To run the code yourself you would have to install the powerful packages `Quandl`, `quantmod` and `PerformanceAnalytics` (all on CRAN). Additionally, you would have to register at quandl.com to receive your own API key (I will not show mine here for obvious reasons).

```
library(Quandl)
## Loading required package: xts
## Loading required package: zoo
##
## Attaching package: 'zoo'
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric

library(quantmod)
## 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(PerformanceAnalytics)
##
## Attaching package: 'PerformanceAnalytics'
## The following object is masked from 'package:graphics':
##
##     legend

# get your API key via free registration at quandl.com and insert here
Quandl.api_key("XXX")
```

As an example, the paper backtests the so-called *split strike conversion* strategy which was allegedly pursued by Bernie Madoff's hedge fund. We will see that this strategy would have fared quite well but unfortunately, it later turned out that Madoff didn't pursue this strategy after all but had built up a large Ponzi scheme (for more on that: How to Catch a Thief: Unmasking Madoff's Ponzi Scheme with Benford's Law).

Anyway, the strategy itself is quite interesting, it consists of

1. the purchase of a group or basket of equity securities that are intended to highly correlate to the S&P 100 index,
2. the sale of "out-of-the-money" S&P 100 index call options in an equivalent contract value dollar amount to the basket of equity securities, and
3. the purchase of an equivalent number of "out-of-the-money" S&P 100 Index put options

First we have to load all the necessary data and transform them as needed:

```
# set parameters for out-of-the-money options
X <- 0.04 # put 4% OOM
Y <- 0.02 # call 2% OOM

# calculate S_tp0 (S&P 100 beginning of the month) and S_tp1 (S&P 100
```

```
end of the month)
getSymbols("^OEX", from = "1990-11-01", to = "2008-11-30", periodicity
= "monthly") # values for S_tp0 and S_tp1
## '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.
## [1] "^OEX"

S <- coredata(OEX[ , "OEX.Adjusted"])
S_tp0 <- S[-length(S)] # remove last value -> November is only
necessary as S_tp1 for October
S_tp1 <- S[-1]         # remove first value -> starting value of S_tp1
is equal to the end value of S_tp0

# calculate monthly sigma_t (Volatility)
getSymbols("^VXO", from = "1990-11-01", to = "2008-10-31", periodicity
= "monthly") # Values for implied volatility
## [1] "^VXO"

sigma_t <- coredata(VXO[ , "VXO.Adjusted"]) / 100

# calculate values for r_t, see also note 5 on p. 13
yield_t <- Quandl("FRED/TB3MS", trim_start = "1990-11-01", trim_end =
"2008-10-31", order = "asc")
yield_t <- yield_t[ , "Value"] / 100
P_t <- 100 * (1 - 91/360 * yield_t)
r_t <- 4 * log(100/P_t)
```

We now define the functions for the payoffs of the puts and calls as stated on page 6 of the paper…

```
Put_t <- function(S_tp0, X, r_t, sigma_t) {
  d1 <- (log(1/(1-X)) + (r_t + sigma_t^2/2) * 1/12) /
(sigma_t*sqrt(1/12))
  d2 <- d1 - sigma_t * sqrt(1/12)
  (1-X) * S_tp0 * exp(-r_t/12) * pnorm(-d2) - S_tp0 * pnorm(-d1) #
pnorm is cumulative density function of normal distribution
}
PutPayoff_tp1 <- function(S_tp0, S_tp1, X) {
  pmax(0, (1-X) * S_tp0 - S_tp1)
}
Call_t <- function(S_tp0, Y, r_t, sigma_t) {
  d1 <- (log(1/(1+Y)) + (r_t + sigma_t^2/2) * 1/12) / (sigma_t *
sqrt(1/12))
  d2 <- d1 - sigma_t * sqrt(1/12)
```

```
  S_tp0 * pnorm(d1) - (1+Y) * S_tp0*exp(-r_t/12) * pnorm(d2)
}
CallPayout_tp1 <- function(S_tp0, S_tp1, Y) {
  pmax(0, S_tp1 - (1+Y) * S_tp0)
}
```

…and finally the function for the actual return of the strike-conversion strategy, i.e. the core of the options strategy backtesting engine:

```
ROR_t <- function(S_tp0, S_tp1, X, Y, r_t, sigma_t) {
  (S_tp1 + PutPayoff_tp1(S_tp0, S_tp1, X) - CallPayout_tp1(S_tp0,
S_tp1, Y)) / (S_tp0 + Put_t(S_tp0, X , r_t , sigma_t) - Call_t(S_tp0,
Y, r_t, sigma_t))
}
```

Putting it all together and letting the actual backtest run:

```
strategy_return <- ROR_t(S_tp0, S_tp1, X, Y, r_t,sigma_t) - 1
benchmark_return <- (S_tp1 / S_tp0) - 1

# create a data.frame with both data and with the dates (monthly basis)
months <- seq(as.Date("1990-11-1"), by = "month", length = 216)
perf <- data.frame(months, strategy_return, benchmark_return)
colnames(perf) <- c("months", "Strike-Conversion Strategy", "S&P 100")

# create an xts out of the data frame
perfxts <- xts(perf[ , -1], order.by = perf[ , 1])
```

