

Bootstrapping Estimates of the CER Model

Econ 424
Eric Zivot
Fall 2008

Updated: October 18, 2008

© Eric Zivot 2006

R Package boot

- Implements a variety of bootstrapping functions
- Background material is book by Davidson and Hinkley, *Bootstrap Methods and Their Application*, Cambridge University Press, 1997.
- Main functions are:
 - `boot()` bootstrap user supplied function
 - `boot.ci()` compute bootstrap confidence interval

© Eric Zivot 2006

Example: Bootstrapping sample mean

```
# function for bootstrapping sample mean
mean.boot = function(x, idx) {
# arguments:
# x      data to be resampled
# idx    vector of scrambled indices created
#        by boot() function
# value:
# ans    mean value computed using resampled
#        data
      ans = mean(x[idx])
      ans
}

```

© Eric Zivot 2006

Example: Bootstrapping sample mean

```
> MSFT.mean.boot = boot(MSFT, statistic = mean.boot, R=999)
> class(MSFT.mean.boot)
[1] "boot"
```

Number of bootstrap samples

```
> MSFT.mean.boot
```

ORDINARY NONPARAMETRIC BOOTSTRAP

Call:

```
boot(data = MSFT, statistic = mean.boot, R = 999)
```

Bootstrap Statistics :

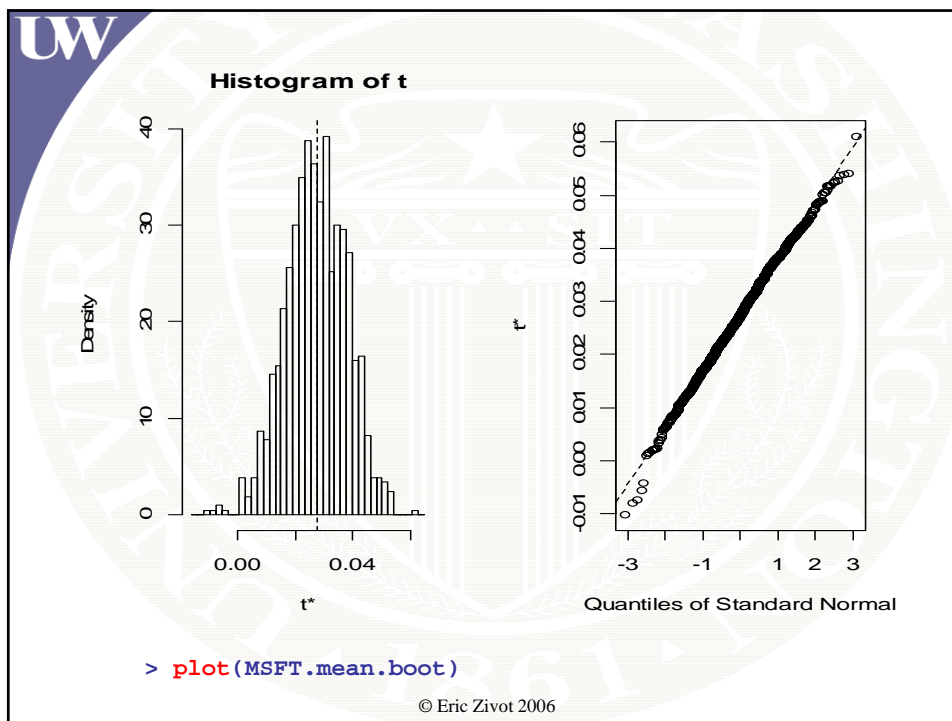
	original	bias	std. error
t1*	0.02756387	-0.0001305493	0.01052834

Sample mean

Bootstrap estimate of bias

Bootstrap estimate of SE

© Eric Zivot 2006



UW

Compare Bootstrap Statistics with Analytic Formulas

ORDINARY NONPARAMETRIC BOOTSTRAP

Call:
`boot(data = MSFT, statistic = mean.boot, R = 999)`

Bootstrap Statistics :

	original	bias	std. error
t1*	0.02756387	-0.0001305493	0.01052834

compare boot SE with analytic SE

```
> se.muhat.MSFT = sigmahat.MSFT/sqrt(length(MSFT))
> se.muhat.MSFT
```

[1] 0.01068234

© Eric Zivot 2006

Bootstrap Confidence Intervals

```
> boot.ci(MSFT.mean.boot, conf = 0.95, type =
+         c("norm","perc"))
BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
Based on 999 bootstrap replicates

CALL :
boot.ci(boot.out = MSFT.mean.boot, conf = 0.95, type =
        c("norm", "perc"))

Intervals :
Level      Normal          Percentile
95%    ( 0.0071, 0.0483 )  ( 0.0065, 0.0471 )
Calculations and Intervals on Original Scale
```

© Eric Zivot 2006

Example: Bootstrapping Sample SD

```
# function for bootstrapping sample standard deviation
sd.boot = function(x, idx) {
# arguments:
# x          data to be resampled
# idx       vector of scrambled indices created by
#           boot() function
# value:
# ans       sd value computed using resampled data
  ans = sd(x[idx])
  ans
}
```

