

# betaMC: Staging

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## 1 Monte Carlo Simulation

```
# Fit the regression model
object <- lm(QUALITY ~ NARTIC + PCTGRT + PCTSUPP, data = nas1982)
# Generate the sampling distribution of parameter estimates
mc <- MC(object, R = 20000, type = "mvn", seed = 42)
```

## 2 Standardized Regression Slopes

```
out <- BetaMC(mc)
# Methods -----
print(out)

#> Call:
#> BetaMC(object = mc)
#>
#> Standardized regression slopes
#> type = "mvn"
#>      est      se      R 0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> NARTIC  0.4951 0.0762 20000 0.2384 0.2905 0.3378 0.6372 0.6795 0.7293
#> PCTGRT  0.3915 0.0769 20000 0.1326 0.1920 0.2359 0.5372 0.5830 0.6422
#> PCTSUPP 0.2632 0.0750 20000 0.0275 0.0758 0.1180 0.4120 0.4630 0.5312

summary(out)

#> Call:
#> BetaMC(object = mc)
#>
#> Standardized regression slopes
#> type = "mvn"
#>      est      se      R 0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> NARTIC  0.4951 0.0762 20000 0.2384 0.2905 0.3378 0.6372 0.6795 0.7293
#> PCTGRT  0.3915 0.0769 20000 0.1326 0.1920 0.2359 0.5372 0.5830 0.6422
#> PCTSUPP 0.2632 0.0750 20000 0.0275 0.0758 0.1180 0.4120 0.4630 0.5312
```

```

coef(out)

#>      NARTIC      PCTGRT      PCTSUPP
#> 0.4951451 0.3914887 0.2632477

vcov(out)

#>              NARTIC      PCTGRT      PCTSUPP
#> NARTIC    0.005800490 -0.003303078 -0.002199499
#> PCTGRT   -0.003303078  0.005917349 -0.001713641
#> PCTSUPP  -0.002199499 -0.001713641  0.005622577

confint(out)

#>              2.5 %      97.5 %
#> NARTIC    0.3377634 0.6372391
#> PCTGRT    0.2359309 0.5372193
#> PCTSUPP   0.1180128 0.4119543

```

### 3 Multiple Correlation

```

out <- RSqMC(mc)
# Methods -----
print(out)

#> Call:
#> RSqMC(object = mc)
#>
#> R-squared and adjusted R-squared
#> type = "mvn"
#>      est      se      R 0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> rsq 0.8045 0.0562 20000 0.5065 0.5980 0.6603 0.8816 0.9024 0.9299
#> adj 0.7906 0.0603 20000 0.4713 0.5692 0.6360 0.8732 0.8954 0.9249

summary(out)

#> Call:
#> RSqMC(object = mc)
#>
#> R-squared and adjusted R-squared
#> type = "mvn"
#>      est      se      R 0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> rsq 0.8045 0.0562 20000 0.5065 0.5980 0.6603 0.8816 0.9024 0.9299
#> adj 0.7906 0.0603 20000 0.4713 0.5692 0.6360 0.8732 0.8954 0.9249

```

```

coef(out)

#>      rsq      adj
#> 0.8045263 0.7905638

vcov(out)

#>      rsq      adj
#> rsq 0.003163524 0.003389490
#> adj 0.003389490 0.003631597

confint(out)

#>      2.5 %    97.5 %
#> rsq 0.6602807 0.8816177
#> adj 0.6360151 0.8731618

```

## 4 Semipartial Correlation

```

out <- SCorMC(mc)
# Methods -----
print(out)

#> Call:
#> SCorMC(object = mc)
#>
#> Semipartial correlations
#> type = "mvn"
#>      est      se      R 0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> NARTIC  0.4312 0.0778 20000 0.1765 0.2264 0.2680 0.5720 0.6266 0.6884
#> PCTGRT  0.3430 0.0743 20000 0.1084 0.1544 0.1940 0.4844 0.5349 0.5889
#> PCTSUPP 0.2385 0.0700 20000 0.0198 0.0654 0.1011 0.3763 0.4271 0.4932

summary(out)

#> Call:
#> SCorMC(object = mc)
#>
#> Semipartial correlations
#> type = "mvn"
#>      est      se      R 0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> NARTIC  0.4312 0.0778 20000 0.1765 0.2264 0.2680 0.5720 0.6266 0.6884
#> PCTGRT  0.3430 0.0743 20000 0.1084 0.1544 0.1940 0.4844 0.5349 0.5889
#> PCTSUPP 0.2385 0.0700 20000 0.0198 0.0654 0.1011 0.3763 0.4271 0.4932

