COMPUTATIONAL FINANCE & RISK MANAGEMENT

UNIVERSITY *of* WASHINGTON

Department of Applied Mathematics

More Monte Carlo and `mcsim(.)` in blotter R Package

CFRM 522

Introduction to Trading Strategies (018a)

Lecture References

- Brian Peterson: Monte Carlo analysis for strategy

  http://braverock.com/brian/monte_carlo.html

- Documentation for the `mcsim(.)` function in blotter help
  - https://opensourcequant.wordpress.com/2017/08/09/monte-carlo-for-your-portfolio-pl/

- Jaekle & Tomasini, Ch 4, § 2 (Monte Carlo Analysis) (Previous Reading Assignment)

- Aronson, Ch 5: Hypothesis Tests and Confidence Intervals (Reading Assignment)

- Jasen Mackie & Brian G. Peterson: Round Turn Trade Simulation (pdf – available on Canvas), 2018 (`mcsim(.)`)

Different forms of Monte Carlo Simulation for Strategy Development

- Equity Curve Simulation
- Weights/Positions/Portfolio
- Round Turn Trades
- Resampled Market Data

Equity Curve Simulation

- Used in texts such as Jaekle & Tomasini, Aronson, and others
- Also implemented in a few commercial backtesters
- This type of simulation takes the equity curve either for a specific instrument or for the entire portfolio and samples from the equity curve
- Almost always done daily. For intraday strategies, it makes sense to consider the daily returns as a synthetic return series, from which inference may be attempted
- Equity curve Monte Carlo is implemented as `mcsim(.)` in blotter
  - Daily P&L
  - Trade (transaction) P&L

Equity Curve Simulation

- To replicate the method of sampling from trades as done in Jaekle & Tomasini:
  - Use `mcsim(.)` with parameter `use = 'txns'`
  - This means the individual transaction P&L values will be rearranged
  - Put replacement = FALSE for simulation *without* replacement, as is done in the text
  - Put replacement = TRUE for simulation *with* replacement

Equity Curve Simulation

- Sampling without replacement (as done in text)
  - Simulation without replacement will yield an equity curve which has the same mean and cumulative P&L as the original equity curve, but which has re-ordered the individual daily returns
  - This model is not as useful as with replacement (Peterson)
  - J&T: Exactly duplicates the probability distribution of the input sequence

- Sampling with replacement
  - Allows individual daily returns to be reused (with replacement) in the simulation.
  - It will create a more varied path, and is more useful for confidence intervals and other standard statistical inference, eg on the potential paths of a Drawdown.
  - J&T: Introduces more randomness – more representative of expected behavior in the future

Equity Curve Simulation

- Upside: One can make a reasonable argument that resampling from daily returns is a valid *risk measurement* or *statistical inference tool*

- Downside: Cannot accept that the evolution of a trade would be the same if we start it at a different point

Market Data Simulation

- Resampled market data is commonly used for evaluating portfolio risk
- It is much harder to use resampled market data to evaluate trading strategies; the usual caveats of i.i.d. (and non-normality) assumptions apply
- It is possible to construct synthetic return series using a bootstrap, or to construct synthetic returns using a multi-moment or other fitted distribution.
  - One can then turn this synthetic return series into a synthetic price series
  - With this synthetic price series, one can apply the strategy to the synthetic price series
  - The data is 'fake', so one can't use the cash P&L from the synthetic data in any real way
  - One can likely (if careful) draw some statistical inference about robustness of the strategy, whether the rules work as intended, and a few other things
  - It is easy, however, to confuse the possible statistical inference with actual possible strategy returns

Having said all that…

- The literature is very thin on these methodologies, and their implications

- Opportunities exist for more research in this area

- Some potential goals would include rigorously defining all the given methods, constructing a full literature survey, comparing the strengths and weaknesses for given input data, and providing some guidance on which methods to use and why

Implementation Example

- Use the Long-short Bollinger Band reversal strategy code from Section 015, through

