betaSandwich: Staging

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Staging...

References

Pesigan, I. J. A., Sun, R. W., & Cheung, S. F. (2023). betaDelta and betaSandwich: Confidence intervals for standardized regression coefficients in R. *Multivariate Behavioral Research*, *58*(6), 1183–1186. https://doi.org/10.1080/00273171.2023.2201277

R Core Team. (2025). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing. Vienna, Austria. https://www.R-project.org/

1 Standardized Slopes

```
df <- nas1982
object <- lm(QUALITY ~ NARTIC + PCTGRT + PCTSUPP, data = df)
mvn <- BetaN(object)
adf <- BetaADF(object)
hc3 <- BetaHC(object, type = "hc3")
summary(mvn)

#> Call:
#> BetaN(object = object)
#>
#> Standardized regression slopes with MVN standard errors:
#>            est     se      t df     p   0.05%   0.5%   2.5%  97.5%  99.5%
#> NARTIC  0.4951 0.0759 6.5272 42 0.000  0.2268 0.2905 0.3421 0.6482 0.6998
#> PCTGRT  0.3915 0.0770 5.0824 42 0.000  0.1190 0.1837 0.2360 0.5469 0.5993
#> PCTSUPP 0.2632 0.0747 3.5224 42 0.001 -0.0011 0.0616 0.1124 0.4141 0.4649
#>         99.95%
#> NARTIC  0.7635
#> PCTGRT  0.6640
#> PCTSUPP 0.5276

summary(adf)

#> Call:
```

```
#> BetaADF(object = object)
#>
#> Standardized regression slopes with MVN standard errors:
#>            est     se      t df      p   0.05%   0.5%   2.5%  97.5%  99.5%
#> NARTIC  0.4951 0.0674 7.3490 42 0.0000  0.2568 0.3134 0.3592 0.6311 0.6769
#> PCTGRT  0.3915 0.0710 5.5164 42 0.0000  0.1404 0.2000 0.2483 0.5347 0.5830
#> PCTSUPP 0.2632 0.0769 3.4231 42 0.0014 -0.0088 0.0558 0.1081 0.4184 0.4707
#>         99.95%
#> NARTIC  0.7335
#> PCTGRT  0.6426
#> PCTSUPP 0.5353

summary(hc3)

#> Call:
#> BetaHC(object = object, type = "hc3")
#>
#> Standardized regression slopes with HC3 standard errors:
#>            est     se      t df      p   0.05%   0.5%   2.5%  97.5%  99.5%
#> NARTIC  0.4951 0.0786 6.3025 42 0.0000  0.2172 0.2832 0.3366 0.6537 0.7071
#> PCTGRT  0.3915 0.0818 4.7831 42 0.0000  0.1019 0.1707 0.2263 0.5567 0.6123
#> PCTSUPP 0.2632 0.0855 3.0786 42 0.0037 -0.0393 0.0325 0.0907 0.4358 0.4940
#>         99.95%
#> NARTIC  0.7731
#> PCTGRT  0.6810
#> PCTSUPP 0.5658

coef(mvn)

#>    NARTIC    PCTGRT   PCTSUPP
#> 0.4951451 0.3914887 0.2632477

coef(adf)

#>    NARTIC    PCTGRT   PCTSUPP
#> 0.4951451 0.3914887 0.2632477

coef(hc3)

#>    NARTIC    PCTGRT   PCTSUPP
#> 0.4951451 0.3914887 0.2632477

vcov(mvn)

#>               NARTIC       PCTGRT      PCTSUPP
#> NARTIC   0.005754524 -0.003360334 -0.002166127
#> PCTGRT  -0.003360334  0.005933462 -0.001769723
#> PCTSUPP -0.002166127 -0.001769723  0.005585256
```

```
vcov(adf)

#>               NARTIC       PCTGRT      PCTSUPP
#> NARTIC   0.004539472 -0.002552698 -0.001742698
#> PCTGRT  -0.002552698  0.005036538 -0.001906216
#> PCTSUPP -0.001742698 -0.001906216  0.005914088

vcov(hc3)

#>               NARTIC       PCTGRT      PCTSUPP
#> NARTIC   0.006172168 -0.003602529 -0.001943469
#> PCTGRT  -0.003602529  0.006699155 -0.002443584
#> PCTSUPP -0.001943469 -0.002443584  0.007311625

confint(mvn)

#>             2.5 %    97.5 %
#> NARTIC  0.3420563 0.6482339
#> PCTGRT  0.2360380 0.5469395
#> PCTSUPP 0.1124272 0.4140682

confint(adf)

#>             2.5 %    97.5 %
#> NARTIC  0.3591757 0.6311146
#> PCTGRT  0.2482683 0.5347091
#> PCTSUPP 0.1080509 0.4184444

confint(hc3)

#>              2.5 %    97.5 %
#> NARTIC  0.33659828 0.6536920
#> PCTGRT  0.22631203 0.5566654
#> PCTSUPP 0.09068548 0.4358099
```