```

```
coef(out)

#>      NARTIC      PCTGRT      PCTSUPP
#> 0.4311525 0.3430075 0.2384789

vcov(out)

#>           NARTIC           PCTGRT           PCTSUPP
#> NARTIC    0.006052555 -0.0012445391 -0.0009525340
#> PCTGRT   -0.001244539  0.0055209652 -0.0007423096
#> PCTSUPP  -0.000952534 -0.0007423096  0.0049012480

confint(out)

#>           2.5 %      97.5 %
#> NARTIC  0.2679836 0.5719904
#> PCTGRT  0.1939501 0.4844166
#> PCTSUPP 0.1011113 0.3762510
```

## 5 Improvement in R-Squared

```
out <- DeltaRSqMC(mc)
# Methods -----
print(out)

#> Call:
#> DeltaRSqMC(object = mc)
#>
#> Improvement in R-squared
#> type = "mvn"
#>      est      se      R 0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> NARTIC  0.1859 0.0662 20000 0.0311 0.0513 0.0718 0.3272 0.3926 0.4739
#> PCTGRT  0.1177 0.0509 20000 0.0117 0.0238 0.0376 0.2347 0.2862 0.3468
#> PCTSUPP 0.0569 0.0343 20000 0.0004 0.0043 0.0102 0.1416 0.1824 0.2432

summary(out)

#> Call:
#> DeltaRSqMC(object = mc)
#>
#> Improvement in R-squared
#> type = "mvn"
#>      est      se      R 0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> NARTIC  0.1859 0.0662 20000 0.0311 0.0513 0.0718 0.3272 0.3926 0.4739
#> PCTGRT  0.1177 0.0509 20000 0.0117 0.0238 0.0376 0.2347 0.2862 0.3468
#> PCTSUPP 0.0569 0.0343 20000 0.0004 0.0043 0.0102 0.1416 0.1824 0.2432
```

```
coef(out)

#>      NARTIC      PCTGRT      PCTSUPP
#> 0.1858925 0.1176542 0.0568722

vcov(out)

#>              NARTIC          PCTGRT          PCTSUPP
#> NARTIC    0.0043823631 -0.0007170694 -0.0003757888
#> PCTGRT   -0.0007170694  0.0025957193 -0.0002266284
#> PCTSUPP  -0.0003757888 -0.0002266284  0.0011785164

confint(out)

#>              2.5 %      97.5 %
#> NARTIC    0.07181522 0.3271731
#> PCTGRT    0.03761665 0.2346594
#> PCTSUPP   0.01022350 0.1415648
```

## 6 Squared Partial Correlation

```
out <- PCorMC(mc)
# Methods -----
print(out)

#> Call:
#> PCorMC(object = mc)
#>
#> Squared partial correlations
#> type = "mvn"
#>      est      se      R 0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> NARTIC  0.4874 0.1058 20000 0.1130 0.1808 0.2407 0.6544 0.7100 0.7760
#> PCTGRT  0.3757 0.1077 20000 0.0459 0.0991 0.1494 0.5647 0.6333 0.7161
#> PCTSUPP 0.2254 0.1001 20000 0.0016 0.0193 0.0467 0.4300 0.5081 0.5988

summary(out)

#> Call:
#> PCorMC(object = mc)
#>
#> Squared partial correlations
#> type = "mvn"
#>      est      se      R 0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> NARTIC  0.4874 0.1058 20000 0.1130 0.1808 0.2407 0.6544 0.7100 0.7760
#> PCTGRT  0.3757 0.1077 20000 0.0459 0.0991 0.1494 0.5647 0.6333 0.7161
#> PCTSUPP 0.2254 0.1001 20000 0.0016 0.0193 0.0467 0.4300 0.5081 0.5988
```

```
coef(out)

#>      NARTIC      PCTGRT      PCTSUPP
#> 0.4874382 0.3757383 0.2253739

vcov(out)

#>              NARTIC      PCTGRT      PCTSUPP
#> NARTIC  0.0112008940 0.0006470635 0.0003538981
#> PCTGRT  0.0006470635 0.0116034548 0.0001757312
#> PCTSUPP 0.0003538981 0.0001757312 0.0100202426

confint(out)

#>              2.5 %      97.5 %
#> NARTIC  0.24066440 0.6544179
#> PCTGRT  0.14935195 0.5646909
#> PCTSUPP 0.04674574 0.4300379
```

