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 0.0765 20000 0.2361 0.2875 0.3368 0.6354 0.6813 0.7353
#> PCTGRT  0.3915 0.0761 20000 0.1416 0.1937 0.2379 0.5368 0.5819 0.6398
#> PCTSUPP 0.2632 0.0747 20000 0.0267 0.0779 0.1178 0.4093 0.4589 0.5320

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 0.0765 20000 0.2361 0.2875 0.3368 0.6354 0.6813 0.7353
#> PCTGRT  0.3915 0.0761 20000 0.1416 0.1937 0.2379 0.5368 0.5819 0.6398
#> PCTSUPP 0.2632 0.0747 20000 0.0267 0.0779 0.1178 0.4093 0.4589 0.5320
```

```
coef(out)

#>    NARTIC    PCTGRT   PCTSUPP
#> 0.4951451 0.3914887 0.2632477

vcov(out)

#>               NARTIC       PCTGRT      PCTSUPP
#> NARTIC   0.005849298 -0.003297148 -0.002165995
#> PCTGRT  -0.003297148  0.005796229 -0.001703916
#> PCTSUPP -0.002165995 -0.001703916  0.005574450

confint(out)

#>             2.5 %    97.5 %
#> NARTIC  0.3368306 0.6354279
#> PCTGRT  0.2378812 0.5368376
#> PCTSUPP 0.1177538 0.4092548
```

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 0.0560 20000 0.5397 0.6006 0.6623 0.8789 0.9038 0.9266
#> adj 0.7906 0.0601 20000 0.5069 0.5721 0.6382 0.8702 0.8969 0.9214

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 0.0560 20000 0.5397 0.6006 0.6623 0.8789 0.9038 0.9266
#> adj 0.7906 0.0601 20000 0.5069 0.5721 0.6382 0.8702 0.8969 0.9214
```

```r
coef(out)

#>       rsq       adj
#> 0.8045263 0.7905638

vcov(out)

#>             rsq         adj
#> rsq 0.003141591 0.003365990
#> adj 0.003365990 0.003606418

confint(out)

#>         2.5 %    97.5 %
#> rsq 0.6623081 0.8788682
#> adj 0.6381872 0.8702159
```

4 Semipartial Correlation

```r
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 0.0783 20000 0.1758 0.2242 0.2678 0.5736 0.6241 0.6966
#> PCTGRT  0.3430 0.0731 20000 0.1104 0.1577 0.1948 0.4805 0.5356 0.5935
#> PCTSUPP 0.2385 0.0699 20000 0.0228 0.0675 0.1016 0.3748 0.4250 0.4978

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 0.0783 20000 0.1758 0.2242 0.2678 0.5736 0.6241 0.6966
#> PCTGRT  0.3430 0.0731 20000 0.1104 0.1577 0.1948 0.4805 0.5356 0.5935
#> PCTSUPP 0.2385 0.0699 20000 0.0228 0.0675 0.1016 0.3748 0.4250 0.4978
```

```
coef(out)

#>    NARTIC    PCTGRT   PCTSUPP
#> 0.4311525 0.3430075 0.2384789

vcov(out)

#>                NARTIC        PCTGRT       PCTSUPP
#> NARTIC   0.0061321623 -0.0012528441 -0.0009082182
#> PCTGRT  -0.0012528441  0.0053483029 -0.0007484783
#> PCTSUPP -0.0009082182 -0.0007484783  0.0048837434

confint(out)

#>             2.5 %    97.5 %
#> NARTIC  0.2677757 0.5736470
#> PCTGRT  0.1947635 0.4804929
#> PCTSUPP 0.1015873 0.3747518
```

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 0.0665 20000 0.0309 0.0502 0.0717 0.3291 0.3895 0.4852
#> PCTGRT  0.1177 0.0501 20000 0.0122 0.0249 0.0379 0.2309 0.2869 0.3522
#> PCTSUPP 0.0569 0.0341 20000 0.0005 0.0046 0.0103 0.1404 0.1807 0.2478