© Eric Zivot 2006

Example: Bootstrapping Sample SD

```
> MSFT.sd.boot = boot(MSFT, statistic = sd.boot, R=999)
> MSFT.sd.boot
```

ORDINARY NONPARAMETRIC BOOTSTRAP

```
Call:
boot(data = MSFT, statistic = sd.boot, R = 999)
```

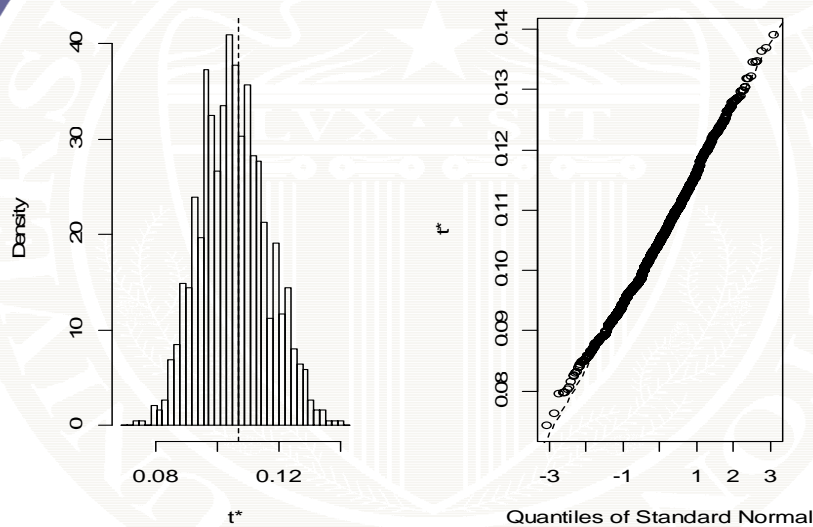
```
Bootstrap Statistics :
  original      bias  std. error
t1* 0.1068234 -0.001457609 0.01078511
```

```
# compare boot SE with analytic SE based on CLT
> se.sigmahat.MSFT = sigmahat.MSFT/sqrt(2*length(MSFT))
> se.sigmahat.MSFT
```

```
[1] 0.007553558
```

© Eric Zivot 2006

Histogram of t



```
> plot(MSFT.sd.boot)
```

© Eric Zivot 2006

Example: Bootstrapping Normal VaR

```
ValueAtRisk.boot = function(x, idx, p=0.05, w=100000) {
# x.mat      data to be resampled
# idx       vector of scrambled indices created by
#           boot() function
# p         probability value for VaR calculation
# w         value of initial investment
# value:
# ans       Value-at-Risk computed using resampled data

  q = mean(x[idx]) + sd(x[idx])*qnorm(p)
  VaR = (exp(q) - 1)*w
  VaR
}
```

© Eric Zivot 2006

Example: Bootstrapping Normal VaR

```
> MSFT.VaR.boot
```

```
ORDINARY NONPARAMETRIC BOOTSTRAP
```

```
Call:
```

```
boot(data = MSFT, statistic = ValueAtRisk.boot, R = 999)
```

```
Bootstrap Statistics :
```

	original	bias	std. error
t1*	-13769.40	210.2801	1886.953

© Eric Zivot 2006

Example: Bootstrapping Normal VaR

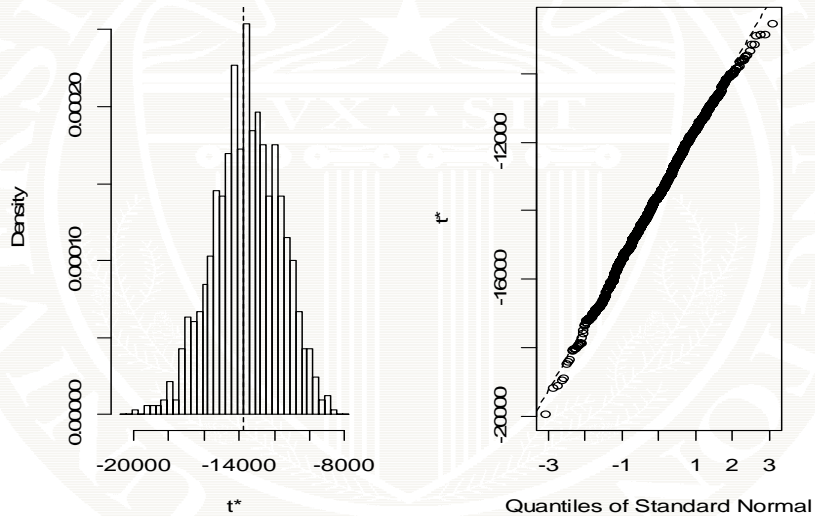
```
> boot.ci(MSFT.VaR.boot, conf=0.95, type=c("norm", "perc"))
BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
Based on 999 bootstrap replicates
```

```
CALL :
boot.ci(boot.out = MSFT.VaR.boot, conf = 0.95, type =
c("norm", "perc"))
```

```
Intervals :
Level      Normal          Percentile
95%      (-17678, -10281 )   (-17212, -10009 )
```

© Eric Zivot 2006

Histogram of t



```
> plot(MSFT.VaR.boot)
```

© Eric Zivot 2006