Model Selection Simulation Study

December 12, 2023

[1]:
```
# ***************************************
# Variable Selection Simulation Study
#
# Jupyter Notebook Interactive Demonstration!
#
# Emma Tarmey
#
# Started:          03/10/2023
# Most Recent Edit: 12/12/2023
# ***************************************
```

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

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

[3]:
```
# extract R code from external files
source("../R/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 = 0.0,
               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)

source("../R/generate_data_plots.R")

scenario.plots(1)
scenario.plots(2)
scenario.plots(3)
scenario.plots(4)
```

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	-0.0000011	0.0000100
lasso	id	0.0000000	0.0000000
ridge	id	-0.0000019	0.0000050
scad	id	-0.0000011	0.0000100
mcp	id	-0.0000011	0.0000100
stepwise	id	-0.0000011	0.0000100
linear	c.1	0.0002129	0.0117545
lasso	c.1	0.0000000	0.0000000
ridge	c.1	-0.0025215	0.0042511
scad	c.1	0.0002130	0.0117532
mcp	c.1	0.0002130	0.0117532
stepwise	c.1	0.0002129	0.0117545
linear	c.2	-0.0002393	0.0117414
lasso	c.2	0.0000000	0.0000000
ridge	c.2	-0.0012241	0.0059777
scad	c.2	-0.0002429	0.0117399
mcp	c.2	-0.0002429	0.0117399
stepwise	c.2	-0.0002393	0.0117414
linear	x.1	0.0001656	0.0040014
lasso	x.1	-0.0006463	0.0039984

ridge	x.1	-0.0000861	0.0040065
scad	x.1	0.0001655	0.0040014
mcp	x.1	0.0001655	0.0040014
stepwise	x.1	0.0001656	0.0040014
linear	x.2	0.0001770	0.0121616
lasso	x.2	0.0080034	0.0057127
ridge	x.2	0.0060417	0.0062380
scad	x.2	0.0001770	0.0121616
mcp	x.2	0.0001770	0.0121616
stepwise	x.2	0.0001770	0.0121616
linear	x.3	0.0002186	0.0085538
lasso	x.3	-0.0099453	0.0075045
ridge	x.3	-0.0050455	0.0074977
scad	x.3	0.0002186	0.0085538
mcp	x.3	0.0002186	0.0085538
stepwise	x.3	0.0002186	0.0085538

Technique	Variable	BiasMean	BiasSD
linear	id	-0.0000004	0.0000106
lasso	id	0.0000000	0.0000000
ridge	id	-0.0000002	0.0000046
scad	id	-0.0000004	0.0000106
mcp	id	-0.0000004	0.0000106
stepwise	id	-0.0000004	0.0000106
linear	c.1	-0.0007450	0.0195969
lasso	c.1	0.0000000	0.0000000
ridge	c.1	-0.0012550	0.0032062
scad	c.1	-0.0007377	0.0195930
mcp	c.1	-0.0007377	0.0195930
stepwise	c.1	-0.0007450	0.0195969
linear	c.2	0.0002019	0.0121621
lasso	c.2	0.0000000	0.0000000
ridge	c.2	0.0002097	0.0051850
scad	c.2	0.0001988	0.0121611
mcp	c.2	0.0001988	0.0121611
stepwise	c.2	0.0002019	0.0121621
linear	x.1	-0.0000369	0.0040065
lasso	x.1	-0.0002364	0.0039793
ridge	x.1	-0.0000290	0.0039891
scad	x.1	-0.0000369	0.0040065
mcp	x.1	-0.0000369	0.0040065
stepwise	x.1	-0.0000369	0.0040065
linear	x.2	0.0008361	0.0301511
lasso	x.2	0.0080124	0.0152011
ridge	x.2	0.0042959	0.0166092

scad	x.2	0.0008273	0.0301436
mcp	x.2	0.0008273	0.0301436
stepwise	x.2	0.0008361	0.0301511
linear	x.3	-0.0003884	0.0082889
lasso	x.3	-0.0024901	0.0051734
ridge	x.3	-0.0005915	0.0052551
scad	x.3	-0.0003884	0.0082889
mcp	x.3	-0.0003884	0.0082889
stepwise	x.3	-0.0003884	0.0082889

