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 0.2416 0.2869 0.3374 0.6365 0.6756 0.7320
#> PCTGRT  0.3915 0.0768 20000 0.1410 0.1965 0.2395 0.5401 0.5853 0.6407
#> PCTSUPP 0.2632 0.0744 20000 0.0307 0.0765 0.1194 0.4104 0.4615 0.5077

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 0.2416 0.2869 0.3374 0.6365 0.6756 0.7320
#> PCTGRT  0.3915 0.0768 20000 0.1410 0.1965 0.2395 0.5401 0.5853 0.6407
#> PCTSUPP 0.2632 0.0744 20000 0.0307 0.0765 0.1194 0.4104 0.4615 0.5077
```

```
coef(out)

#>    NARTIC    PCTGRT   PCTSUPP
#> 0.4951451 0.3914887 0.2632477

vcov(out)

#>               NARTIC       PCTGRT      PCTSUPP
#> NARTIC   0.005855414 -0.003342667 -0.002187467
#> PCTGRT  -0.003342667  0.005902455 -0.001669725
#> PCTSUPP -0.002187467 -0.001669725  0.005541865

confint(out)

#>             2.5 %    97.5 %
#> NARTIC  0.3373784 0.6364844
#> PCTGRT  0.2395242 0.5401378
#> PCTSUPP 0.1194307 0.4103937
```

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 0.0563 20000 0.5072 0.5978 0.6622 0.8820 0.9042 0.9313
#> adj 0.7906 0.0604 20000 0.4720 0.5691 0.6381 0.8735 0.8973 0.9264

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 0.0563 20000 0.5072 0.5978 0.6622 0.8820 0.9042 0.9313
#> adj 0.7906 0.0604 20000 0.4720 0.5691 0.6381 0.8735 0.8973 0.9264
```

```r
coef(out)

#>       rsq       adj
#> 0.8045263 0.7905638

vcov(out)

#>             rsq         adj
#> rsq 0.003174789 0.003401559
#> adj 0.003401559 0.003644528

confint(out)

#>         2.5 %    97.5 %
#> rsq 0.6622208 0.8819643
#> adj 0.6380937 0.8735331
```

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 0.0780 20000 0.1737 0.2271 0.2668 0.5723 0.6268 0.6996
#> PCTGRT  0.3430 0.0739 20000 0.1047 0.1586 0.1944 0.4850 0.5355 0.6011
#> PCTSUPP 0.2385 0.0696 20000 0.0286 0.0660 0.1029 0.3757 0.4265 0.4790

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 0.0780 20000 0.1737 0.2271 0.2668 0.5723 0.6268 0.6996
#> PCTGRT  0.3430 0.0739 20000 0.1047 0.1586 0.1944 0.4850 0.5355 0.6011
#> PCTSUPP 0.2385 0.0696 20000 0.0286 0.0660 0.1029 0.3757 0.4265 0.4790
```

```
coef(out)

#>    NARTIC    PCTGRT   PCTSUPP
#> 0.4311525 0.3430075 0.2384789

vcov(out)

#>                NARTIC       PCTGRT       PCTSUPP
#> NARTIC   0.0060913992 -0.001277676 -0.0009384268
#> PCTGRT  -0.0012776761  0.005459685 -0.0007390450
#> PCTSUPP -0.0009384268 -0.000739045  0.0048375376

confint(out)