## 7 Differences of Standardized Slopes

```
out <- DiffBetaMC(mc)
# Methods -----
print(out)

#> Call:
#> DiffBetaMC(object = mc)
#>
#> Differences of standardized regression slopes
#> type = "mvn"
#>           est      se      R  0.05%   0.5%   2.5%  97.5%  99.5%  99.95%
#> NARTIC-PCTGRT  0.1037 0.1354 20000 -0.3423 -0.2441 -0.1622 0.3650 0.4463 0.5229
#> NARTIC-PCTSUPP 0.2319 0.1258 20000 -0.2009 -0.1132 -0.0216 0.4693 0.5411 0.6035
#> PCTGRT-PCTSUPP 0.1282 0.1223 20000 -0.2802 -0.1956 -0.1179 0.3636 0.4349 0.5149

summary(out)

#> Call:
#> DiffBetaMC(object = mc)
#>
#> Differences of standardized regression slopes
#> type = "mvn"
#>           est      se      R  0.05%   0.5%   2.5%  97.5%  99.5%  99.95%
#> NARTIC-PCTGRT  0.1037 0.1354 20000 -0.3423 -0.2441 -0.1622 0.3650 0.4463 0.5229
#> NARTIC-PCTSUPP 0.2319 0.1258 20000 -0.2009 -0.1132 -0.0216 0.4693 0.5411 0.6035
#> PCTGRT-PCTSUPP 0.1282 0.1223 20000 -0.2802 -0.1956 -0.1179 0.3636 0.4349 0.5149
```

```

coef(out)

#>   NARTIC-PCTGRT NARTIC-PCTSUPP PCTGRT-PCTSUPP
#>      0.1036564      0.2318974      0.1282410

vcov(out)

#>               NARTIC-PCTGRT NARTIC-PCTSUPP PCTGRT-PCTSUPP
#> NARTIC-PCTGRT      0.018323995      0.009589425      -0.00873457
#> NARTIC-PCTSUPP      0.009589425      0.015822065       0.00623264
#> PCTGRT-PCTSUPP     -0.008734570      0.006232640       0.01496721

confint(out)

#>               2.5 %      97.5 %
#> NARTIC-PCTGRT  -0.16216294  0.3649672
#> NARTIC-PCTSUPP -0.02160187  0.4693024
#> PCTGRT-PCTSUPP -0.11794195  0.3635986

```

## 8 Monte Carlo Simulation - Multiple Imputation

```

nas1982_missing <- mice::ampute(nas1982, mech = "MCAR")$amp
# Fit the regression model
object <- lm(QUALITY ~ NARTIC + PCTGRT + PCTSUPP, data = nas1982_missing)
# Generate the sampling distribution of parameter estimates
mi <- mice::mice(nas1982_missing, m = 100, seed = 42, print = FALSE)
mc <- MCMC(object, mi = mi, R = 20000, type = "mvn",
            seed = 42)

```

## 9 Standardized Regression Slopes

```

out <- BetaMC(mc)
# Methods -----
print(out)

#> Call:
#> BetaMC(object = mc)
#>
#> Standardized regression slopes
#> type = "mvn"
#>      est      se      R  0.05%  0.5%  2.5%  97.5%  99.5%  99.95%
#> NARTIC  0.4930 0.0837 20000  0.2049 0.2704 0.3201 0.6492 0.6978 0.7463

```

```

#> PCTGRT  0.3974 0.0832 20000  0.1119 0.1798 0.2284 0.5559 0.6039 0.6611
#> PCTSUPP 0.2427 0.0846 20000 -0.0301 0.0294 0.0802 0.4128 0.4654 0.5344

summary(out)

#> Call:
#> BetaMC(object = mc)
#>
#> Standardized regression slopes
#> type = "mvn"
#>      est      se      R  0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> NARTIC  0.4930 0.0837 20000  0.2049 0.2704 0.3201 0.6492 0.6978 0.7463
#> PCTGRT  0.3974 0.0832 20000  0.1119 0.1798 0.2284 0.5559 0.6039 0.6611
#> PCTSUPP 0.2427 0.0846 20000 -0.0301 0.0294 0.0802 0.4128 0.4654 0.5344

coef(out)

#>      NARTIC      PCTGRT      PCTSUPP
#> 0.4929845 0.3973692 0.2427459

vcov(out)

#>           NARTIC           PCTGRT           PCTSUPP
#> NARTIC  0.007002768 -0.003750411 -0.002894797
#> PCTGRT -0.003750411  0.006922144 -0.002033649
#> PCTSUPP -0.002894797 -0.002033649  0.007160281

confint(out)

#>           2.5 %      97.5 %
#> NARTIC  0.3200581 0.6492466
#> PCTGRT  0.2283692 0.5559488
#> PCTSUPP 0.0801568 0.4127532