Technique	Variable	BiasMean	BiasSD
linear	id	0.0000000	0.0000036
lasso	id	0.0000000	0.0000000
ridge	id	0.0000001	0.0000021
scad	id	0.0000000	0.0000036
mcp	id	0.0000000	0.0000036
stepwise	id	0.0000000	0.0000036
linear	c.1	-0.0001543	0.0042633
lasso	c.1	0.0000000	0.0000000
ridge	c.1	-0.0000690	0.0016544
scad	c.1	-0.0001537	0.0042628
mcp	c.1	-0.0001537	0.0042628
stepwise	c.1	-0.0001543	0.0042633
linear	c.2	-0.0001884	0.0040704
lasso	c.2	0.0000000	0.0000000
ridge	c.2	-0.0000788	0.0022554
scad	c.2	-0.0001877	0.0040699
mcp	c.2	-0.0001877	0.0040699
stepwise	c.2	-0.0001884	0.0040704
linear	x.1	-0.0001220	0.0096482
lasso	x.1	0.0021411	0.0087217
ridge	x.1	-0.0000183	0.0092871
scad	x.1	-0.0001226	0.0096476
mcp	x.1	-0.0001226	0.0096476
stepwise	x.1	-0.0001220	0.0096482
linear	x.2	0.0001174	0.0096590
lasso	x.2	0.0010291	0.0095383
ridge	x.2	0.0001626	0.0096083
scad	x.2	0.0001172	0.0096591
mcp	x.2	0.0001172	0.0096591
stepwise	x.2	0.0001174	0.0096590
linear	x.3	-0.0000996	0.0029243
lasso	x.3	-0.0002609	0.0010508
ridge	x.3	0.0000219	0.0013895
scad	x.3	-0.0000996	0.0029243

