Model Selection Simulation Study

November 2, 2023

[1]:
```
# ***************************************
# Variable Selection Simulation Study
#
# Jupyter Notebook Interactive Demonstration!
#
# Emma Tarmey
#
# Started:          03/10/2023
# Most Recent Edit: 02/11/2023
# ***************************************
```

[2]:
```
# sanity check file location
getwd()
```

'/home/aa22294/Desktop/PhD - Computational Statistics/Projects/Model Selection Sim Study/Code/Jupyter'

[3]:
```
# pull from R file
source("../R/simulation.R")
#file.show("simulation.R")
```

[4]:
```
# run simulation
# S = number of scenarios
# N = repetitions for this scenario
# M = number of VS techniques under investigation
# p = number of variables in data (includes id, excludes intercept and outcome
 ↪y)
# n = synthetic data-set size

run.simulation(S = 4,
               N = 1000,
               M = 6,
               p = 6,
               n = 10000,
               mech.missing = "MCAR",
               prop.missing = 0.2,
               messages     = FALSE)
```

```
Scenario  1 / 4

Scenario  2 / 4

Scenario  3 / 4

Scenario  4 / 4
```

[5]:
```
source("interpret_bias_results.R")

all.results <- get.results.data()

bias.results.s1 <- all.results[[1]]
bias.results.s2 <- all.results[[2]]
bias.results.s3 <- all.results[[3]]
bias.results.s4 <- all.results[[4]]

coef.results.s1 <- all.results[[5]]
coef.results.s2 <- all.results[[6]]
coef.results.s3 <- all.results[[7]]
coef.results.s4 <- all.results[[8]]

all.means <- bias.tables(bias.results.s1, bias.results.s2, bias.results.s3,␣
↪bias.results.s4,
                         coef.results.s1, coef.results.s2, coef.results.s3,␣
↪coef.results.s4)

s1.bias.means <- all.means[[1]]
s2.bias.means <- all.means[[2]]
s3.bias.means <- all.means[[3]]
s4.bias.means <- all.means[[4]]

s1.bias.means %>% knitr::kable()
s2.bias.means %>% knitr::kable()
s3.bias.means %>% knitr::kable()
s4.bias.means %>% knitr::kable()

bias.plots(s1.bias.means, s2.bias.means, s3.bias.means, s4.bias.means)
```

```
Raw Bias Values:
```

```
Mean Bias of each VS Technique for each Parameter estimate:
```

Scenario = 1, N = 1000

Scenario = 2, N = 1000

Scenario = 3, N = 1000

Scenario = 4, N = 1000

Technique	Variable	BiasMean	BiasSD
linear	id	0.0000000	0.0000224
lasso	id	0.0000000	0.0000006
ridge	id	0.0000943	0.0000188
scad	id	0.0000002	0.0000098
mcp	id	0.0000002	0.0000098
stepwise	id	0.0000000	0.0000224
linear	c.1	-0.0009753	0.0274231
lasso	c.1	0.0001950	0.0016002
ridge	c.1	0.2594338	0.0220012
scad	c.1	-0.0004431	0.0130341
mcp	c.1	-0.0004431	0.0130341
stepwise	c.1	-0.0009753	0.0274231
linear	c.2	0.0010376	0.0257469
lasso	c.2	0.0000011	0.0000279
ridge	c.2	0.1316157	0.0225500
scad	c.2	0.0003240	0.0104077
mcp	c.2	0.0003240	0.0104077
stepwise	c.2	0.0010376	0.0257469
linear	x.1	0.0002507	0.0085478
lasso	x.1	-0.0316221	0.0086030
ridge	x.1	-0.4256509	0.0065475
scad	x.1	0.0002529	0.0085513
mcp	x.1	0.0002529	0.0085513
stepwise	x.1	0.0002507	0.0085478
linear	x.2	-0.0003579	0.0256979
lasso	x.2	0.0306945	0.0128136

ridge	x.2	0.0896181	0.0156947
scad	x.2	-0.0003813	0.0256804
mcp	x.2	-0.0003813	0.0256804
stepwise	x.2	-0.0003579	0.0256979
linear	x.3	-0.0001384	0.0186738
lasso	x.3	-0.0326328	0.0166517
ridge	x.3	-0.2445441	0.0161914
scad	x.3	-0.0001484	0.0186712
mcp	x.3	-0.0001484	0.0186712
stepwise	x.3	-0.0001384	0.0186738

