ISLR: Bootstrap quiz

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Download the file `5.R.RData` and load it into R using the `load` function.

```
data_address <- "https://lagunita.stanford.edu/c4x/HumanitiesSciences/StatLearning/asset/5.R.RData"
download.file(data_address, paste0(getwd(), "/R"))
```

5.R.R1

Consider the linear regression model of y on X1 and X2. What is the standard error for β_1?

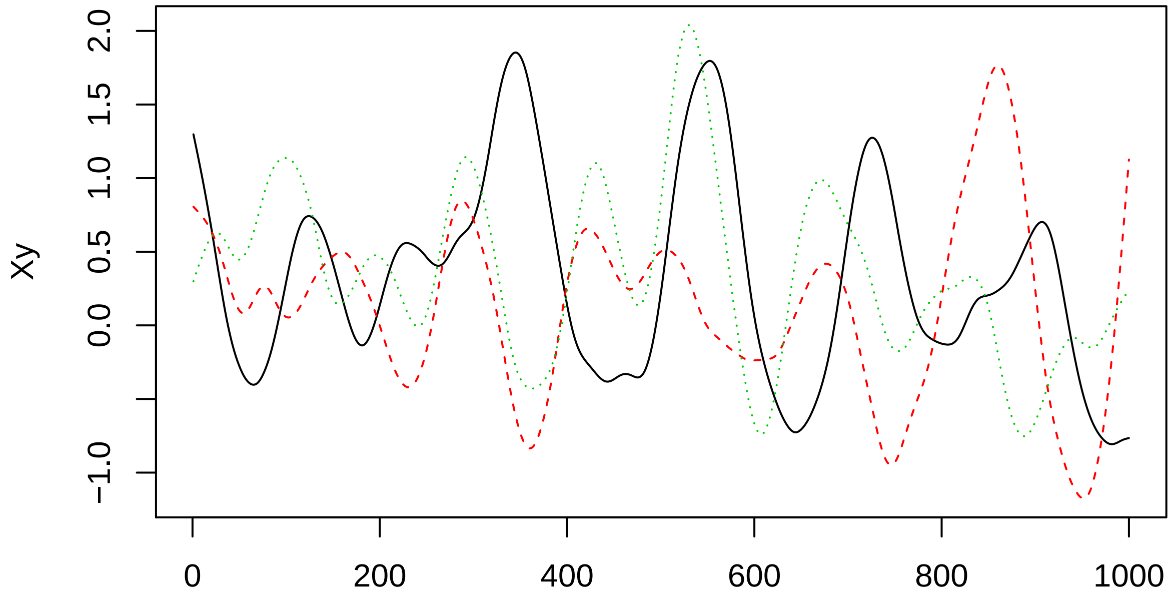
```
load(path.expand("~/R/Statistical-Learning/data/5.R.RData"))

model_51 <- lm(y ~ X1 + X2, data = Xy)

summary(model_51)
```

```
##
## Call:
## lm(formula = y ~ X1 + X2, data = Xy)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -1.44171 -0.25468 -0.01736  0.33081  1.45860
##
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)
## (Intercept)  0.26583    0.01988  13.372  < 2e-16 ***
## X1           0.14533    0.02593   5.604 2.71e-08 ***
## X2           0.31337    0.02923  10.722  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.5451 on 997 degrees of freedom
## Multiple R-squared:  0.1171, Adjusted R-squared:  0.1154
## F-statistic: 66.14 on 2 and 997 DF,  p-value: < 2.2e-16
```

5.R.R2

Next, plot the data using `matplot(Xy, type="l")`. Which of the following do you think is most likely given what you see?

```r
matplot(Xy, type="l")
```



5.R.R3

Now, use the (standard) bootstrap to estimate s.e.($\hat{\beta}_1$). To within 10%, what do you get?

```r
beta_hat_1 <- function(data, index, formula) {

    model <- lm(formula, data = data[index, ])

    summary(model)$coefficients[2, 1]
}

library(boot)
boot_model_51 <- boot(data = Xy, statistic = beta_hat_1, R = 15000, formula = y ~
    X1 + X2, parallel = "snow", ncpus = 4)

boot.ci(boot_model_51, conf = 0.9)
```

```
## Warning in boot.ci(boot_model_51, conf = 0.9): bootstrap variances needed
## for studentized intervals
```

```
## BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
## Based on 15000 bootstrap replicates
##
## CALL :
## boot.ci(boot.out = boot_model_51, conf = 0.9)
##
## Intervals :
## Level      Normal              Basic
## 90%   ( 0.0970,  0.1929 )   ( 0.0970,  0.1930 )
##
## Level     Percentile            BCa
## 90%   ( 0.0976,  0.1937 )   ( 0.0974,  0.1935 )
## Calculations and Intervals on Original Scale
```

```r
boot_model_51
```

```
##
## ORDINARY NONPARAMETRIC BOOTSTRAP
##
##
## Call:
## boot(data = Xy, statistic = beta_hat_1, R = 15000, formula = y ~
##     X1 + X2, parallel = "snow", ncpus = 4)
##
##
## Bootstrap Statistics :
##      original       bias    std. error
## t1* 0.1453263 0.0003725628  0.02915797
```

5.R.R4

Finally, use the block bootstrap to estimate s.e.($\hat{\beta}_1$). Use blocks of 100 contiguous observations, and resample ten whole blocks with replacement then paste them together to construct each bootstrap time series. For example, one of your bootstrap resamples could be:

```
block_boot_model_51 <- tsboot(Xy, beta_hat_1, formula = y ~ X1 + X2, R = 15000,
    sim = "fixed", l = 100, parallel = "snow", ncpus = 4)

boot.ci(block_boot_model_51, conf = 0.9)
```

```
## Warning in boot.ci(block_boot_model_51, conf = 0.9): bootstrap variances
## needed for studentized intervals
```

```
## Warning in boot.ci(block_boot_model_51, conf = 0.9): BCa intervals not
## defined for time series bootstraps
```

```
## BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
## Based on 15000 bootstrap replicates
##
## CALL :
## boot.ci(boot.out = block_boot_model_51, conf = 0.9)
##
## Intervals :
## Level      Normal              Basic              Percentile
## 90%   (-0.1787,  0.4657 )   (-0.1709,  0.4609 )   (-0.1702,  0.4615 )
## Calculations and Intervals on Original Scale
```

```
block_boot_model_51
```

```
##
## BLOCK BOOTSTRAP FOR TIME SERIES
##
## Fixed Block Length of 100
##
## Call:
## tsboot(tseries = Xy, statistic = beta_hat_1, R = 15000, l = 100,
##     sim = "fixed", formula = y ~ X1 + X2, parallel = "snow",
##     ncpus = 4)
##
##
## Bootstrap Statistics :
##      original      bias    std. error
## t1* 0.1453263 0.001818073   0.1958623
```