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 0.0665 20000 0.0309 0.0502 0.0717 0.3291 0.3895 0.4852
#> PCTGRT  0.1177 0.0501 20000 0.0122 0.0249 0.0379 0.2309 0.2869 0.3522
#> PCTSUPP 0.0569 0.0341 20000 0.0005 0.0046 0.0103 0.1404 0.1807 0.2478
```

```
coef(out)

#>    NARTIC    PCTGRT   PCTSUPP
#> 0.1858925 0.1176542 0.0568722

vcov(out)

#>                NARTIC        PCTGRT       PCTSUPP
#> NARTIC   0.0044289021 -0.0007116463 -0.0003586200
#> PCTGRT  -0.0007116463  0.0025137273 -0.0002249326
#> PCTSUPP -0.0003586200 -0.0002249326  0.0011662150

confint(out)

#>              2.5 %    97.5 %
#> NARTIC  0.07170384 0.3290709
#> PCTGRT  0.03793281 0.2308734
#> PCTSUPP 0.01031999 0.1404389
```

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 0.1057 20000 0.1107 0.1774 0.2463 0.6536 0.7115 0.7651
#> PCTGRT  0.3757 0.1070 20000 0.0506 0.1029 0.1466 0.5626 0.6249 0.6973
#> PCTSUPP 0.2254 0.0989 20000 0.0029 0.0192 0.0459 0.4256 0.5040 0.6004

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 0.1057 20000 0.1107 0.1774 0.2463 0.6536 0.7115 0.7651
#> PCTGRT  0.3757 0.1070 20000 0.0506 0.1029 0.1466 0.5626 0.6249 0.6973
#> PCTSUPP 0.2254 0.0989 20000 0.0029 0.0192 0.0459 0.4256 0.5040 0.6004
```

```
coef(out)

#>    NARTIC    PCTGRT   PCTSUPP
#> 0.4874382 0.3757383 0.2253739

vcov(out)

#>                NARTIC       PCTGRT      PCTSUPP
#> NARTIC  0.0111704616 6.346398e-04 2.324141e-04
#> PCTGRT  0.0006346398 1.144963e-02 6.321237e-05
#> PCTSUPP 0.0002324141 6.321237e-05 9.771910e-03

confint(out)

#>              2.5 %    97.5 %
#> NARTIC  0.24631873 0.6535594
#> PCTGRT  0.14663732 0.5625980
#> PCTSUPP 0.04591214 0.4255732
```

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 0.1351 20000 -0.3222 -0.2492 -0.1646 0.3636 0.4396 0.5234
#> NARTIC-PCTSUPP 0.2319 0.1255 20000 -0.2169 -0.1058 -0.0219 0.4673 0.5376 0.6141
#> PCTGRT-PCTSUPP 0.1282 0.1216 20000 -0.2715 -0.1853 -0.1120 0.3615 0.4424 0.5251

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 0.1351 20000 -0.3222 -0.2492 -0.1646 0.3636 0.4396 0.5234
#> NARTIC-PCTSUPP 0.2319 0.1255 20000 -0.2169 -0.1058 -0.0219 0.4673 0.5376 0.6141
#> PCTGRT-PCTSUPP 0.1282 0.1216 20000 -0.2715 -0.1853 -0.1120 0.3615 0.4424 0.5251
```

```
coef(out)

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

vcov(out)

#>                NARTIC-PCTGRT NARTIC-PCTSUPP PCTGRT-PCTSUPP
#> NARTIC-PCTGRT    0.018239823    0.009608525   -0.008631298
#> NARTIC-PCTSUPP   0.009608525    0.015755737    0.006147212
#> PCTGRT-PCTSUPP  -0.008631298    0.006147212    0.014778510

confint(out)

