.of.European.call.option	3.0
price.of.European.put.option	3.0
strike.price	20.0
time.to.expiration	3.0
risk.free.rate	0.1
stock.price	19.0
expected.dividend	1.0
time.until.dividend.received	1.0

```r
## What is the present value of the expected dividend?
(expected.dividend * exp(-risk.free.rate *
(time.until.dividend.received/12)))
```

```
## [1] 0.9917013

print("the present value of the expected dividend is: $0.99")

## [1] "the present value of the expected dividend is: $0.99"

## What is the value of the Left-Hand Side (LHS) of
# the put-call parity equation above?
(price.of.European.call.option + 0.99 +
    (strike.price * exp(-risk.free.rate *
                          (time.to.expiration/12)))) %>% round(2)

## [1] 23.5

print("The value of the Left-Hand Side (LHS) of the put-call parity is:
$23.50")

## [1] "The value of the Left-Hand Side (LHS) of the put-call parity is:
$23.50"

## What is the value of the Right-Hand Side (RHS) of the put-call parity
equation above?
(price.of.European.put.option + stock.price)

## [1] 22

print("The value of the Right-Hand Side (RHS) of the put-call parity is
$22.00")

## [1] "The value of the Right-Hand Side (RHS) of the put-call parity is
$22.00"

## Which side of the put-call parity equation is overvalued (and should
therefore be "sold")?

print("the Left-Hand Side (LHS) of the put-call parity equation is
overvalued")

## [1] "the Left-Hand Side (LHS) of the put-call parity equation is
overvalued"

## Payoff Table for the Arbitrage Opportunity
## Hint: Refer to Table 10.3 in the textbook

(sell.a.call.option <- c(price.of.European.call.option, "", "(S-$20.00)",
"$0.00"))

## [1] "3"          ""            "(S-$20.00)" "$0.00"

(sell.a.bond.FV.D.maturity <- c("$0.99","-$1.00","",""))

## [1] "$0.99"  "-$1.00" ""       ""
```

```r
(sell.a.bond.FV.K.maturity <- c(round(strike.price *exp(-risk.free.rate *
(time.to.expiration/12)),2),
                                                                                 "","-
$20.00", "-$20.00"))
```

```
## [1] "19.51"   ""         "-$20.00" "-$20.00"
```

```r
(buy.a.put.option <- c(-(price.of.European.put.option), "", "$0.00",
"($20.00-S)"))
```

```
## [1] "-3"         ""             "$0.00"      "($20.00-S)"
```

```r
(buy.a.share.of.stock <- c(-(stock.price), "","Sell Stock", "Sell Stock"))
```

```
## [1] "-19"        ""             "Sell Stock" "Sell Stock"
```

```r
(receive.the.divident.in.1.month <- c("", expected.dividend,"",""))
```

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

```r
(Totals <- c("$1.50", "$0.00", "$0.00", "$0.00"))
```

```
## [1] "$1.50" "$0.00" "$0.00" "$0.00"
```

```r
# let's put it in a table
(df5 <- rbind(sell.a.call.option,
              sell.a.bond.FV.D.maturity,
              sell.a.bond.FV.K.maturity,
              buy.a.put.option,
              buy.a.share.of.stock,
              receive.the.divident.in.1.month,
              Totals))
```

```
##                                 [,1]    [,2]     [,3]         [,4]
## sell.a.call.option              "3"     ""       "(S-$20.00)" "$0.00"
## sell.a.bond.FV.D.maturity       "$0.99" "-$1.00" ""           ""
## sell.a.bond.FV.K.maturity       "19.51" ""       "-$20.00"    "-$20.00"
## buy.a.put.option                "-3"    ""       "$0.00"      "($20.00-S)"
## buy.a.share.of.stock            "-19"   ""       "Sell Stock" "Sell Stock"
## receive.the.divident.in.1.month ""      "1"      ""           ""
## Totals                          "$1.50" "$0.00"  "$0.00"      "$0.00"
```

```r
# rename column name
c("T = 0",
  "T = 1/12",
  "ST ≥ K",
  "ST < K") -> colnames(df5)

# Visualize it
kable(df5, align = "c")
```

	T = 0	T = 1/12	ST ≥ K	ST < K

sell.a.call.option	3		(S-$20.00)	$0.00
sell.a.bond.FV.D.maturity	$0.99	-$1.00		
sell.a.bond.FV.K.maturity	19.51		-$20.00	-$20.00
buy.a.put.option	-3		$0.00	($20.00-S)
buy.a.share.of.stock	-19		Sell Stock	Sell Stock
receive.the.divident.in.1.month		1		
Totals	$1.50	$0.00	$0.00	$0.00