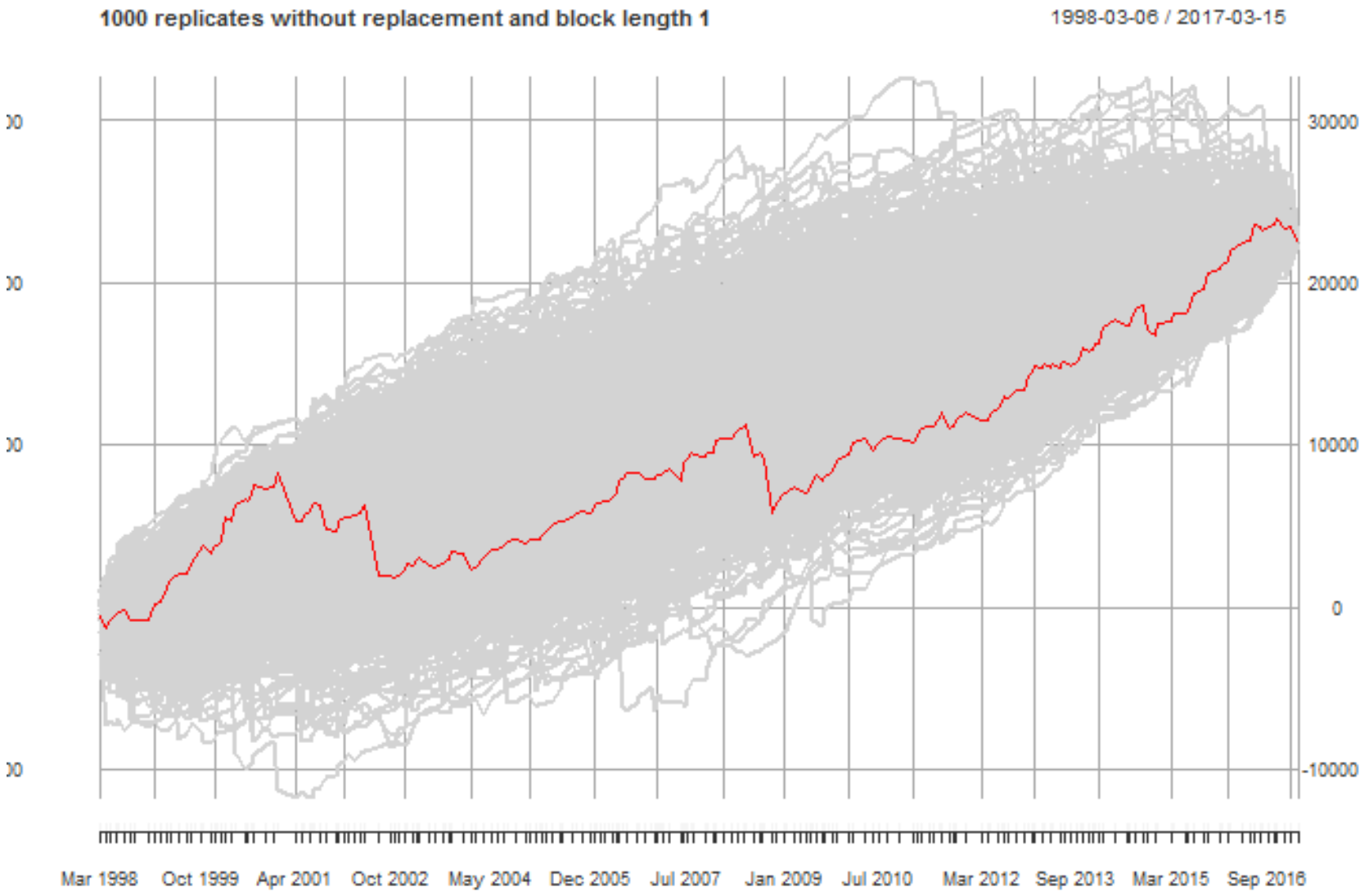
```
initEq <- 0    # Set to 0 for Monte Carlo analysis
applyStrategy(strategy = stratName,
              portfolios=portName,parameters=list(sd=SD,n=N))

updatePortf(Portfolio = portName)
updateAcct(name = acctName)
updateEndEq(Account = acctName)
```