#>                       2.5 %    97.5 %
#> NARTIC-PCTGRT  -0.16461689 0.3636014
#> NARTIC-PCTSUPP -0.02186839 0.4672556
#> PCTGRT-PCTSUPP -0.11203309 0.3615385
```

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 <- MCMI(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 0.0832 20000  0.2139 0.2688 0.3203 0.6474 0.6932 0.7443
```

```
#> PCTGRT  0.3974 0.0832 20000  0.1126 0.1771 0.2289 0.5536 0.6055 0.6585
#> PCTSUPP 0.2427 0.0847 20000 -0.0329 0.0280 0.0810 0.4121 0.4638 0.5340

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 0.0832 20000  0.2139 0.2688 0.3203 0.6474 0.6932 0.7443
#> PCTGRT  0.3974 0.0832 20000  0.1126 0.1771 0.2289 0.5536 0.6055 0.6585
#> PCTSUPP 0.2427 0.0847 20000 -0.0329 0.0280 0.0810 0.4121 0.4638 0.5340

coef(out)

#>    NARTIC    PCTGRT   PCTSUPP
#> 0.4929845 0.3973692 0.2427459

vcov(out)

#>                NARTIC       PCTGRT      PCTSUPP
#> NARTIC   0.006921537 -0.003662301 -0.002918884
#> PCTGRT  -0.003662301  0.006915142 -0.002030679
#> PCTSUPP -0.002918884 -0.002030679  0.007181030

confint(out)

#>              2.5 %    97.5 %
#> NARTIC  0.32025412 0.6474388
#> PCTGRT  0.22885611 0.5536124
#> PCTSUPP 0.08098128 0.4120640
```

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 0.0648 20000 0.4670 0.5600 0.6270 0.8793 0.9071 0.9410
#> adj 0.7715 0.0715 20000 0.4119 0.5145 0.5884 0.8669 0.8975 0.9349

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 0.0648 20000 0.4670 0.5600 0.6270 0.8793 0.9071 0.9410
#> adj 0.7715 0.0715 20000 0.4119 0.5145 0.5884 0.8669 0.8975 0.9349

coef(out)

#>       rsq       adj
#> 0.7867234 0.7714893

vcov(out)

#>             rsq         adj
#> rsq 0.004196874 0.004631034
#> adj 0.004631034 0.005110106

confint(out)

#>         2.5 %    97.5 %
#> rsq 0.6269981 0.8793330
#> adj 0.5884117 0.8668502
```

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 0.0848 20000  0.1466 0.1984 0.2479 0.5778 0.6339 0.7005
```

```
#> PCTGRT  0.3510 0.0806 20000  0.0931 0.1446 0.1885 0.5037 0.5553 0.6193
#> PCTSUPP 0.2190 0.0786 20000 -0.0243 0.0246 0.0687 0.3754 0.4303 0.5025

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 0.0848 20000  0.1466 0.1984 0.2479 0.5778 0.6339 0.7005
#> PCTGRT  0.3510 0.0806 20000  0.0931 0.1446 0.1885 0.5037 0.5553 0.6193
#> PCTSUPP 0.2190 0.0786 20000 -0.0243 0.0246 0.0687 0.3754 0.4303 0.5025

coef(out)

#>    NARTIC    PCTGRT   PCTSUPP
#> 0.4232313 0.3509918 0.2189535

vcov(out)

#>                NARTIC       PCTGRT      PCTSUPP
#> NARTIC   0.007183121 -0.001422813 -0.001416730
#> PCTGRT  -0.001422813  0.006488409 -0.001143686
#> PCTSUPP -0.001416730 -0.001143686  0.006185222

confint(out)

#>              2.5 %    97.5 %
#> NARTIC  0.24788988 0.5778069
#> PCTGRT  0.18847764 0.5036596
#> PCTSUPP 0.06869658 0.3754167
```

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 0.0708 20000 0.0215 0.0394 0.0614 0.3339 0.4018 0.4908
#> PCTGRT  0.1232 0.0563 20000 0.0087 0.0209 0.0355 0.2537 0.3084 0.3836
#> PCTSUPP 0.0479 0.0359 20000 0.0000 0.0008 0.0047 0.1409 0.1851 0.2525