|mcp |x.3 | -0.0000996| 0.0029243|
|stepwise |x.3 | -0.0000996| 0.0029243|

Technique	Variable	BiasMean	BiasSD
linear	id	0.0000000	0.0000034
lasso	id	0.0000000	0.0000000
ridge	id	-0.0000002	0.0000020
scad	id	0.0000000	0.0000034
mcp	id	0.0000000	0.0000034
stepwise	id	0.0000000	0.0000034
linear	c.1	-0.0002936	0.0055875
lasso	c.1	0.0000000	0.0000000
ridge	c.1	-0.0013143	0.0012355
scad	c.1	-0.0002964	0.0055867
mcp	c.1	-0.0002964	0.0055867
stepwise	c.1	-0.0002936	0.0055875
linear	c.2	0.0000298	0.0040775
lasso	c.2	0.0000000	0.0000000
ridge	c.2	-0.0000246	0.0021487
scad	c.2	0.0000305	0.0040771
mcp	c.2	0.0000305	0.0040771
stepwise	c.2	0.0000298	0.0040775
linear	x.1	0.0012182	0.0345646
lasso	x.1	0.0245645	0.0195765
ridge	x.1	0.0176987	0.0210977
scad	x.1	0.0012299	0.0345665
mcp	x.1	0.0012299	0.0345665
stepwise	x.1	0.0012182	0.0345646
linear	x.2	-0.0002586	0.0099956
lasso	x.2	0.0015753	0.0096212
ridge	x.2	0.0007667	0.0097467
scad	x.2	-0.0002585	0.0099962
mcp	x.2	-0.0002585	0.0099962
stepwise	x.2	-0.0002586	0.0099956