Technique	Variable	BiasMean	BiasSD
linear	id	-0.0000001	0.0000228
lasso	id	0.0000008	0.0000040
ridge	id	0.0000855	0.0000190
scad	id	0.0000003	0.0000107
mcp	id	0.0000003	0.0000107
stepwise	id	-0.0000001	0.0000228
linear	c.1	0.0005074	0.0415138
lasso	c.1	0.0548909	0.0365868
ridge	c.1	0.3447449	0.0199500
scad	c.1	0.0004282	0.0176848
mcp	c.1	0.0004282	0.0176848
stepwise	c.1	0.0005074	0.0415138
linear	c.2	0.0007822	0.0264786
lasso	c.2	0.0010365	0.0043675
ridge	c.2	0.1197065	0.0224650
scad	c.2	-0.0000988	0.0122576
mcp	c.2	-0.0000988	0.0122576
stepwise	c.2	0.0007822	0.0264786
linear	x.1	-0.0001414	0.0087834
lasso	x.1	-0.0200756	0.0087596
ridge	x.1	-0.2813145	0.0073681
scad	x.1	-0.0001601	0.0087691
mcp	x.1	-0.0001601	0.0087691
stepwise	x.1	-0.0001414	0.0087834
linear	x.2	-0.0009003	0.0669147
lasso	x.2	-0.1045389	0.0638328
ridge	x.2	-0.3013854	0.0332831
scad	x.2	-0.0008538	0.0481312
mcp	x.2	-0.0008538	0.0481312
stepwise	x.2	-0.0009003	0.0669147
linear	x.3	-0.0004976	0.0191094
lasso	x.3	0.0012685	0.0129138
ridge	x.3	-0.1180466	0.0129413

scad	x.3	-0.0004702	0.0191076
mcp	x.3	-0.0004702	0.0191076
stepwise	x.3	-0.0004976	0.0191094

Technique	Variable	BiasMean	BiasSD
linear	id	0.0000002	0.0000077
lasso	id	0.0000000	0.0000001
ridge	id	0.0000653	0.0000069
scad	id	0.0000000	0.0000000
mcp	id	0.0000000	0.0000000
stepwise	id	0.0000002	0.0000077
linear	c.1	0.0000511	0.0093955
lasso	c.1	0.0164091	0.0074346
ridge	c.1	0.2163311	0.0078020
scad	c.1	0.0000000	0.0000000
mcp	c.1	0.0000000	0.0000000
stepwise	c.1	0.0000511	0.0093955
linear	c.2	-0.0001261	0.0088400
lasso	c.2	0.0000308	0.0004010
ridge	c.2	0.0900983	0.0079759
scad	c.2	0.0000006	0.0000134
mcp	c.2	0.0000006	0.0000134
stepwise	c.2	-0.0001261	0.0088400
linear	x.1	-0.0001019	0.0222234
lasso	x.1	-0.0743404	0.0221646
ridge	x.1	-0.2715574	0.0200673
scad	x.1	-0.0000384	0.0211943
mcp	x.1	-0.0000384	0.0211943
stepwise	x.1	-0.0001019	0.0222234
linear	x.2	-0.0003389	0.0228689
lasso	x.2	-0.0917777	0.0228434
ridge	x.2	-0.2874367	0.0211577
scad	x.2	-0.0003532	0.0226182
mcp	x.2	-0.0003532	0.0226182
stepwise	x.2	-0.0003389	0.0228689
linear	x.3	0.0003031	0.0059937
lasso	x.3	-0.0018865	0.0043248
ridge	x.3	-0.1697529	0.0047725
scad	x.3	0.0003004	0.0059801
mcp	x.3	0.0003004	0.0059801
stepwise	x.3	0.0003031	0.0059937