Implementation Example

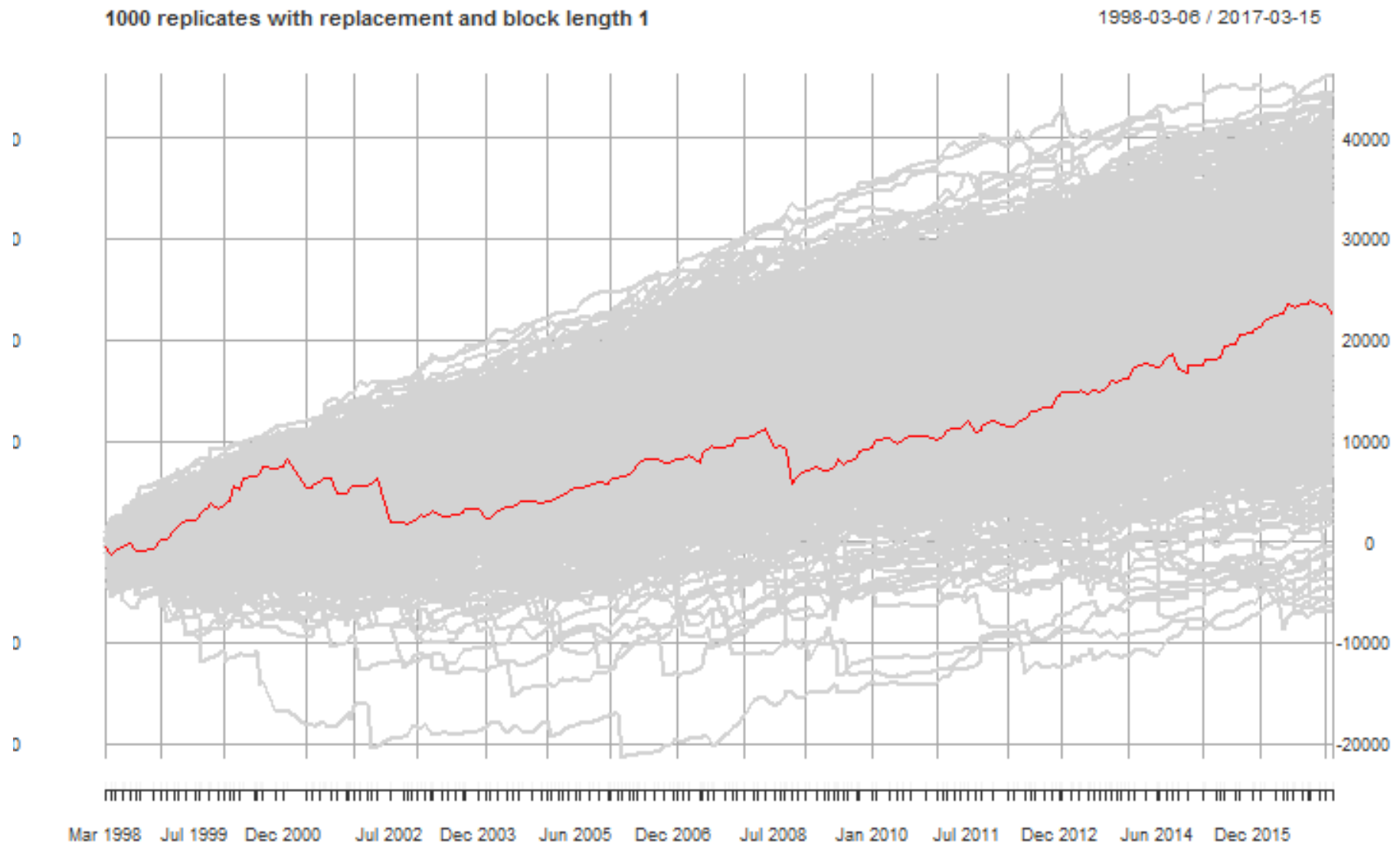
- Then, append the following:

```
# 1st do replacement = FALSE a la J & T book (use = 'txns'):
bbsim <- mcsim(Portfolio = portName, Account = acctName, n = 1000,
               replacement = FALSE, use = 'txns')

quantile(bbsim)
summary(bbsim)

plot(bbsim, normalize=FALSE)

hist(bbsim, normalize = FALSE)

# bbsimRep: sample WITH Replacement
bbsimRep <- mcsim(Portfolio = portName, Account = acctName, n = 1000,
               replacement = TRUE, use = 'txns')

quantile(bbsimRep)
summary(bbsimRep)

plot(bbsimRep, normalize=FALSE)
hist(bbsimRep, normalize = FALSE)
```

Compare plots of without vs with replacement



Compare plots of without vs with replacement



More Results, with replacement (normalized)

```
> quantile(bbsimRep)
            0%            25%            50%            75%           100%
-4.399028e-03 -7.886864e-06 1.912950e-04 3.495302e-04 1.420225e-03
```

More Results, with replacement (normalized)

```
> summary(bbsimRep)
         Sample Mean Sample Median      Backtest       Lower CI
mean    0.0001067514  0.0001084382  0.0001055970  2.477312e-05
median  0.0001866789  0.0001911880  0.0001915528  1.440206e-04
stddev  0.0005874713  0.0005892130  0.0006053529  3.898585e-04
maxDD  -0.0059030003 -0.0053135753 -0.0064269159 -1.096739e-02
sharpe  0.1972262435  0.1891255507  0.0006053529 -4.136289e-03

          Upper CI   Std. Error
mean    0.0001887297 4.182643e-05
median  0.0002293371 2.176481e-05
stddev  0.0007850842 1.008248e-04
maxDD  -0.0008386129 2.583919e-03
sharpe  0.3985887761 1.027379e-01
```