#>             2.5 %    97.5 %
#> NARTIC  0.2667500 0.5722613
#> PCTGRT  0.1944016 0.4850499
#> PCTSUPP 0.1029251 0.3756988
```

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 0.0663 20000 0.0302 0.0516 0.0712 0.3275 0.3929 0.4895
#> PCTGRT  0.1177 0.0509 20000 0.0110 0.0252 0.0378 0.2353 0.2868 0.3613
#> PCTSUPP 0.0569 0.0339 20000 0.0008 0.0044 0.0106 0.1411 0.1819 0.2295

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 0.0663 20000 0.0302 0.0516 0.0712 0.3275 0.3929 0.4895
#> PCTGRT  0.1177 0.0509 20000 0.0110 0.0252 0.0378 0.2353 0.2868 0.3613
#> PCTSUPP 0.0569 0.0339 20000 0.0008 0.0044 0.0106 0.1411 0.1819 0.2295
```

```
coef(out)

#>    NARTIC    PCTGRT   PCTSUPP
#> 0.1858925 0.1176542 0.0568722

vcov(out)

#>                NARTIC        PCTGRT       PCTSUPP
#> NARTIC   0.0043960905 -0.0007302909 -0.0003683045
#> PCTGRT  -0.0007302909  0.0025911799 -0.0002265225
#> PCTSUPP -0.0003683045 -0.0002265225  0.0011498248

confint(out)

#>              2.5 %    97.5 %
#> NARTIC  0.07115559 0.3274830
#> PCTGRT  0.03779197 0.2352734
#> PCTSUPP 0.01059357 0.1411496
```

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 0.1210 0.1801 0.2408 0.6530 0.7077 0.7756
#> PCTGRT  0.3757 0.1082 20000 0.0520 0.1001 0.1474 0.5688 0.6381 0.7061
#> PCTSUPP 0.2254 0.0992 20000 0.0035 0.0198 0.0472 0.4273 0.4982 0.5763

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 0.1210 0.1801 0.2408 0.6530 0.7077 0.7756
#> PCTGRT  0.3757 0.1082 20000 0.0520 0.1001 0.1474 0.5688 0.6381 0.7061
#> PCTSUPP 0.2254 0.0992 20000 0.0035 0.0198 0.0472 0.4273 0.4982 0.5763
```

```
coef(out)

#>    NARTIC    PCTGRT   PCTSUPP
#> 0.4874382 0.3757383 0.2253739

vcov(out)

#>                NARTIC       PCTGRT      PCTSUPP
#> NARTIC  0.0111975007 0.0006762126 0.0002985984
#> PCTGRT  0.0006762126 0.0117076719 0.0002499549
#> PCTSUPP 0.0002985984 0.0002499549 0.0098451610

confint(out)

#>              2.5 %    97.5 %
#> NARTIC  0.24076178 0.6529756
#> PCTGRT  0.14741748 0.5687977
#> PCTSUPP 0.04717967 0.4273490
```

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 0.1358 20000 -0.3362 -0.2509 -0.1707 0.3615 0.4411 0.5050
#> NARTIC-PCTSUPP 0.2319 0.1256 20000 -0.2007 -0.1080 -0.0231 0.4715 0.5399 0.6130
#> PCTGRT-PCTSUPP 0.1282 0.1216 20000 -0.2626 -0.1843 -0.1138 0.3664 0.4371 0.5269

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 0.1358 20000 -0.3362 -0.2509 -0.1707 0.3615 0.4411 0.5050
#> NARTIC-PCTSUPP 0.2319 0.1256 20000 -0.2007 -0.1080 -0.0231 0.4715 0.5399 0.6130
#> PCTGRT-PCTSUPP 0.1282 0.1216 20000 -0.2626 -0.1843 -0.1138 0.3664 0.4371 0.5269
```

```
coef(out)

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

vcov(out)

#>                NARTIC-PCTGRT NARTIC-PCTSUPP PCTGRT-PCTSUPP
#> NARTIC-PCTGRT    0.018443203    0.009715823   -0.008727380
#> NARTIC-PCTSUPP   0.009715823    0.015772213    0.006056389
#> PCTGRT-PCTSUPP  -0.008727380    0.006056389    0.014783770

confint(out)

#>                       2.5 %    97.5 %
#> NARTIC-PCTGRT  -0.17070611 0.3614905
#> NARTIC-PCTSUPP -0.02314239 0.4715098
#> PCTGRT-PCTSUPP -0.11383192 0.3664444
```

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  0.5222 0.0799 20000  0.2480 0.3029 0.3556 0.6673 0.7081 0.7682
```

```
#> PCTGRT  0.3797 0.0807 20000  0.1037 0.1745 0.2195 0.5373 0.5819 0.6306
#> PCTSUPP 0.2432 0.0829 20000 -0.0189 0.0360 0.0820 0.4081 0.4615 0.5381