Technique	Variable	BiasMean	BiasSD

```
|linear    |id       | -0.0000003| 0.0000075|
|lasso     |id       |  0.0000000| 0.0000000|
|ridge     |id       |  0.0000604| 0.0000068|
|scad      |id       |  0.0000000| 0.0000000|
|mcp       |id       |  0.0000000| 0.0000000|
|stepwise  |id       | -0.0000003| 0.0000075|
|linear    |c.1      |  0.0001676| 0.0114853|
|lasso     |c.1      |  0.0106965| 0.0094578|
|ridge     |c.1      |  0.1456737| 0.0079487|
|scad      |c.1      |  0.0000000| 0.0000000|
|mcp       |c.1      |  0.0000000| 0.0000000|
|stepwise  |c.1      |  0.0001676| 0.0114853|
|linear    |c.2      | -0.0003215| 0.0089874|
|lasso     |c.2      |  0.0000419| 0.0004981|
|ridge     |c.2      |  0.1033448| 0.0081122|
|scad      |c.2      |  0.0000000| 0.0000000|
|mcp       |c.2      |  0.0000000| 0.0000000|
|stepwise  |c.2      | -0.0003215| 0.0089874|
|linear    |x.1      | -0.0028213| 0.0774481|
|lasso     |x.1      | -0.0360572| 0.0668850|
|ridge     |x.1      |  0.3858466| 0.0514244|
|scad      |x.1      | -0.0021181| 0.0586953|
|mcp       |x.1      | -0.0021181| 0.0586953|
|stepwise  |x.1      | -0.0028213| 0.0774481|
|linear    |x.2      |  0.0001438| 0.0225188|
|lasso     |x.2      | -0.1126829| 0.0217144|
|ridge     |x.2      | -0.2855793| 0.0199056|
|scad      |x.2      | -0.0000054| 0.0213078|
|mcp       |x.2      | -0.0000054| 0.0213078|
|stepwise  |x.2      |  0.0001438| 0.0225188|
|linear    |x.3      |  0.0001558| 0.0059168|
|lasso     |x.3      |  0.0019190| 0.0043990|
|ridge     |x.3      | -0.1800434| 0.0050417|
|scad      |x.3      |  0.0001684| 0.0059069|
|mcp       |x.3      |  0.0001684| 0.0059069|
|stepwise  |x.3      |  0.0001558| 0.0059168|
```

```
[1] 36
[1] 4
[1] NA
```

```
Changing plot `p1`

Changing plot `p2`

Changing plot `p3`
```