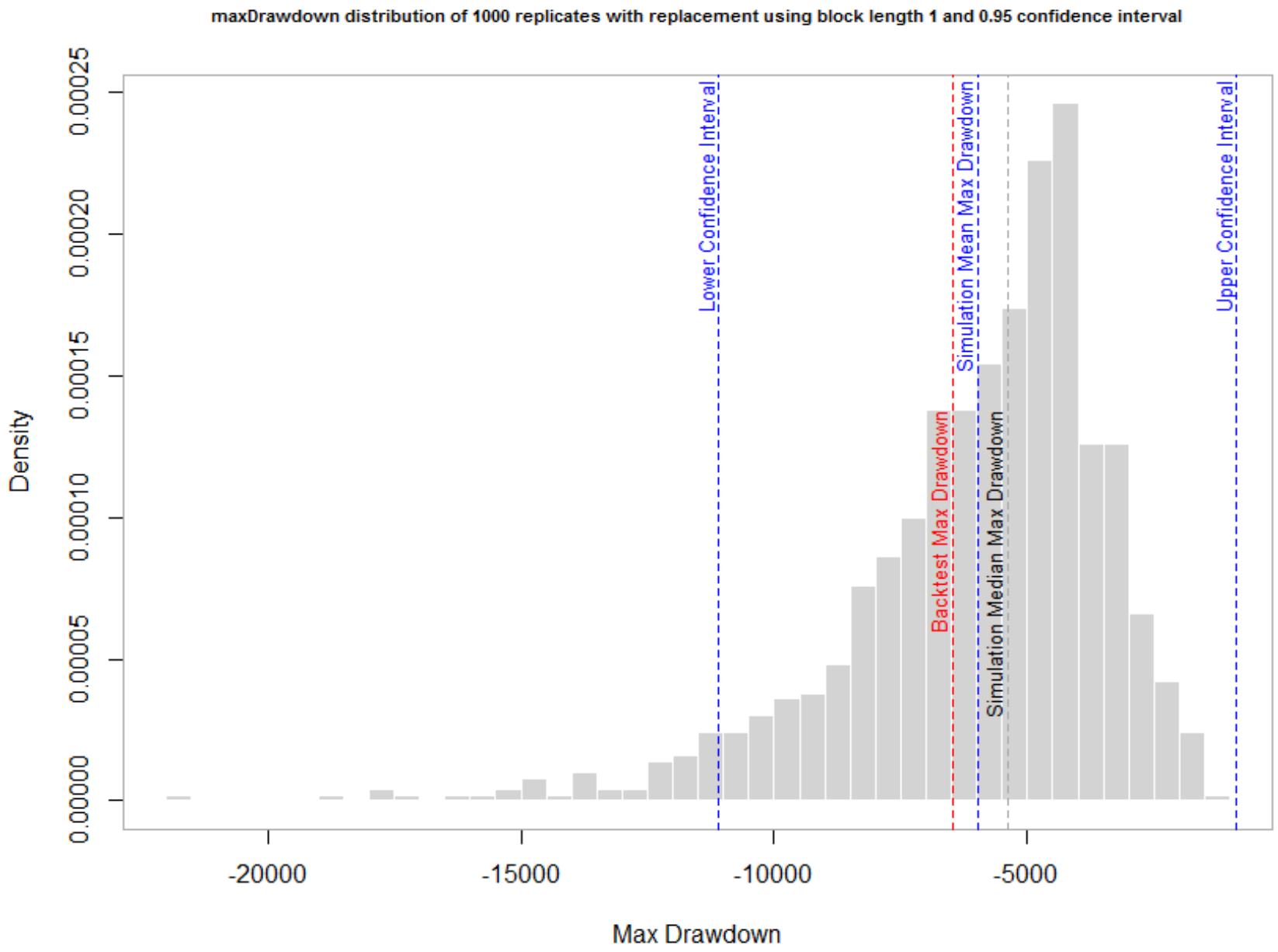
Mean max DD = -0.5903%
Worst case max DD = -1.0967%