2 Multiple Correlation

```
df <- nas1982
object <- lm(QUALITY ~ NARTIC + PCTGRT + PCTSUPP, data = df)
std_mvn <- BetaN(object)
std_adf <- BetaADF(object)
std_hc3 <- BetaHC(object, type = "hc3")
mvn <- RSqBetaSandwich(std_mvn)
adf <- RSqBetaSandwich(std_adf)
hc3 <- RSqBetaSandwich(std_hc3)
```

```
summary(mvn)
```

```
#> Call:
#> RSqBetaSandwich(object = std_mvn)
#>
#> Multiple correlation with MVN standard errors:
#>        est     se       t df p  0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> rsq 0.8045 0.0328 24.5344 42 0 0.6885 0.7161 0.7383 0.8707 0.8930 0.9205
#> adj 0.7906 0.0351 22.5014 42 0 0.6663 0.6958 0.7197 0.8615 0.8854 0.9149
```

```
summary(adf)
```

```
#> Call:
#> RSqBetaSandwich(object = std_adf)
#>
#> Multiple correlation with MVN standard errors:
#>        est     se       t df p  0.05%   0.5%   2.5%  97.5%  99.5% 99.95%
#> rsq 0.8045 0.0287 28.0431 42 0 0.7030 0.7271 0.7466 0.8624 0.8819 0.9060
#> adj 0.7906 0.0307 25.7193 42 0 0.6818 0.7076 0.7285 0.8526 0.8735 0.8993
```

```
summary(hc3)
```

```
#> Call:
#> RSqBetaSandwich(object = std_hc3)
#>
#> Multiple correlation with HC3 standard errors:
#>        est     se       t df p  0.05% 0.5%   2.5%  97.5%  99.5% 99.95%
#> rsq 0.8045 0.0313 25.6916 42 0 0.6937 0.72 0.7413 0.8677 0.8890 0.9153
#> adj 0.7906 0.0336 23.5627 42 0 0.6719 0.70 0.7229 0.8583 0.8811 0.9093
```

```
coef(mvn)
```

```
#>   rsq.rsq   adj.adj
#> 0.8045263 0.7905638
```

```
coef(adf)
```

```
#>   rsq.rsq   adj.adj
#> 0.8045263 0.7905638
```

```
coef(hc3)
```

```
#>   rsq.rsq   adj.adj
#> 0.8045263 0.7905638
```

```
vcov(mvn)
```

```
#>             rsq         adj
#> rsq 0.001075300 0.001152107
#> adj 0.001152107 0.001234400
```

```
vcov(adf)

#>              rsq          adj
#> rsq 0.0008230557 0.0008818454
#> adj 0.0008818454 0.0009448343

vcov(hc3)

#>              rsq         adj
#> rsq 0.0009806163 0.001050660
#> adj 0.0010506603 0.001125707

confint(mvn)

#>         2.5 %    97.5 %
#> rsq 0.7383498 0.8707027
#> adj 0.7196605 0.8614672

confint(adf)

#>         2.5 %    97.5 %
#> rsq 0.7466296 0.8624229
#> adj 0.7285317 0.8525960

confint(hc3)

#>         2.5 %    97.5 %
#> rsq 0.7413304 0.8677221
#> adj 0.7228540 0.8582736
```