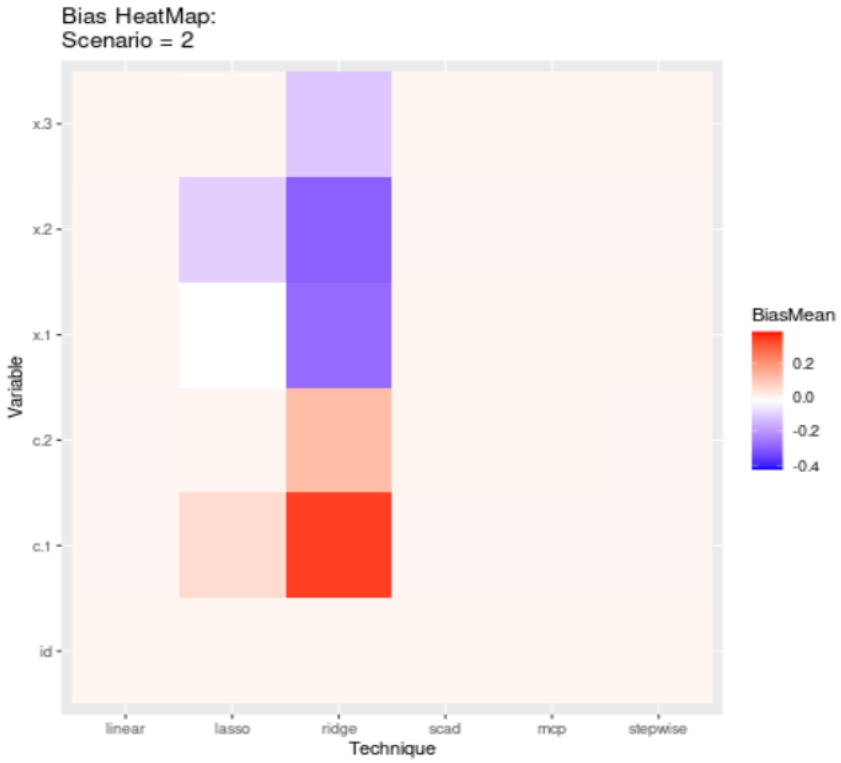
```
Changing plot `p4`
```

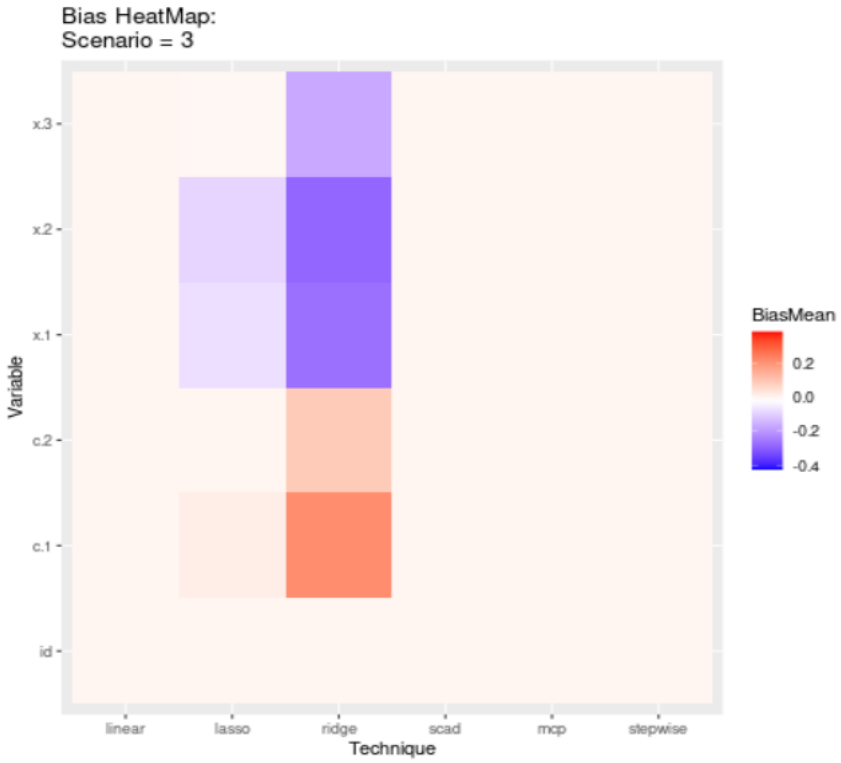
```
[1] "/home/aa22294/Desktop/PhD - Computational Statistics/Projects/Model
Selection Sim Study/Code/R"
```