More Results, with replacement

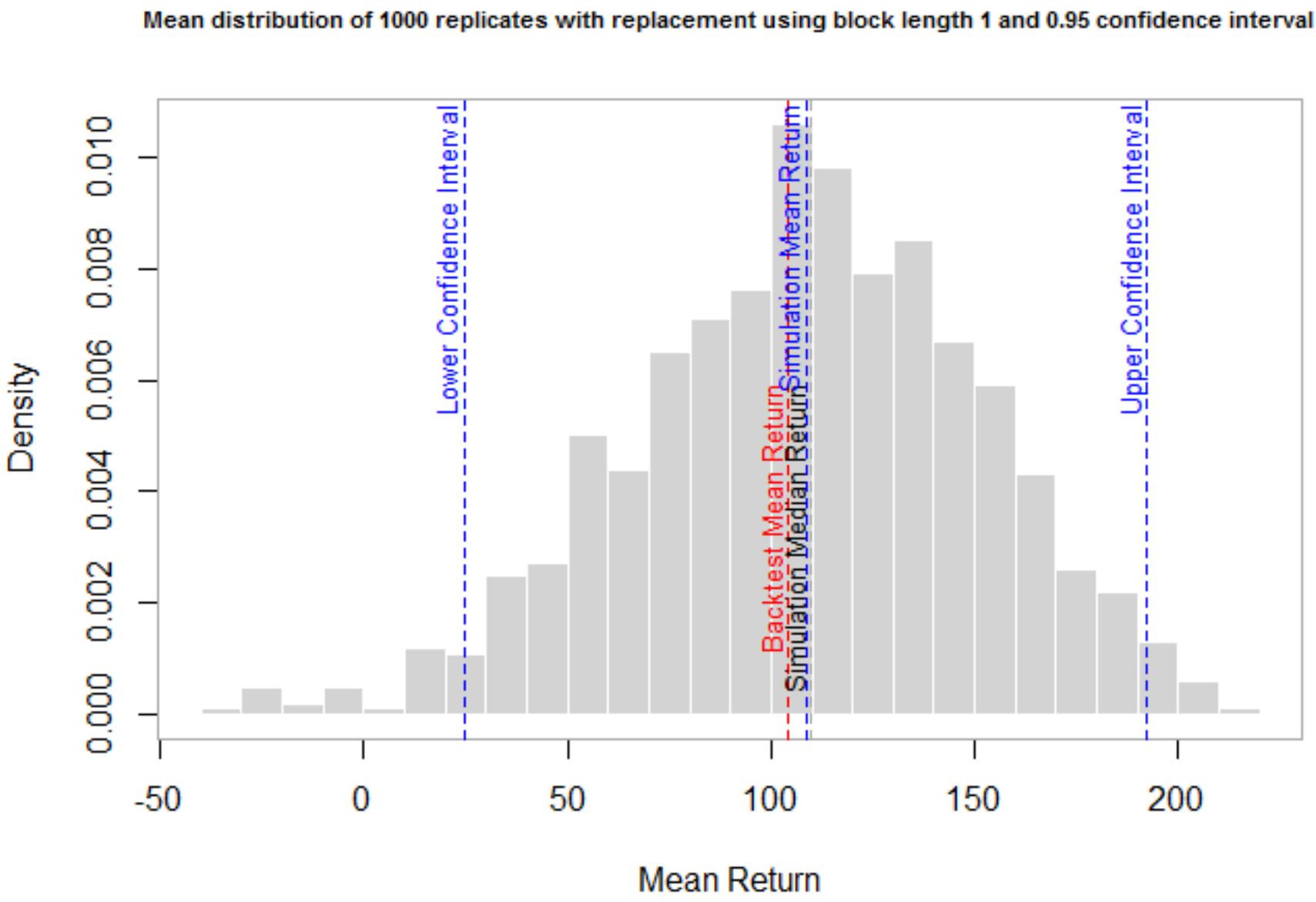
- `hist(bbsimRep, normalize = FALSE)`

- Gives multiple histograms with respect to different metrics; eg,
  - Max Drawdown
  - Mean Return
  - Volatility
  - etc