3 Differences of Standardized Slopes

```
df <- nas1982
object <- lm(QUALITY ~ NARTIC + PCTGRT + PCTSUPP, data = df)
std_mvn <- BetaN(object)
std_adf <- BetaADF(object)
std_hc3 <- BetaHC(object, type = "hc3")
mvn <- DiffBetaSandwich(std_mvn)
adf <- DiffBetaSandwich(std_adf)
hc3 <- DiffBetaSandwich(std_hc3)
summary(mvn)

#> Call:
#> DiffBetaSandwich(object = std_mvn)
#>
```

```
#> Difference between standardized regression coefficients with MVN standard errors:
#>                    est     se      z      p   0.05%    0.5%    2.5%  97.5%
#> NARTIC-PCTGRT  0.1037 0.1357 0.7640 0.4449 -0.3428 -0.2458 -0.1623 0.3696
#> NARTIC-PCTSUPP 0.2319 0.1252 1.8524 0.0640 -0.1800 -0.0906 -0.0135 0.4773
#> PCTGRT-PCTSUPP 0.1282 0.1227 1.0451 0.2960 -0.2755 -0.1878 -0.1123 0.3688
#>                  99.5% 99.95%
#> NARTIC-PCTGRT  0.4531 0.5501
#> NARTIC-PCTSUPP 0.5544 0.6438
#> PCTGRT-PCTSUPP 0.4443 0.5320

summary(adf)

#> Call:
#> DiffBetaSandwich(object = std_adf)
#>
#> Difference between standardized regression coefficients with MVN standard errors:
#>                    est     se      z      p   0.05%    0.5%    2.5%  97.5%
#> NARTIC-PCTGRT  0.1037 0.1212 0.8555 0.3923 -0.2950 -0.2084 -0.1338 0.3411
#> NARTIC-PCTSUPP 0.2319 0.1181 1.9642 0.0495 -0.1566 -0.0722  0.0005 0.4633
#> PCTGRT-PCTSUPP 0.1282 0.1215 1.0555 0.2912 -0.2716 -0.1847 -0.1099 0.3664
#>                  99.5% 99.95%
#> NARTIC-PCTGRT  0.4158 0.5024
#> NARTIC-PCTSUPP 0.5360 0.6204
#> PCTGRT-PCTSUPP 0.4412 0.5281

summary(hc3)

#> Call:
#> DiffBetaSandwich(object = std_hc3)
#>
#> Difference between standardized regression coefficients with HC3 standard errors:
#>                    est     se      z      p   0.05%    0.5%    2.5%  97.5%
#> NARTIC-PCTGRT  0.1037 0.1417 0.7316 0.4644 -0.3626 -0.2613 -0.1741 0.3814
#> NARTIC-PCTSUPP 0.2319 0.1318 1.7595 0.0785 -0.2018 -0.1076 -0.0264 0.4902
#> PCTGRT-PCTSUPP 0.1282 0.1375 0.9329 0.3509 -0.3241 -0.2259 -0.1412 0.3977
#>                  99.5% 99.95%
#> NARTIC-PCTGRT  0.4686 0.5699
#> NARTIC-PCTSUPP 0.5714 0.6656
#> PCTGRT-PCTSUPP 0.4823 0.5806

coef(mvn)

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

coef(adf)

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

```
coef(hc3)

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

vcov(mvn)

#>                NARTIC-PCTGRT NARTIC-PCTSUPP PCTGRT-PCTSUPP
#> NARTIC-PCTGRT    0.018408653    0.009511262   -0.008897391
#> NARTIC-PCTSUPP   0.009511262    0.015672035    0.006160773
#> PCTGRT-PCTSUPP  -0.008897391    0.006160773    0.015058164

vcov(adf)

#>                NARTIC-PCTGRT NARTIC-PCTSUPP PCTGRT-PCTSUPP
#> NARTIC-PCTGRT    0.014681407    0.006928651   -0.007752755
#> NARTIC-PCTSUPP   0.006928651    0.013938955    0.007010303
#> PCTGRT-PCTSUPP  -0.007752755    0.007010303    0.014763058

vcov(hc3)

#>                NARTIC-PCTGRT NARTIC-PCTSUPP PCTGRT-PCTSUPP
#> NARTIC-PCTGRT    0.020076382    0.009274583   -0.010801799
#> NARTIC-PCTSUPP   0.009274583    0.017370731    0.008096148
#> PCTGRT-PCTSUPP  -0.010801799    0.008096148    0.018897947

confint(mvn)

#>                       2.5 %    97.5 %
#> NARTIC-PCTGRT  -0.16226855 0.3695814
#> NARTIC-PCTSUPP -0.01346652 0.4772614
#> PCTGRT-PCTSUPP -0.11226950 0.3687516

confint(adf)

#>                         2.5 %    97.5 %
#> NARTIC-PCTGRT  -0.1338262589 0.3411391
#> NARTIC-PCTSUPP  0.0004975295 0.4632974
#> PCTGRT-PCTSUPP -0.1099011119 0.3663832

confint(hc3)

#>                       2.5 %    97.5 %
#> NARTIC-PCTGRT  -0.17405314 0.3813660
#> NARTIC-PCTSUPP -0.02642203 0.4902169
#> PCTGRT-PCTSUPP -0.14119483 0.3976769
```

References

Pesigan, I. J. A., Sun, R. W., & Cheung, S. F. (2023). betaDelta and betaSandwich: Confidence intervals for standardized regression coefficients in R. *Multivariate Behavioral Research*, *58*(6), 1183–1186. https://doi.org/10.1080/00273171.2023.2201277

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