linear	x.3	-0.0001294	0.0029080
lasso	x.3	-0.0024876	0.0019617
ridge	x.3	-0.0008681	0.0019547
scad	x.3	-0.0001294	0.0029081
mcp	x.3	-0.0001294	0.0029081
stepwise	x.3	-0.0001294	0.0029080

```
[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

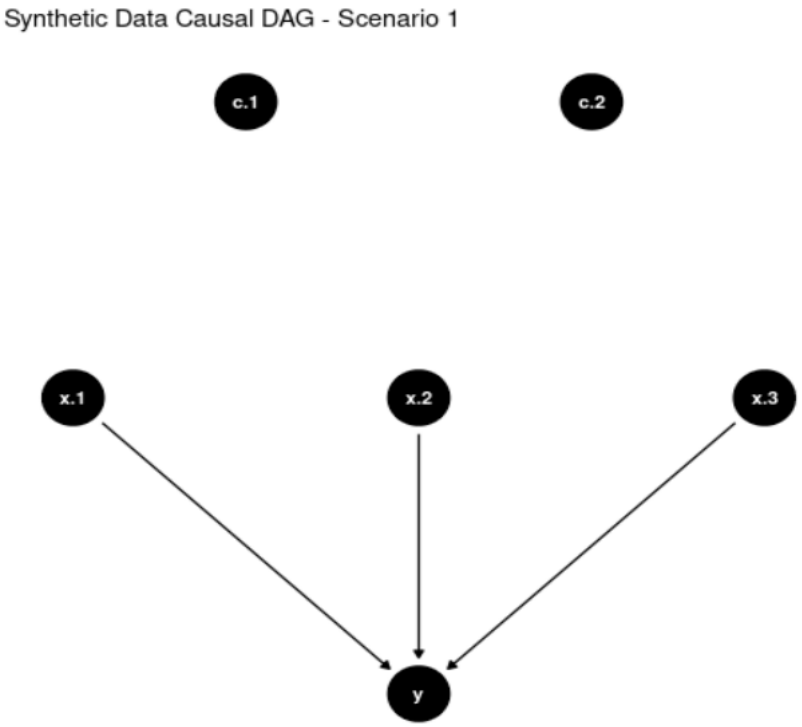
png: 2

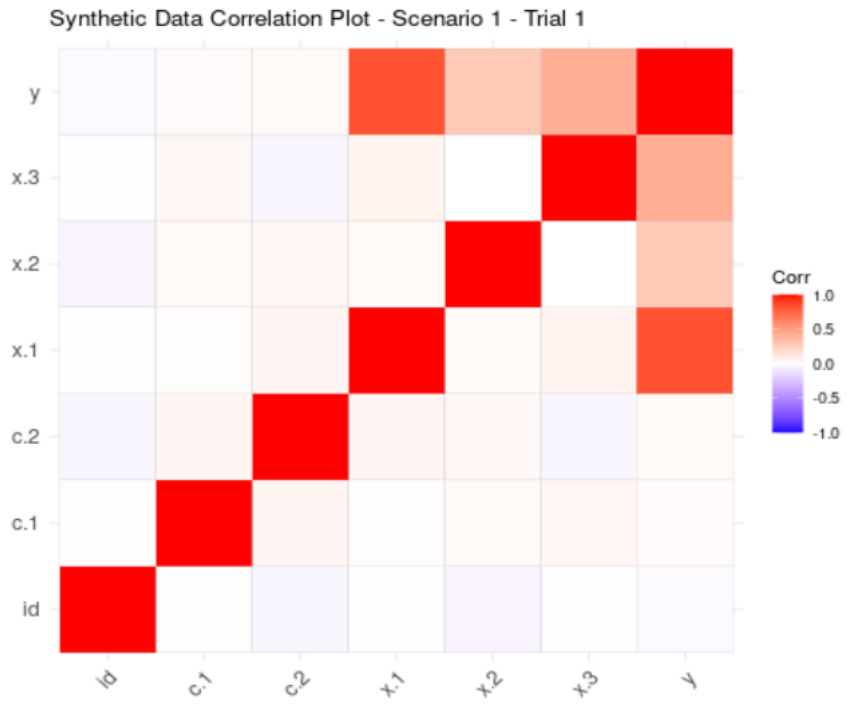
png: 2

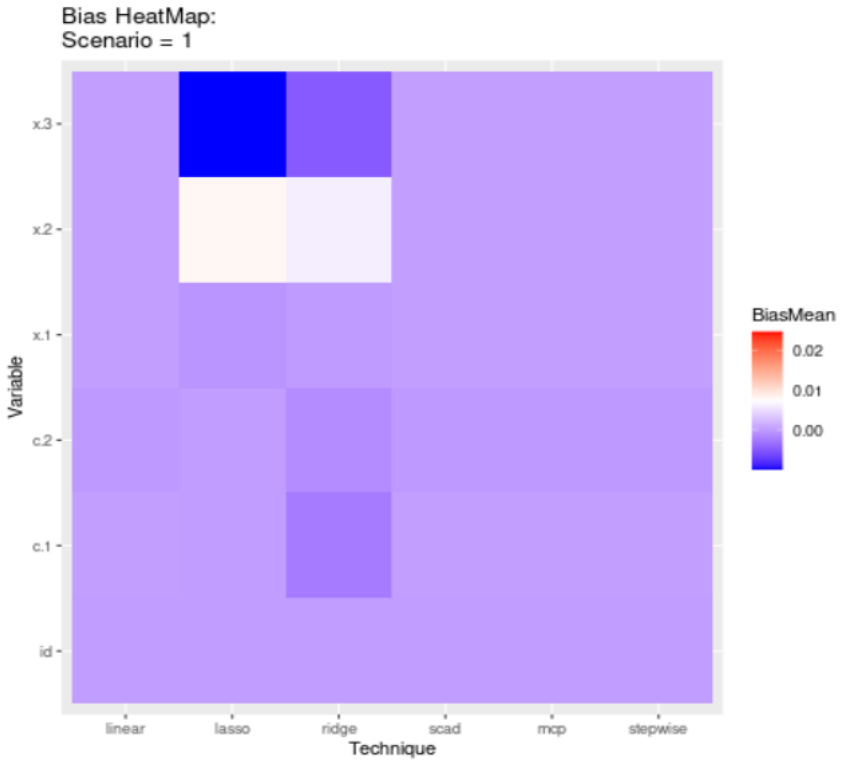
png: 2

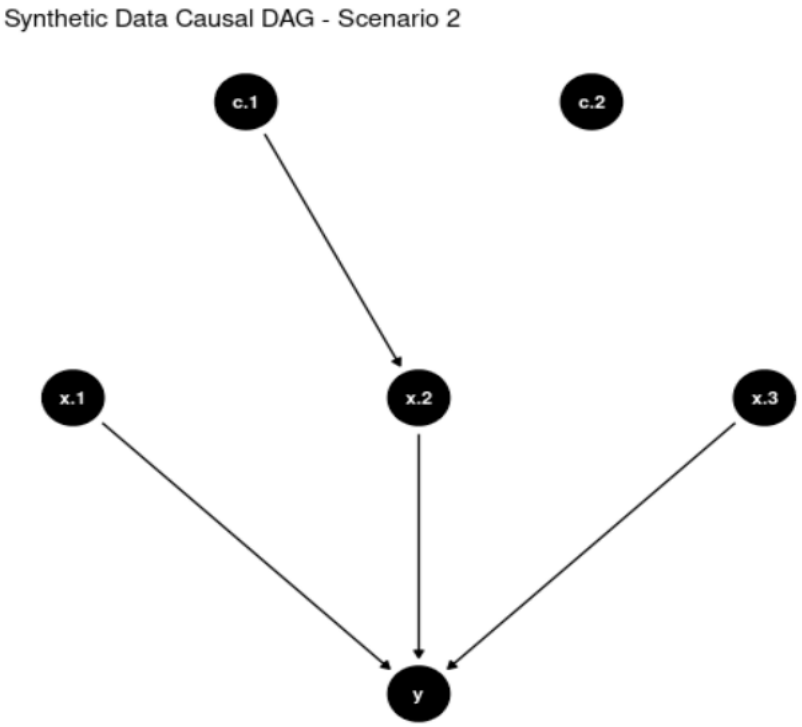
png: 2

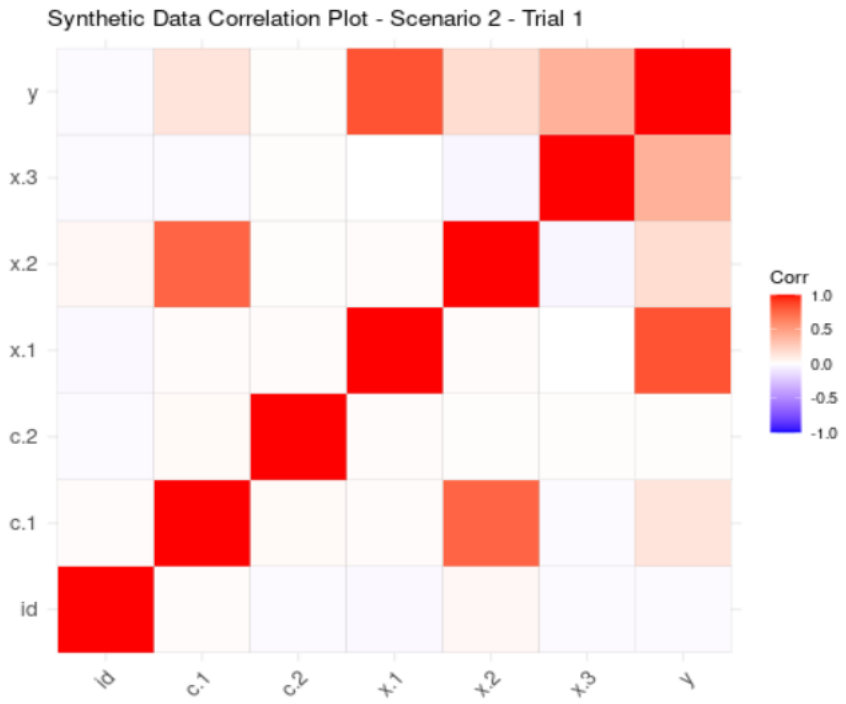
[6]:
```
library("png")