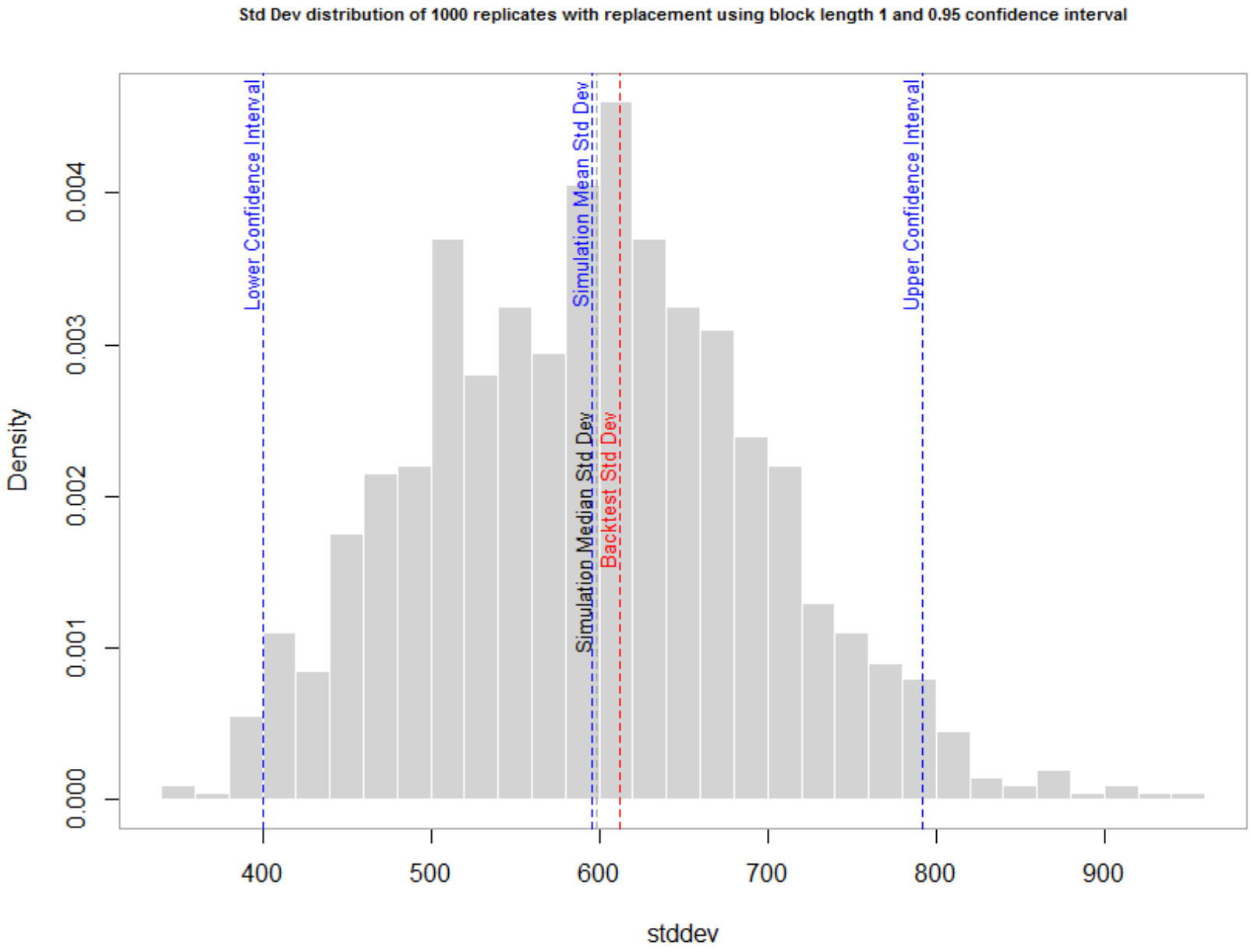
More Results, with replacement



More Results, with replacement



More Results, with replacement



bbsim and B B King

txnsim

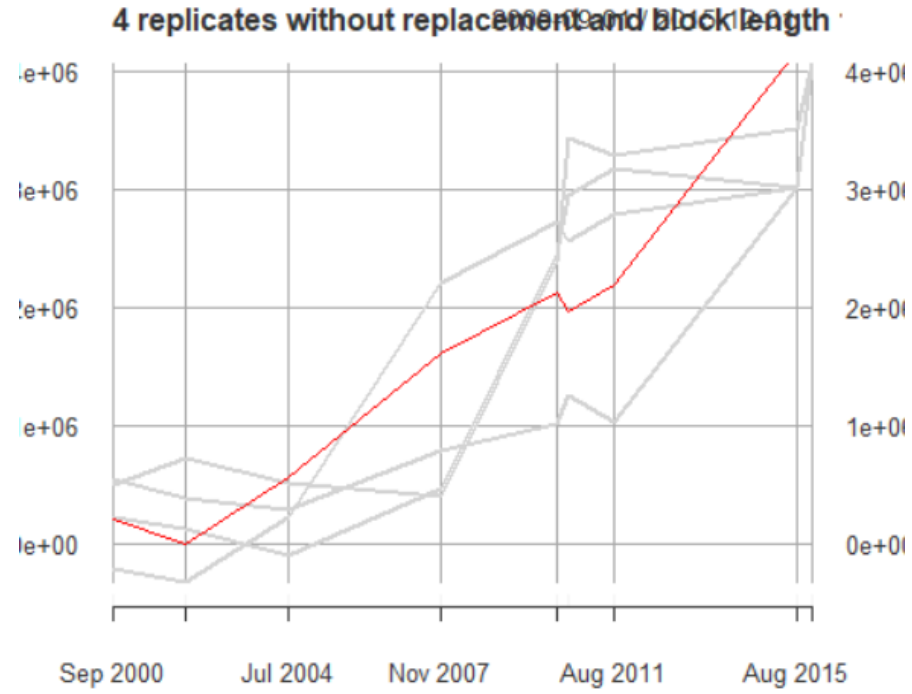
- txnsim is a newer feature in blotter
- mcsim is merely a re-ordering of the P&L observations
  - Daily
  - Trade P&L
- txnsim samples from the observed characteristics of the original strategy
  - How long was the strategy long, short, and flat?
  - What were the number of levels building up a trade?
  - What was the max position size etc?
  - Using those as constraints, resample the strategy such that the random versions of the strategy mimic the structure of the original
  - These are random, however, and therefore exhibit no skill
  - Can compare the original backtest graphically to test skill vs luck