We can now calculate a multitude of performance and risk statistics:

```
table.Stats(perfxts)
##                 Strike-Conversion Strategy  S&P 100
## Observations                       216.0000 216.0000
## NAs                                  0.0000   0.0000
## Minimum                             -0.0341  -0.1459
## Quartile 1                          -0.0107  -0.0181
## Median                               0.0174   0.0098
## Arithmetic Mean                      0.0083   0.0057
## Geometric Mean                       0.0080   0.0048
## Quartile 3                           0.0273   0.0320
## Maximum                              0.0338   0.1079
## SE Mean                              0.0015   0.0029
## LCL Mean (0.95)                      0.0053   0.0000
## UCL Mean (0.95)                      0.0112   0.0115
## Variance                             0.0005   0.0018
## Stdev                                0.0222   0.0426
## Skewness                            -0.6451  -0.5578
## Kurtosis                            -1.0751   1.0153

table.DownsideRisk(perfxts)
##                              Strike-Conversion Strategy S&P 100
## Semi Deviation                                   0.0175  0.0321
## Gain Deviation                                   0.0085  0.0244
```

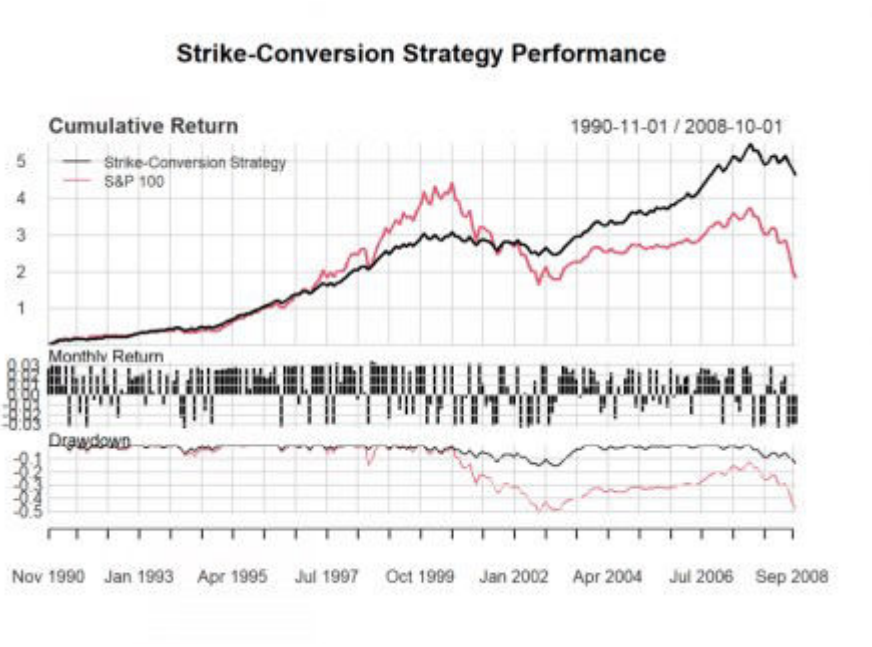
```
## Loss Deviation                                  0.0110  0.0314
## Downside Deviation (MAR=10%)                    0.0176  0.0334
## Downside Deviation (Rf=0%)                      0.0131  0.0293
## Downside Deviation (0%)                         0.0131  0.0293
## Maximum Drawdown                                0.1555  0.5078
## Historical VaR (95%)                           -0.0311 -0.0724
## Historical ES (95%)                            -0.0323 -0.0973
## Modified VaR (95%)                             -0.0325 -0.0698
## Modified ES (95%)                              -0.0347 -0.1005
```

Interestingly enough, the strike-conversion strategy yielded about the same mean return as the returns reported by Mr. Madoff… but with much bigger volatility (a.k.a. risk).

This was one of the tricks of Madoff to lull his investors into a sense of safety by not reporting over-the-top returns but “only” manipulating the price swings. His equity curve looked like being drawn with a ruler, which is of course totally unrealistic for an investment with this level of return.

A now for the big finale, the performance summary plot, which consists of the equity curves, the monthly returns, and the drawdowns…

```
charts.PerformanceSummary(perfxts)
```

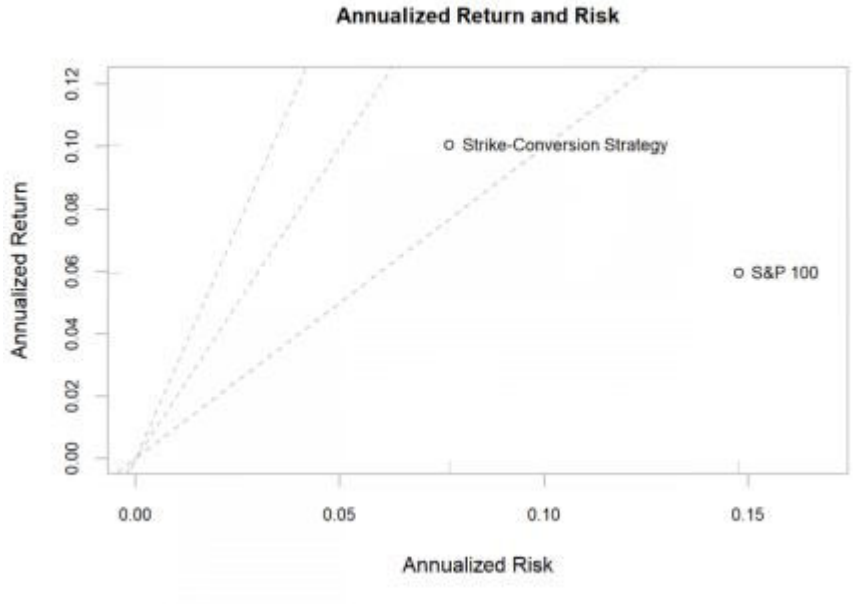


…the relative performance plot…

```
chart.RelativePerformance(perfxts[ , 1], perfxts[ , 2])
```

…and the risk-return scatterplot:

```
chart.RiskReturnScatter(perfxts)
```



As you can see, the risk-return profile of the strike-conversion strategy is much better than that of the underlying index.

With this template you will now be able to backtest different options strategies of your own, you only have to modify `ROR_t` accordingly. I am looking forward to your insights and feedback in general in the comments.