```

## 10 Multiple Correlation

```

out <- RSqMC(mc)
# Methods -----
print(out)

#> Call:
#> RSqMC(object = mc)
#>
#> R-squared and adjusted R-squared
#> type = "mvn"

```



```

#>      est      se      R 0.05%  0.5%   2.5%  97.5%  99.5% 99.95%
#> rsq 0.7867 0.0652 20000 0.4322 0.5586 0.6262 0.8799 0.9087 0.9382
#> adj 0.7715 0.0719 20000 0.3734 0.5129 0.5876 0.8675 0.8993 0.9318

summary(out)

#> Call:
#> RSqMC(object = mc)
#>
#> R-squared and adjusted R-squared
#> type = "mvn"
#>      est      se      R 0.05%  0.5%   2.5%  97.5%  99.5% 99.95%
#> rsq 0.7867 0.0652 20000 0.4322 0.5586 0.6262 0.8799 0.9087 0.9382
#> adj 0.7715 0.0719 20000 0.3734 0.5129 0.5876 0.8675 0.8993 0.9318

coef(out)

#>      rsq      adj
#> 0.7867234 0.7714893

vcov(out)

#>      rsq      adj
#> rsq 0.004245977 0.004685216
#> adj 0.004685216 0.005169893

confint(out)

#>      2.5 %    97.5 %
#> rsq 0.6262241 0.8798885
#> adj 0.5875576 0.8674632

```

## 11 Semipartial Correlation

```

out <- SCorMC(mc)
# Methods -----
print(out)

#> Call:
#> SCorMC(object = mc)
#>
#> Semipartial correlations
#> type = "mvn"
#>      est      se      R 0.05%  0.5%   2.5%  97.5%  99.5% 99.95%
#> NARTIC 0.4232 0.0851 20000 0.1551 0.2014 0.2472 0.5803 0.6370 0.7006

```

```

#> PCTGRT  0.3510 0.0804 20000  0.0939 0.1415 0.1878 0.5014 0.5579 0.6260
#> PCTSUPP 0.2190 0.0787 20000 -0.0222 0.0244 0.0684 0.3770 0.4332 0.4943

summary(out)

#> Call:
#> SCorMC(object = mc)
#>
#> Semipartial correlations
#> type = "mvn"
#>      est      se      R  0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> NARTIC  0.4232 0.0851 20000  0.1551 0.2014 0.2472 0.5803 0.6370 0.7006
#> PCTGRT  0.3510 0.0804 20000  0.0939 0.1415 0.1878 0.5014 0.5579 0.6260
#> PCTSUPP 0.2190 0.0787 20000 -0.0222 0.0244 0.0684 0.3770 0.4332 0.4943

coef(out)

#>      NARTIC      PCTGRT      PCTSUPP
#> 0.4232313 0.3509918 0.2189535

vcov(out)

#>      NARTIC      PCTGRT      PCTSUPP
#> NARTIC  0.007247553 -0.001554738 -0.001367987
#> PCTGRT -0.001554738  0.006456763 -0.001178817
#> PCTSUPP -0.001367987 -0.001178817  0.006188656

confint(out)

#>      2.5 %   97.5 %
#> NARTIC  0.2471657 0.5802803
#> PCTGRT  0.1878162 0.5014294
#> PCTSUPP 0.0683932 0.3770499

```

## 12 Improvement in R-Squared

```

out <- DeltaRSqMC(mc)
# Methods -----
print(out)

#> Call:
#> DeltaRSqMC(object = mc)
#>
#> Improvement in R-squared
#> type = "mvn"

```

```

#>           est      se      R 0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> NARTIC   0.1791 0.0713 20000 0.0241 0.0406 0.0611 0.3367 0.4057 0.4908
#> PCTGRT   0.1232 0.0562 20000 0.0088 0.0200 0.0353 0.2514 0.3113 0.3918
#> PCTSUPP  0.0479 0.0361 20000 0.0000 0.0007 0.0047 0.1422 0.1876 0.2444

summary(out)

#> Call:
#> DeltaRSqMC(object = mc)
#>
#> Improvement in R-squared
#> type = "mvn"
#>           est      se      R 0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> NARTIC   0.1791 0.0713 20000 0.0241 0.0406 0.0611 0.3367 0.4057 0.4908
#> PCTGRT   0.1232 0.0562 20000 0.0088 0.0200 0.0353 0.2514 0.3113 0.3918
#> PCTSUPP  0.0479 0.0361 20000 0.0000 0.0007 0.0047 0.1422 0.1876 0.2444

coef(out)

#>      NARTIC      PCTGRT      PCTSUPP
#> 0.17912477 0.12319522 0.04794063

vcov(out)

#>           NARTIC      PCTGRT      PCTSUPP
#> NARTIC   0.0050787545 -0.0008867177 -0.0004782472
#> PCTGRT  -0.0008867177  0.0031622647 -0.0003411482
#> PCTSUPP -0.0004782472 -0.0003411482  0.0013024844

confint(out)

#>           2.5 %    97.5 %
#> NARTIC   0.06109089 0.3367253
#> PCTGRT   0.03527492 0.2514314
#> PCTSUPP  0.00467763 0.1421666