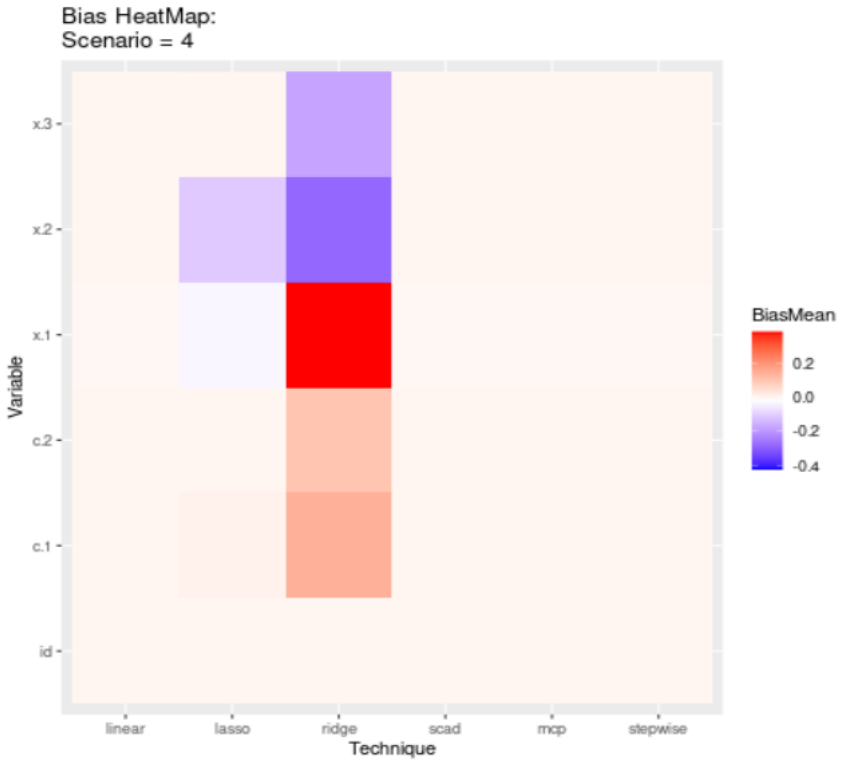
png: 2

[6]:
```
library("png")

plot.new()
pp <- readPNG("../plots/bias_s1.png")
rasterImage(pp, 0.00, 0.00, 1.00, 1.00)

plot.new()
pp <- readPNG("../plots/bias_s2.png")
rasterImage(pp, 0.00, 0.00, 1.00, 1.00)

plot.new()
pp <- readPNG("../plots/bias_s3.png")
rasterImage(pp, 0.00, 0.00, 1.00, 1.00)

plot.new()
pp <- readPNG("../plots/bias_s4.png")
rasterImage(pp, 0.00, 0.00, 1.00, 1.00)
```


Bias HeatMap:
Scenario = 1
x.3
x.2
x.1
c.2
c.1
id
Variable
linear
lasso
ridge
scad
mcp
stepwise
Technique
BiasMean
0.2
0.0
-0.2
-0.4


Bias HeatMap:
Scenario = 2
x.3
x.2
x.1
c.2
c.1
id
Variable
linear
lasso
ridge
scad
mcp
stepwise
Technique
BiasMean
0.2
0.0
-0.2
-0.4


Bias HeatMap:
Scenario = 3
x.3
x.2
x.1
c.2
c.1
id
Variable
linear
lasso
ridge
scad
mcp
stepwise
Technique
BiasMean
0.2
0.0
-0.2
-0.4



[7]:
```
source("interpret_coef_results.R")

all.results <- get.results.data()

bias.results.s1 <- all.results[[1]]
bias.results.s2 <- all.results[[2]]
bias.results.s3 <- all.results[[3]]
bias.results.s4 <- all.results[[4]]

coef.results.s1 <- all.results[[5]]
coef.results.s2 <- all.results[[6]]
coef.results.s3 <- all.results[[7]]
coef.results.s4 <- all.results[[8]]
```

```r
lr.coef <- coef.tables(method = "linear", coef.results.s1, coef.results.s2,␣
 ↪coef.results.s3, coef.results.s4)

lr.coef.summary.s1 <- lr.coef[[1]]
lr.coef.summary.s2 <- lr.coef[[2]]
lr.coef.summary.s3 <- lr.coef[[3]]
lr.coef.summary.s4 <- lr.coef[[4]]

lr.coef.summary.s1 %>% knitr::kable()
lr.coef.summary.s2 %>% knitr::kable()
lr.coef.summary.s3 %>% knitr::kable()
lr.coef.summary.s4 %>% knitr::kable()


lasso.coef <- coef.tables(method = "lasso", coef.results.s1, coef.results.s2,␣
 ↪coef.results.s3, coef.results.s4)

lasso.coef.summary.s1 <- lasso.coef[[1]]
lasso.coef.summary.s2 <- lasso.coef[[2]]
lasso.coef.summary.s3 <- lasso.coef[[3]]
lasso.coef.summary.s4 <- lasso.coef[[4]]

lasso.coef.summary.s1 %>% knitr::kable()
lasso.coef.summary.s2 %>% knitr::kable()
lasso.coef.summary.s3 %>% knitr::kable()
lasso.coef.summary.s4 %>% knitr::kable()


ridge.coef <- coef.tables(method = "ridge", coef.results.s1, coef.results.s2,␣
 ↪coef.results.s3, coef.results.s4)

ridge.coef.summary.s1 <- ridge.coef[[1]]
ridge.coef.summary.s2 <- ridge.coef[[2]]
ridge.coef.summary.s3 <- ridge.coef[[3]]
ridge.coef.summary.s4 <- ridge.coef[[4]]

ridge.coef.summary.s1 %>% knitr::kable()
ridge.coef.summary.s2 %>% knitr::kable()
ridge.coef.summary.s3 %>% knitr::kable()
ridge.coef.summary.s4 %>% knitr::kable()


scad.coef <- coef.tables(method = "scad", coef.results.s1, coef.results.s2,␣
 ↪coef.results.s3, coef.results.s4)
```

```
scad.coef.summary.s1 <- scad.coef[[1]]
scad.coef.summary.s2 <- scad.coef[[2]]
scad.coef.summary.s3 <- scad.coef[[3]]
scad.coef.summary.s4 <- scad.coef[[4]]

scad.coef.summary.s1 %>% knitr::kable()
scad.coef.summary.s2 %>% knitr::kable()
scad.coef.summary.s3 %>% knitr::kable()
scad.coef.summary.s4 %>% knitr::kable()


mcp.coef <- coef.tables(method = "mcp", coef.results.s1, coef.results.s2, coef.
 ↪results.s3, coef.results.s4)

mcp.coef.summary.s1 <- mcp.coef[[1]]
mcp.coef.summary.s2 <- mcp.coef[[2]]
mcp.coef.summary.s3 <- mcp.coef[[3]]
mcp.coef.summary.s4 <- mcp.coef[[4]]

mcp.coef.summary.s1 %>% knitr::kable()
mcp.coef.summary.s2 %>% knitr::kable()
mcp.coef.summary.s3 %>% knitr::kable()
mcp.coef.summary.s4 %>% knitr::kable()


step.coef <- coef.tables(method = "stepwise", coef.results.s1, coef.results.s2,␣
 ↪coef.results.s3, coef.results.s4)

step.coef.summary.s1 <- step.coef[[1]]
step.coef.summary.s2 <- step.coef[[2]]
step.coef.summary.s3 <- step.coef[[3]]
step.coef.summary.s4 <- step.coef[[4]]

step.coef.summary.s1 %>% knitr::kable()
step.coef.summary.s2 %>% knitr::kable()
step.coef.summary.s3 %>% knitr::kable()
step.coef.summary.s4 %>% knitr::kable()
```