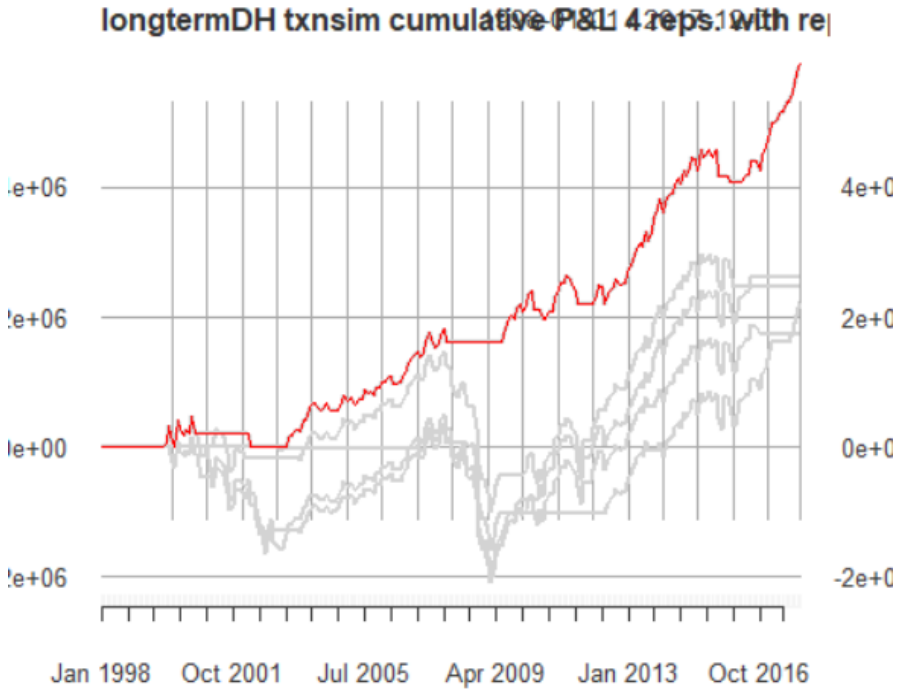
Round Turn Trades and txnsim

- More generally, trade resampling is really about sampling the properties of the trade, primarily quantity, direction, and duration
- A round turn trade may consist of multiple transactions
  - Building up to a position
  - Unwinding a position
- It is also important to sample flat periods, if any exist
- The goal is to create a 'random' strategy that trades with similar behavior to the strategy that you are evaluating
- This type of sampling can also account for trade definitions other than flat to flat (as in the text), where a strategy levels into or out of a position
- This method is most useful for analyzing skill versus luck, because all of the synthetic/sampled results are from random strategies that trade in a similar manner, on the same data, as the strategy we are trying to analyze

txnsim Example

- Faber strategy, with four simulations
- Compare mcsim vs txnsim, without replacement:





