

TP2 Risk Management

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2023-03-24

Libraries

Risk Management: Estimating the Risk of a Book of European Options

The objective is to implement (part of) the risk management framework for estimating the risk of a book of European call options by taking into account the risk drivers such as underlying and implied volatility.

Data

Load the database Market. Identify the price of the **SP500**, the **VIX index**, the term structure of interest rates (current and past), and the traded options (calls and puts).

```
# load dataset into environment
load(file = here("data_raw", "Market.rda"))

# reassign name and inspect structure of loaded data
mkt <- Market
summary(mkt)
```

```
##      Length Class  Mode
## sp500 3410   xts    numeric
## vix   3410   xts    numeric
## rf     14  -none- numeric
## calls 1266  -none- numeric
## puts  2250  -none- numeric
```

```
str(mkt)
```

```
## List of 5
## $ sp500:An 'xts' object on 2000-01-03/2013-09-10 containing:
##   Data: num [1:3410, 1] 1455 1399 1402 1403 1441 ...
##   Indexed by objects of class: [Date] TZ: UTC
##   xts Attributes:
##    NULL
## $ vix :An 'xts' object on 2000-01-03/2013-09-10 containing:
##   Data: num [1:3410, 1] 0.242 0.27 0.264 0.257 0.217 ...
##   Indexed by objects of class: [Date] TZ: UTC
##   xts Attributes:
##    NULL
## $ rf : num [1:14, 1] 0.00071 0.00098 0.00128 0.00224 0.00342 ...
##   .. attr(*, "names")= chr [1:14] "0.00273972602739726" "0.0192307692307692" "0.0833333333333333" "0.25" .
## $ calls: num [1:422, 1:3] 1280 1370 1380 1400 1415 ...
##   .. attr(*, "dimnames")=List of 2
##    .. ..$ : NULL
##    .. ..$ : chr [1:3] "K" "tau" "IV"
```

```
## $ puts : num [1:750, 1:3] 1000 1025 1050 1075 1100 ...
##    .- attr(*, "dimnames")=List of 2
##    .. ..$ : NULL
##    .. ..$ : chr [1:3] "K" "tau" "IV"
```

Let's unpack these into the env. individually:

```
# unpack each of the elements in the mkt list
sp500 <- mkt$sp500
vix <- mkt$vix
Rf <- mkt$rf # risk-free rates
calls <- mkt$calls
puts <- mkt$puts

# assign colname for aesthetic
colnames(sp500) <- "sp500"
colnames(vix) <- "vix"
```

SP500 and VIX

By inspection, we observe that we the SP500 and VIX indices are contained in the `sp500` and `vix` xts objects respectively.

```
# show head of both indexes
head(sp500)
```

```
##           sp500
## 2000-01-03 1455.22
## 2000-01-04 1399.42
## 2000-01-05 1402.11
## 2000-01-06 1403.45
## 2000-01-07 1441.47
## 2000-01-10 1457.60
```

```
head(vix)
```

```
##           vix
## 2000-01-03 0.2421
## 2000-01-04 0.2701
## 2000-01-05 0.2641
## 2000-01-06 0.2573
## 2000-01-07 0.2172
## 2000-01-10 0.2171
```

Interest Rates

The **interest rates** are given in the `$rf` attribute. We can see that

```
Rf
```

```
##           [,1]
## [1,] 0.0007099993
## [2,] 0.00097999908
## [3,] 0.0012799317
## [4,] 0.0022393730
## [5,] 0.0034170792
## [6,] 0.0045123559
## [7,] 0.0043206525
## [8,] 0.0064284968
## [9,] 0.0090558654
```

```
## [10,] 0.0117237591
## [11,] 0.0141196498
## [12,] 0.0176131823
## [13,] 0.0207989304
## [14,] 0.0203526819
## attr(,"names")
## [1] "0.00273972602739726" "0.0192307692307692" "0.0833333333333333"
## [4] "0.25" "0.5" "0.75"
## [7] "1" "2" "3"
## [10] "4" "5" "7"
## [13] "10" "30"
```

We see that these are the yearly risk-free rates, yearly.

Calls

The `calls` object displays the different values of K (**Strike Price**), τ (**maturity**) and $\sigma = IV$ (**Implied Volatility**)

```
dim(calls)
```

```
## [1] 422 3
```

```
head(calls)
```

```
##      K      tau      IV
## [1,] 1280 0.02557005 0.7370370
## [2,] 1370 0.02557005 0.9691616
## [3,] 1380 0.02557005 0.9451401
## [4,] 1400 0.02557005 0.5274481
## [5,] 1415 0.02557005 0.5083375
## [6,] 1425 0.02557005 0.4820041
```

Puts

```
dim(puts)
```

```
## [1] 750 3
```

```
head(puts)
```

```
##      K      tau      IV
## [1,] 1000 0.02557005 1.0144250
## [2,] 1025 0.02557005 1.0083110
## [3,] 1050 0.02557005 0.9622093
## [4,] 1075 0.02557005 0.9170457
## [5,] 1100 0.02557005 0.8728757
## [6,] 1120 0.02557005 0.8381910
```

Pricing a Portfolio of Options

Assume the following book of European Call Options:

- 1x strike $K = 1600$, with maturity $T = 20d$ (**TO COMPLETE**)