linear Parameter Estimates for each Scenario

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000000	0.0000224	0.0000000	0.0000224

c.1	0	-0.0009753	0.0274231	-0.0009753	0.0274231
c.2	0	0.0010376	0.0257469	0.0010376	0.0257469
x.1	1	1.0002507	0.0085478	0.0002507	0.0085478
x.2	1	0.9996421	0.0256979	-0.0003579	0.0256979
x.3	1	0.9998616	0.0186738	-0.0001384	0.0186738

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	-0.0000001	0.0000228	-0.0000001	0.0000228
c.1	0	0.0005074	0.0415138	0.0005074	0.0415138
c.2	0	0.0007822	0.0264786	0.0007822	0.0264786
x.1	1	0.9998586	0.0087834	-0.0001414	0.0087834
x.2	1	0.9990997	0.0669147	-0.0009003	0.0669147
x.3	1	0.9995024	0.0191094	-0.0004976	0.0191094

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000002	0.0000077	0.0000002	0.0000077
c.1	0	0.0000511	0.0093955	0.0000511	0.0093955
c.2	0	-0.0001261	0.0088400	-0.0001261	0.0088400
x.1	1	0.9998981	0.0222234	-0.0001019	0.0222234
x.2	1	0.9996611	0.0228689	-0.0003389	0.0228689
x.3	1	1.0003031	0.0059937	0.0003031	0.0059937

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	-0.0000003	0.0000075	-0.0000003	0.0000075
c.1	0	0.0001676	0.0114853	0.0001676	0.0114853
c.2	0	-0.0003215	0.0089874	-0.0003215	0.0089874
x.1	1	0.9971787	0.0774481	-0.0028213	0.0774481
x.2	1	1.0001438	0.0225188	0.0001438	0.0225188
x.3	1	1.0001558	0.0059168	0.0001558	0.0059168

lasso Parameter Estimates for each Scenario

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000000	0.0000006	0.0000000	0.0000006
c.1	0	0.0001950	0.0016002	0.0001950	0.0016002

c.2	0	0.0000011	0.0000279	0.0000011	0.0000279
x.1	1	0.9683779	0.0086030	-0.0316221	0.0086030
x.2	1	1.0306945	0.0128136	0.0306945	0.0128136
x.3	1	0.9673672	0.0166517	-0.0326328	0.0166517