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  0.5222 0.0799 20000  0.2480 0.3029 0.3556 0.6673 0.7081 0.7682
#> PCTGRT  0.3797 0.0807 20000  0.1037 0.1745 0.2195 0.5373 0.5819 0.6306
#> PCTSUPP 0.2432 0.0829 20000 -0.0189 0.0360 0.0820 0.4081 0.4615 0.5381

coef(out)

#>    NARTIC    PCTGRT   PCTSUPP
#> 0.5222438 0.3796524 0.2431948

vcov(out)

#>                NARTIC       PCTGRT      PCTSUPP
#> NARTIC   0.006377888 -0.003527484 -0.002475092
#> PCTGRT  -0.003527484  0.006509939 -0.002009889
#> PCTSUPP -0.002475092 -0.002009889  0.006873409

confint(out)

#>              2.5 %    97.5 %
#> NARTIC  0.35558830 0.6672895
#> PCTGRT  0.21950783 0.5372601
#> PCTSUPP 0.08200066 0.4080524
```

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 0.8029 0.0619 20000 0.5064 0.5906 0.6494 0.8914 0.9209 0.9476
#> adj 0.7889 0.0686 20000 0.4535 0.5468 0.6119 0.8798 0.9124 0.9420

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 0.8029 0.0619 20000 0.5064 0.5906 0.6494 0.8914 0.9209 0.9476
#> adj 0.7889 0.0686 20000 0.4535 0.5468 0.6119 0.8798 0.9124 0.9420

coef(out)

#>       rsq       adj
#> 0.8029376 0.7888617

vcov(out)

#>             rsq         adj
#> rsq 0.003833959 0.004244740
#> adj 0.004244740 0.004699534

confint(out)

#>         2.5 %    97.5 %
#> rsq 0.6494141 0.8914298
#> adj 0.6118513 0.8797973
```

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  0.4601 0.0834 20000  0.1655 0.2350 0.2836 0.6101 0.6620 0.7369
```

```
#> PCTGRT  0.3312 0.0771 20000  0.0790 0.1377 0.1776 0.4812 0.5307 0.5883
#> PCTSUPP 0.2183 0.0766 20000 -0.0159 0.0294 0.0691 0.3696 0.4247 0.4975

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  0.4601 0.0834 20000  0.1655 0.2350 0.2836 0.6101 0.6620 0.7369
#> PCTGRT  0.3312 0.0771 20000  0.0790 0.1377 0.1776 0.4812 0.5307 0.5883
#> PCTSUPP 0.2183 0.0766 20000 -0.0159 0.0294 0.0691 0.3696 0.4247 0.4975

coef(out)

#>    NARTIC    PCTGRT   PCTSUPP
#> 0.4601125 0.3311773 0.2183476

vcov(out)

#>                NARTIC        PCTGRT       PCTSUPP
#> NARTIC   0.006952654 -0.0013966795 -0.0010453358
#> PCTGRT  -0.001396679  0.0059381991 -0.0009131141
#> PCTSUPP -0.001045336 -0.0009131141  0.0058708649

confint(out)

#>              2.5 %    97.5 %
#> NARTIC  0.28356805 0.6101212
#> PCTGRT  0.17761296 0.4811563
#> PCTSUPP 0.06913635 0.3696167
```

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  0.2117 0.0750 20000 0.0274 0.0552 0.0804 0.3722 0.4382 0.5431
#> PCTGRT  0.1097 0.0512 20000 0.0062 0.0190 0.0315 0.2315 0.2816 0.3461
#> PCTSUPP 0.0477 0.0348 20000 0.0000 0.0009 0.0048 0.1366 0.1804 0.2475

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  0.2117 0.0750 20000 0.0274 0.0552 0.0804 0.3722 0.4382 0.5431
#> PCTGRT  0.1097 0.0512 20000 0.0062 0.0190 0.0315 0.2315 0.2816 0.3461
#> PCTSUPP 0.0477 0.0348 20000 0.0000 0.0009 0.0048 0.1366 0.1804 0.2475

coef(out)

#>     NARTIC     PCTGRT    PCTSUPP
#> 0.21170355 0.10967840 0.04767569

vcov(out)

#>                NARTIC        PCTGRT       PCTSUPP
#> NARTIC   0.0056235676 -0.0008247462 -0.0004056533
#> PCTGRT  -0.0008247462  0.0026233718 -0.0002439773
#> PCTSUPP -0.0004056533 -0.0002439773  0.0012077140

confint(out)

#>               2.5 %    97.5 %
#> NARTIC  0.080410838 0.3722479
#> PCTGRT  0.031546363 0.2315113
#> PCTSUPP 0.004779835 0.1366165
```