```

## 13 Squared Partial Correlation

```

out <- PCorMC(mc)
# Methods -----
print(out)

#> Call:
#> PCorMC(object = mc)
#>

```

```

#> Squared partial correlations
#> type = "mvn"
#>           est      se      R 0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> NARTIC   0.4573 0.1194 20000 0.0840 0.1373 0.1935 0.6576 0.7223 0.8209
#> PCTGRT   0.3677 0.1186 20000 0.0314 0.0746 0.1234 0.5825 0.6590 0.7368
#> PCTSUPP 0.1860 0.1052 20000 0.0001 0.0030 0.0193 0.4203 0.5071 0.6227

summary(out)

#> Call:
#> PCorMC(object = mc)
#>
#> Squared partial correlations
#> type = "mvn"
#>           est      se      R 0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> NARTIC   0.4573 0.1194 20000 0.0840 0.1373 0.1935 0.6576 0.7223 0.8209
#> PCTGRT   0.3677 0.1186 20000 0.0314 0.0746 0.1234 0.5825 0.6590 0.7368
#> PCTSUPP 0.1860 0.1052 20000 0.0001 0.0030 0.0193 0.4203 0.5071 0.6227

coef(out)

#>      NARTIC      PCTGRT      PCTSUPP
#> 0.4572612 0.3676734 0.1859643

vcov(out)

#>           NARTIC      PCTGRT      PCTSUPP
#> NARTIC 0.0142620747 0.0019618742 0.0005255032
#> PCTGRT 0.0019618742 0.0140571213 0.0004846195
#> PCTSUPP 0.0005255032 0.0004846195 0.0110758269

confint(out)

#>           2.5 %    97.5 %
#> NARTIC 0.19349141 0.6576123
#> PCTGRT 0.12335919 0.5825345
#> PCTSUPP 0.01934744 0.4202882

```

## 14 Differences of Standardized Slopes

```

out <- DiffBetaMC(mc)
# Methods -----
print(out)

#> Call:

```

```

#> DiffBetaMC(object = mc)
#>
#> Differences of standardized regression slopes
#> type = "mvn"
#>           est      se      R  0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> NARTIC-PCTGRT  0.0956 0.1464 20000 -0.3757 -0.2774 -0.1928 0.3789 0.4642 0.5573
#> NARTIC-PCTSUPP 0.2502 0.1413 20000 -0.2476 -0.1302 -0.0406 0.5158 0.5974 0.6967
#> PCTGRT-PCTSUPP 0.1546 0.1347 20000 -0.2915 -0.1973 -0.1178 0.4122 0.4930 0.5863

summary(out)

#> Call:
#> DiffBetaMC(object = mc)
#>
#> Differences of standardized regression slopes
#> type = "mvn"
#>           est      se      R  0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> NARTIC-PCTGRT  0.0956 0.1464 20000 -0.3757 -0.2774 -0.1928 0.3789 0.4642 0.5573
#> NARTIC-PCTSUPP 0.2502 0.1413 20000 -0.2476 -0.1302 -0.0406 0.5158 0.5974 0.6967
#> PCTGRT-PCTSUPP 0.1546 0.1347 20000 -0.2915 -0.1973 -0.1178 0.4122 0.4930 0.5863

coef(out)

#>   NARTIC-PCTGRT NARTIC-PCTSUPP PCTGRT-PCTSUPP
#>    0.09561529    0.25023858    0.15462329

vcov(out)

#>           NARTIC-PCTGRT NARTIC-PCTSUPP PCTGRT-PCTSUPP
#> NARTIC-PCTGRT    0.021425734    0.011614327   -0.009811407
#> NARTIC-PCTSUPP    0.011614327    0.019952643    0.008338316
#> PCTGRT-PCTSUPP   -0.009811407    0.008338316    0.018149723

confint(out)

#>           2.5 %    97.5 %
#> NARTIC-PCTGRT  -0.19281315 0.3789082
#> NARTIC-PCTSUPP -0.04063053 0.5157603
#> PCTGRT-PCTSUPP -0.11783047 0.4122433

```

## References

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