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000008	0.0000040	0.0000008	0.0000040
c.1	0	0.0548909	0.0365868	0.0548909	0.0365868
c.2	0	0.0010365	0.0043675	0.0010365	0.0043675
x.1	1	0.9799244	0.0087596	-0.0200756	0.0087596
x.2	1	0.8954611	0.0638328	-0.1045389	0.0638328
x.3	1	1.0012685	0.0129138	0.0012685	0.0129138

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000000	0.0000001	0.0000000	0.0000001
c.1	0	0.0164091	0.0074346	0.0164091	0.0074346
c.2	0	0.0000308	0.0004010	0.0000308	0.0004010
x.1	1	0.9256596	0.0221646	-0.0743404	0.0221646
x.2	1	0.9082223	0.0228434	-0.0917777	0.0228434
x.3	1	0.9981135	0.0043248	-0.0018865	0.0043248

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000000	0.0000000	0.0000000	0.0000000
c.1	0	0.0106965	0.0094578	0.0106965	0.0094578
c.2	0	0.0000419	0.0004981	0.0000419	0.0004981
x.1	1	0.9639428	0.0668850	-0.0360572	0.0668850
x.2	1	0.8873171	0.0217144	-0.1126829	0.0217144
x.3	1	1.0019190	0.0043990	0.0019190	0.0043990

ridge Parameter Estimates for each Scenario

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000943	0.0000188	0.0000943	0.0000188
c.1	0	0.2594338	0.0220012	0.2594338	0.0220012
c.2	0	0.1316157	0.0225500	0.1316157	0.0225500

x.1	1	0.5743491	0.0065475	-0.4256509	0.0065475
x.2	1	1.0896181	0.0156947	0.0896181	0.0156947
x.3	1	0.7554559	0.0161914	-0.2445441	0.0161914

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000855	0.0000190	0.0000855	0.0000190
c.1	0	0.3447449	0.0199500	0.3447449	0.0199500
c.2	0	0.1197065	0.0224650	0.1197065	0.0224650
x.1	1	0.7186855	0.0073681	-0.2813145	0.0073681
x.2	1	0.6986146	0.0332831	-0.3013854	0.0332831
x.3	1	0.8819534	0.0129413	-0.1180466	0.0129413

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000653	0.0000069	0.0000653	0.0000069
c.1	0	0.2163311	0.0078020	0.2163311	0.0078020
c.2	0	0.0900983	0.0079759	0.0900983	0.0079759
x.1	1	0.7284426	0.0200673	-0.2715574	0.0200673
x.2	1	0.7125633	0.0211577	-0.2874367	0.0211577
x.3	1	0.8302471	0.0047725	-0.1697529	0.0047725

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000604	0.0000068	0.0000604	0.0000068
c.1	0	0.1456737	0.0079487	0.1456737	0.0079487
c.2	0	0.1033448	0.0081122	0.1033448	0.0081122
x.1	1	1.3858466	0.0514244	0.3858466	0.0514244
x.2	1	0.7144207	0.0199056	-0.2855793	0.0199056
x.3	1	0.8199566	0.0050417	-0.1800434	0.0050417

scad Parameter Estimates for each Scenario

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000002	0.0000098	0.0000002	0.0000098
c.1	0	-0.0004431	0.0130341	-0.0004431	0.0130341
c.2	0	0.0003240	0.0104077	0.0003240	0.0104077
x.1	1	1.0002529	0.0085513	0.0002529	0.0085513

|x.2 | 1| 0.9996187| 0.0256804| -0.0003813| 0.0256804|
|x.3 | 1| 0.9998516| 0.0186712| -0.0001484| 0.0186712|

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000003	0.0000107	0.0000003	0.0000107
c.1	0	0.0004282	0.0176848	0.0004282	0.0176848
c.2	0	-0.0000988	0.0122576	-0.0000988	0.0122576
x.1	1	0.9998399	0.0087691	-0.0001601	0.0087691
x.2	1	0.9991462	0.0481312	-0.0008538	0.0481312
x.3	1	0.9995298	0.0191076	-0.0004702	0.0191076

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000000	0.0000000	0.0000000	0.0000000
c.1	0	0.0000000	0.0000000	0.0000000	0.0000000
c.2	0	0.0000006	0.0000134	0.0000006	0.0000134
x.1	1	0.9999616	0.0211943	-0.0000384	0.0211943
x.2	1	0.9996468	0.0226182	-0.0003532	0.0226182
x.3	1	1.0003004	0.0059801	0.0003004	0.0059801