for (s in list(1, 2, 3, 4)) {
    plot.new()
    pp <- readPNG(paste("../plots/synthetic_data_s", s, "_DAG.png", sep = ""))
    rasterImage(pp, 0.00, 0.00, 1.00, 1.00)

    plot.new()
    pp <- readPNG(paste("../plots/synthetic_data_s", s, "_t1_corr.png", sep =␣
 ↪""))
    rasterImage(pp, 0.00, 0.00, 1.00, 1.00)

    plot.new()
    pp <- readPNG(paste("../plots/bias_s", s, ".png", sep = ""))
    rasterImage(pp, 0.00, 0.00, 1.00, 1.00)
}
```

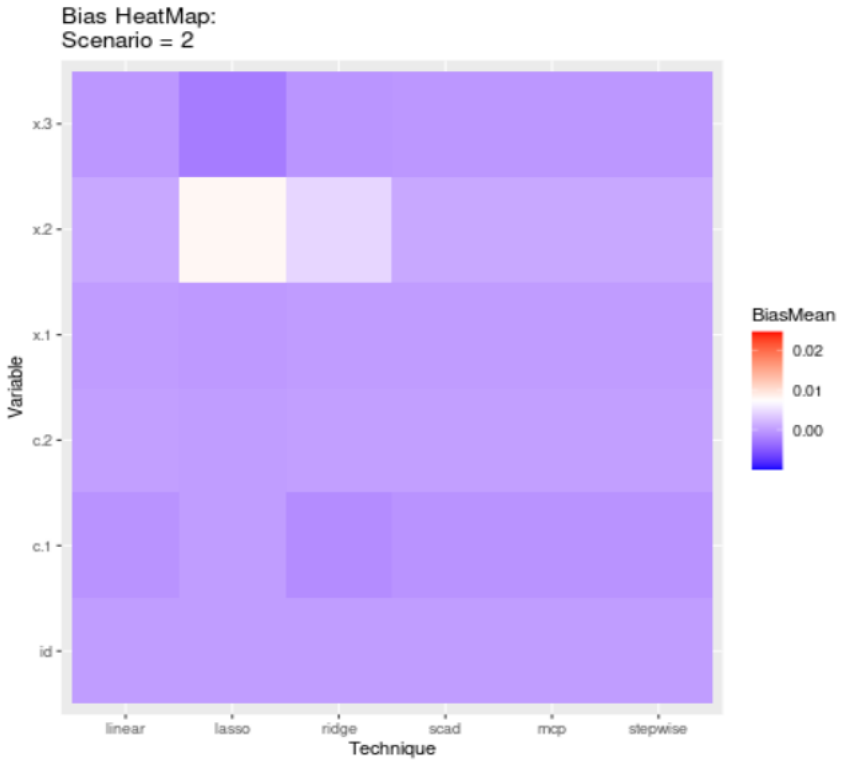

Synthetic Data Causal DAG - Scenario 1
c.1
c.2
x.1
x.2
x.3
y

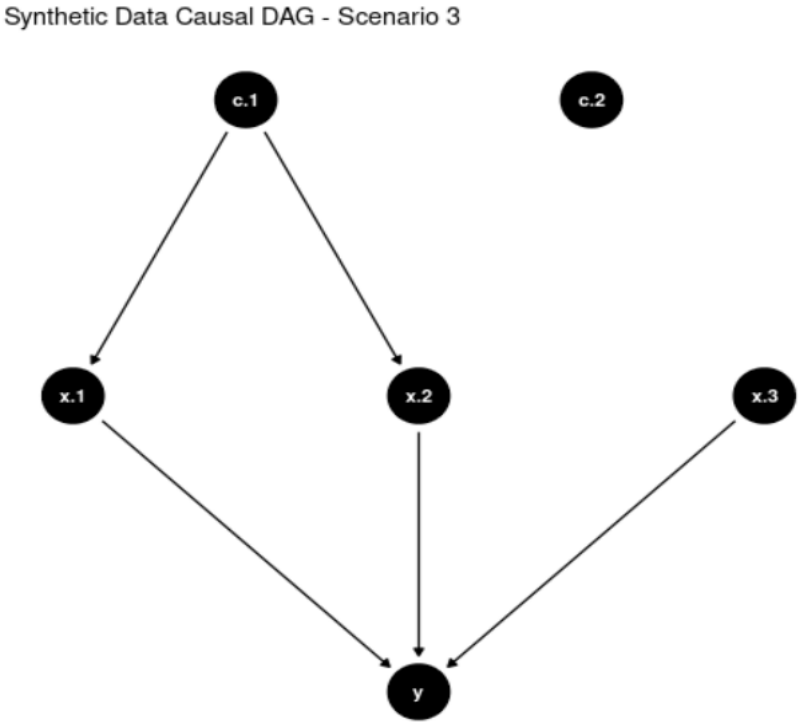

Synthetic Data Correlation Plot - Scenario 1 - Trial 1
y
x.3
x.2
x.1
c.2
c.1
id
id
c.1
c.2
x.1
x.2
x.3
y
Corr
1.0
0.5
0.0
-0.5
-1.0

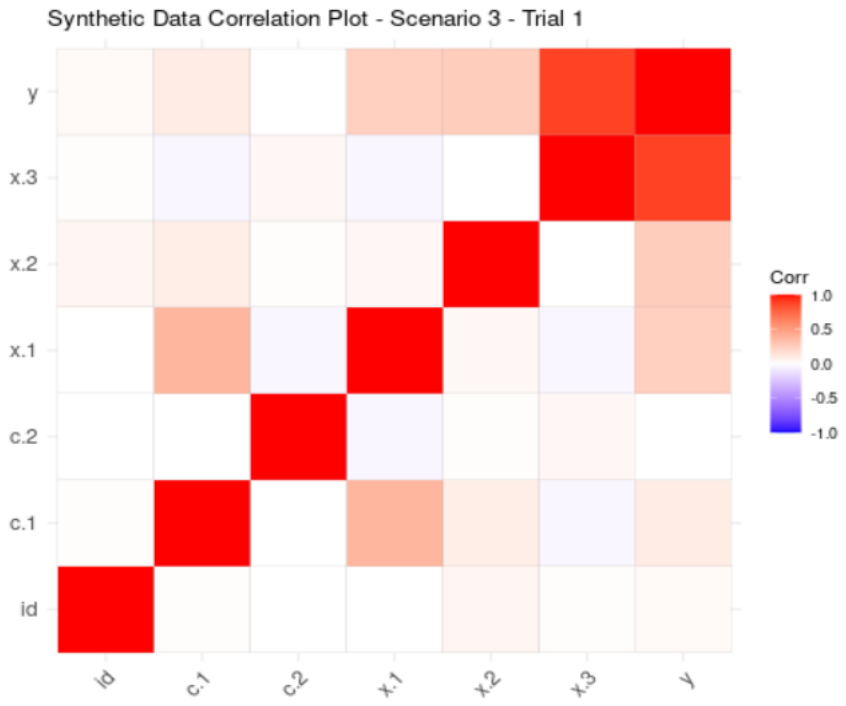

Bias HeatMap:
Scenario = 1
x.3
x.2
x.1
c.2
c.1
id
Variable
linear
lasso
ridge
scad
mcp
stepwise
Technique
BiasMean
0.02
0.01
0.00