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  0.5188 0.1148 20000 0.1108 0.1855 0.2532 0.6997 0.7646 0.8282
#> PCTGRT  0.3592 0.1154 20000 0.0327 0.0789 0.1249 0.5717 0.6529 0.7541
#> PCTSUPP 0.1989 0.1095 20000 0.0001 0.0044 0.0216 0.4374 0.5282 0.6262

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  0.5188 0.1148 20000 0.1108 0.1855 0.2532 0.6997 0.7646 0.8282
#> PCTGRT  0.3592 0.1154 20000 0.0327 0.0789 0.1249 0.5717 0.6529 0.7541
#> PCTSUPP 0.1989 0.1095 20000 0.0001 0.0044 0.0216 0.4374 0.5282 0.6262

coef(out)

#>    NARTIC    PCTGRT   PCTSUPP
#> 0.5187942 0.3591718 0.1989111

vcov(out)

#>              NARTIC       PCTGRT      PCTSUPP
#> NARTIC  0.013180180 0.0017380785 0.0015036079
#> PCTGRT  0.001738078 0.0133056899 0.0007733401
#> PCTSUPP 0.001503608 0.0007733401 0.0120007992

confint(out)

#>              2.5 %    97.5 %
#> NARTIC  0.25315794 0.6997445
#> PCTGRT  0.12493162 0.5716581
#> PCTSUPP 0.02160196 0.4374294
```

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  0.1426 0.1412 20000 -0.3148 -0.2252 -0.1404 0.4107 0.4915 0.5825
#> NARTIC-PCTSUPP 0.2790 0.1349 20000 -0.1926 -0.0856  0.0019 0.5299 0.6047 0.6728
#> PCTGRT-PCTSUPP 0.1365 0.1319 20000 -0.2912 -0.2064 -0.1270 0.3922 0.4724 0.5646

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  0.1426 0.1412 20000 -0.3148 -0.2252 -0.1404 0.4107 0.4915 0.5825
#> NARTIC-PCTSUPP 0.2790 0.1349 20000 -0.1926 -0.0856  0.0019 0.5299 0.6047 0.6728
#> PCTGRT-PCTSUPP 0.1365 0.1319 20000 -0.2912 -0.2064 -0.1270 0.3922 0.4724 0.5646

coef(out)

#>  NARTIC-PCTGRT NARTIC-PCTSUPP PCTGRT-PCTSUPP
#>      0.1425914      0.2790490      0.1364576

vcov(out)

#>                NARTIC-PCTGRT NARTIC-PCTSUPP PCTGRT-PCTSUPP
#> NARTIC-PCTGRT     0.01994279    0.010370574   -0.009572220
#> NARTIC-PCTSUPP    0.01037057    0.018201480    0.007830906
#> PCTGRT-PCTSUPP   -0.00957222    0.007830906    0.017403127

confint(out)

#>                       2.5 %    97.5 %
#> NARTIC-PCTGRT  -0.14042521 0.4107107
#> NARTIC-PCTSUPP  0.00194249 0.5298746
#> PCTGRT-PCTSUPP -0.12704538 0.3922386
```

References

Pesigan, I. J. A., & Cheung, S. F. (2023). Monte Carlo confidence intervals for the indirect effect with missing data. *Behavior Research Methods*, *56*(3), 1678–1696. https://doi.org/10.3758/s13428-023-02114-4

R Core Team. (2024). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. Vienna, Austria. https://www.R-project.org/