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000000	0.0000000	0.0000000	0.0000000
c.1	0	0.0000000	0.0000000	0.0000000	0.0000000
c.2	0	0.0000000	0.0000000	0.0000000	0.0000000
x.1	1	0.9978819	0.0586953	-0.0021181	0.0586953
x.2	1	0.9999946	0.0213078	-0.0000054	0.0213078
x.3	1	1.0001684	0.0059069	0.0001684	0.0059069

mcp Parameter Estimates for each Scenario

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000002	0.0000098	0.0000002	0.0000098
c.1	0	-0.0004431	0.0130341	-0.0004431	0.0130341
c.2	0	0.0003240	0.0104077	0.0003240	0.0104077
x.1	1	1.0002529	0.0085513	0.0002529	0.0085513
x.2	1	0.9996187	0.0256804	-0.0003813	0.0256804

|x.3 | 1| 0.9998516| 0.0186712| -0.0001484| 0.0186712|

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000003	0.0000107	0.0000003	0.0000107
c.1	0	0.0004282	0.0176848	0.0004282	0.0176848
c.2	0	-0.0000988	0.0122576	-0.0000988	0.0122576
x.1	1	0.9998399	0.0087691	-0.0001601	0.0087691
x.2	1	0.9991462	0.0481312	-0.0008538	0.0481312
x.3	1	0.9995298	0.0191076	-0.0004702	0.0191076

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000000	0.0000000	0.0000000	0.0000000
c.1	0	0.0000000	0.0000000	0.0000000	0.0000000
c.2	0	0.0000006	0.0000134	0.0000006	0.0000134
x.1	1	0.9999616	0.0211943	-0.0000384	0.0211943
x.2	1	0.9996468	0.0226182	-0.0003532	0.0226182
x.3	1	1.0003004	0.0059801	0.0003004	0.0059801

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000000	0.0000000	0.0000000	0.0000000
c.1	0	0.0000000	0.0000000	0.0000000	0.0000000
c.2	0	0.0000000	0.0000000	0.0000000	0.0000000
x.1	1	0.9978819	0.0586953	-0.0021181	0.0586953
x.2	1	0.9999946	0.0213078	-0.0000054	0.0213078
x.3	1	1.0001684	0.0059069	0.0001684	0.0059069

stepwise Parameter Estimates for each Scenario

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000000	0.0000224	0.0000000	0.0000224
c.1	0	-0.0009753	0.0274231	-0.0009753	0.0274231
c.2	0	0.0010376	0.0257469	0.0010376	0.0257469
x.1	1	1.0002507	0.0085478	0.0002507	0.0085478
x.2	1	0.9996421	0.0256979	-0.0003579	0.0256979
x.3	1	0.9998616	0.0186738	-0.0001384	0.0186738

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	-0.0000001	0.0000228	-0.0000001	0.0000228
c.1	0	0.0005074	0.0415138	0.0005074	0.0415138
c.2	0	0.0007822	0.0264786	0.0007822	0.0264786
x.1	1	0.9998586	0.0087834	-0.0001414	0.0087834
x.2	1	0.9990997	0.0669147	-0.0009003	0.0669147
x.3	1	0.9995024	0.0191094	-0.0004976	0.0191094

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000002	0.0000077	0.0000002	0.0000077
c.1	0	0.0000511	0.0093955	0.0000511	0.0093955
c.2	0	-0.0001261	0.0088400	-0.0001261	0.0088400
x.1	1	0.9998981	0.0222234	-0.0001019	0.0222234
x.2	1	0.9996611	0.0228689	-0.0003389	0.0228689
x.3	1	1.0003031	0.0059937	0.0003031	0.0059937

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	-0.0000003	0.0000075	-0.0000003	0.0000075
c.1	0	0.0001676	0.0114853	0.0001676	0.0114853
c.2	0	-0.0003215	0.0089874	-0.0003215	0.0089874
x.1	1	0.9971787	0.0774481	-0.0028213	0.0774481
x.2	1	1.0001438	0.0225188	0.0001438	0.0225188
x.3	1	1.0001558	0.0059168	0.0001558	0.0059168

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