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 0.0708 20000 0.0215 0.0394 0.0614 0.3339 0.4018 0.4908
#> PCTGRT  0.1232 0.0563 20000 0.0087 0.0209 0.0355 0.2537 0.3084 0.3836
#> PCTSUPP 0.0479 0.0359 20000 0.0000 0.0008 0.0047 0.1409 0.1851 0.2525

coef(out)

#>     NARTIC     PCTGRT    PCTSUPP
#> 0.17912477 0.12319522 0.04794063

vcov(out)

#>                NARTIC        PCTGRT       PCTSUPP
#> NARTIC   0.0050135898 -0.0008245693 -0.0005038695
#> PCTGRT  -0.0008245693  0.0031747919 -0.0003271520
#> PCTSUPP -0.0005038695 -0.0003271520  0.0012914882

confint(out)

#>              2.5 %    97.5 %
#> NARTIC  0.06144939 0.3338608
#> PCTGRT  0.03552382 0.2536730
#> PCTSUPP 0.00471922 0.1409377
```

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 0.1192 20000 0.0731 0.1317 0.1940 0.6568 0.7255 0.8146
#> PCTGRT  0.3677 0.1184 20000 0.0313 0.0747 0.1249 0.5830 0.6525 0.7392
#> PCTSUPP 0.1860 0.1052 20000 0.0001 0.0032 0.0200 0.4200 0.5080 0.6225

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 0.1192 20000 0.0731 0.1317 0.1940 0.6568 0.7255 0.8146
#> PCTGRT  0.3677 0.1184 20000 0.0313 0.0747 0.1249 0.5830 0.6525 0.7392
#> PCTSUPP 0.1860 0.1052 20000 0.0001 0.0032 0.0200 0.4200 0.5080 0.6225

coef(out)

#>    NARTIC    PCTGRT   PCTSUPP
#> 0.4572612 0.3676734 0.1859643

vcov(out)

#>               NARTIC       PCTGRT      PCTSUPP
#> NARTIC  0.0142132012 0.0021278594 0.0004805051
#> PCTGRT  0.0021278594 0.0140291593 0.0004793035
#> PCTSUPP 0.0004805051 0.0004793035 0.0110752599

confint(out)

#>             2.5 %    97.5 %
#> NARTIC  0.1940481 0.6567998
#> PCTGRT  0.1248577 0.5830498
#> PCTSUPP 0.0200106 0.4199937
```

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 0.1455 20000 -0.3933 -0.2798 -0.1910 0.3761 0.4663 0.5537
#> NARTIC-PCTSUPP 0.2502 0.1412 20000 -0.2514 -0.1320 -0.0400 0.5123 0.6008 0.6805
#> PCTGRT-PCTSUPP 0.1546 0.1347 20000 -0.2769 -0.2007 -0.1171 0.4100 0.4912 0.5843

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 0.1455 20000 -0.3933 -0.2798 -0.1910 0.3761 0.4663 0.5537
#> NARTIC-PCTSUPP 0.2502 0.1412 20000 -0.2514 -0.1320 -0.0400 0.5123 0.6008 0.6805
#> PCTGRT-PCTSUPP 0.1546 0.1347 20000 -0.2769 -0.2007 -0.1171 0.4100 0.4912 0.5843

coef(out)

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

vcov(out)

#>                NARTIC-PCTGRT NARTIC-PCTSUPP PCTGRT-PCTSUPP
#> NARTIC-PCTGRT    0.021161280    0.011472043   -0.009689237
#> NARTIC-PCTSUPP   0.011472043    0.019940336    0.008468292
#> PCTGRT-PCTSUPP  -0.009689237    0.008468292    0.018157529

confint(out)

#>                       2.5 %    97.5 %
#> NARTIC-PCTGRT  -0.19098331 0.3760516
#> NARTIC-PCTSUPP -0.03998989 0.5122987
#> PCTGRT-PCTSUPP -0.11711752 0.4100395
```

References

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