txnsim Example

- Faber strategy, with four simulations
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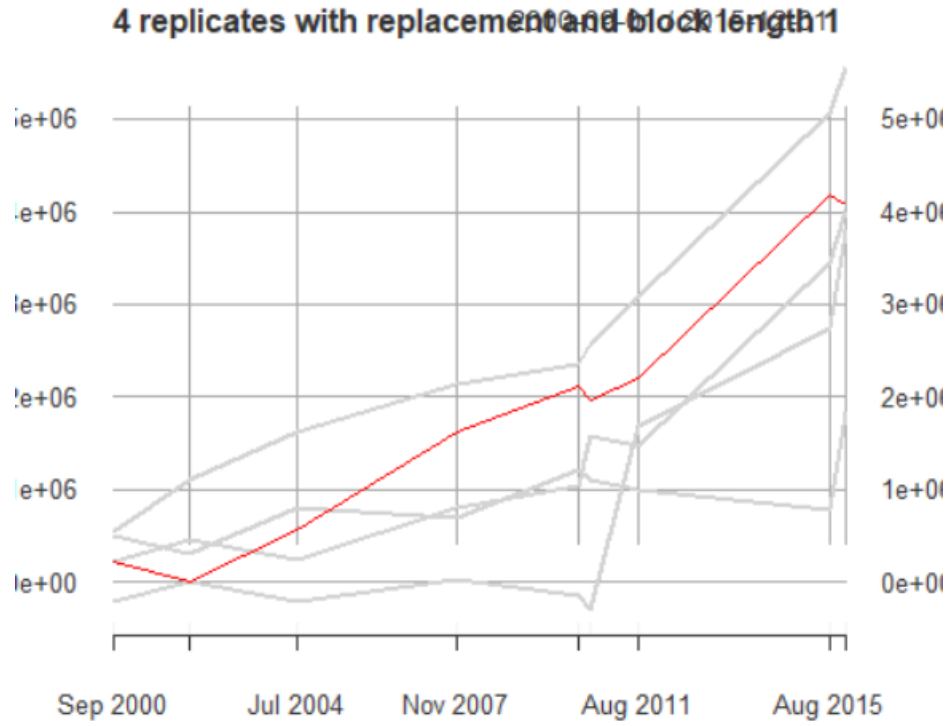

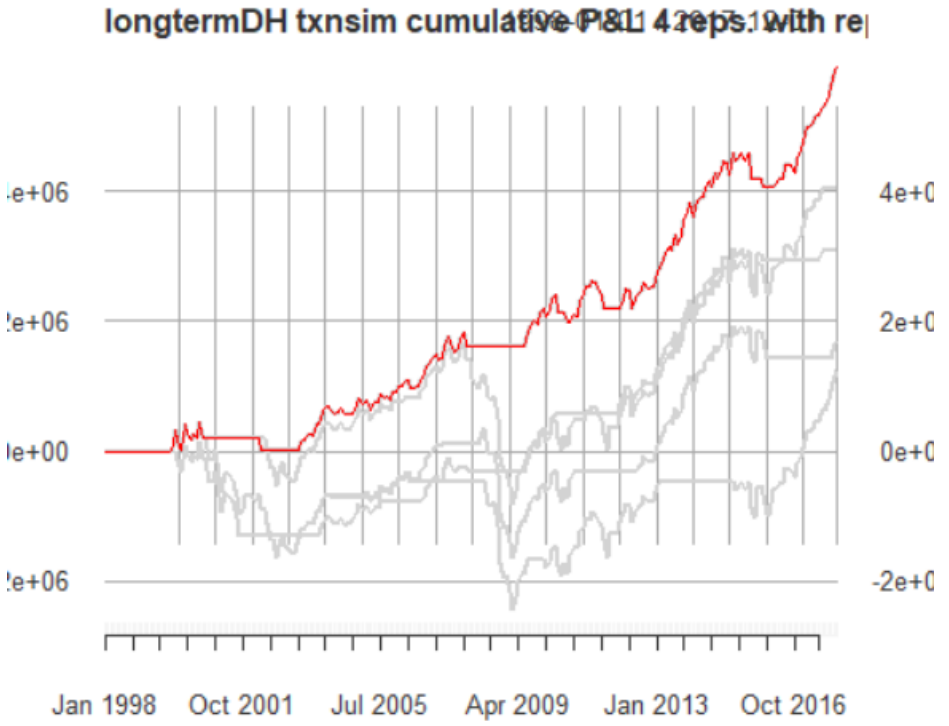

txnsim Example

- txnsim also has
  - Summary of confidence intervals
  - Cumulative P&L distributions (quantile(.))
  - Histograms of various performance measures with CI's overlayed
- See example: CFRM522_018a_FaberStrategy_mcsim_txnsim.R

Summary

- Overview of Monte Carlo methods
- `mcsim(.)` examples
- Generating results and plots
- Sampling without replacement not as useful as with replacement; `mcsim(.)` assumes daily statistics and will not be as realistic in the latter case

- `txnsim(.)` examples
- Generating results and plots
- Simulations better reflect characteristics of the strategy rather than just rearranging P&L values
- Can be a useful tool for visualizing skill vs luck