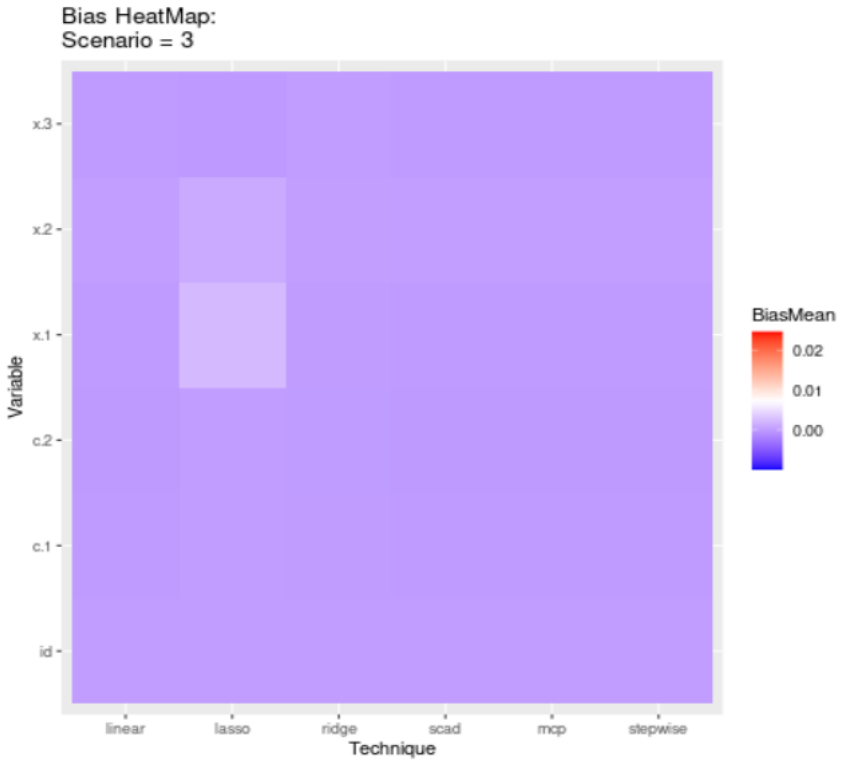

Synthetic Data Causal DAG - Scenario 2
c.1
c.2
x.1
x.2
x.3
y

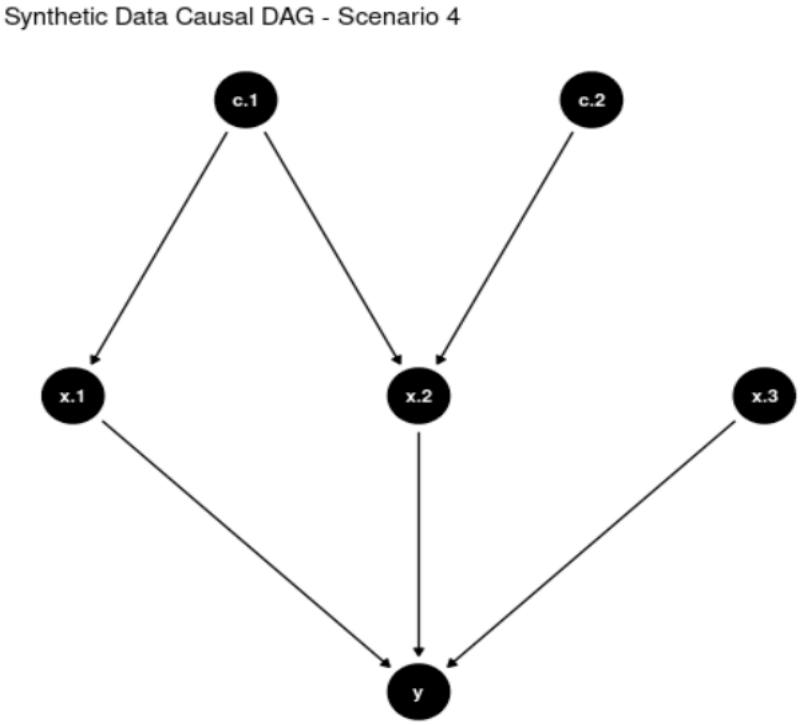

Synthetic Data Correlation Plot - Scenario 2 - Trial 1
y
x.3
x.2
x.1
c.2
c.1
id
id
c.1
c.2
x.1
x.2
x.3
y
Corr
1.0
0.5
0.0
-0.5
-1.0

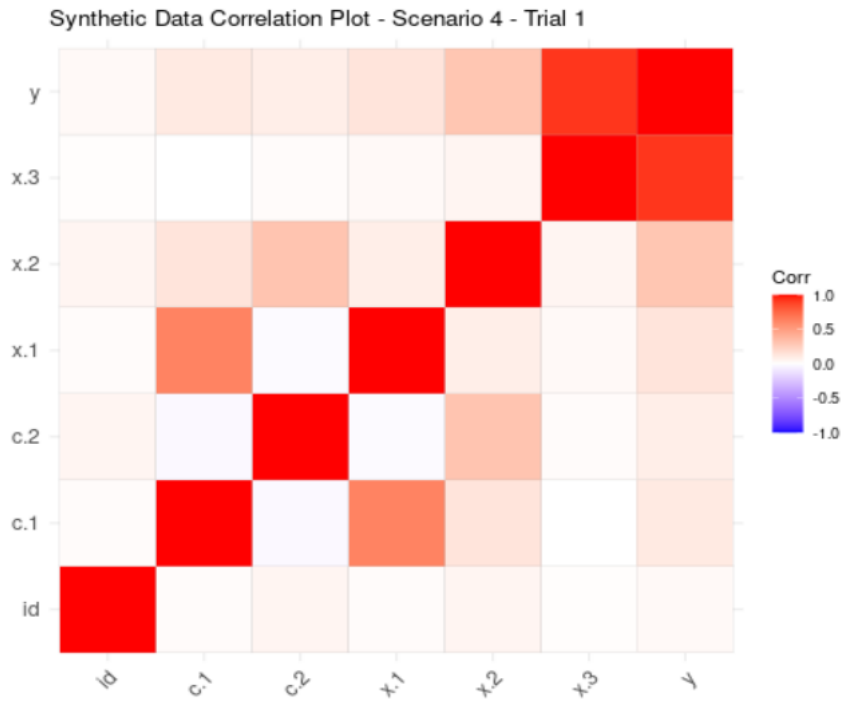

Bias HeatMap:
Scenario = 2
x.3
x.2
x.1
c.2
c.1
id
Variable
linear
lasso
ridge
scad
mcp
stepwise
Technique
BiasMean
0.02
0.01
0.00

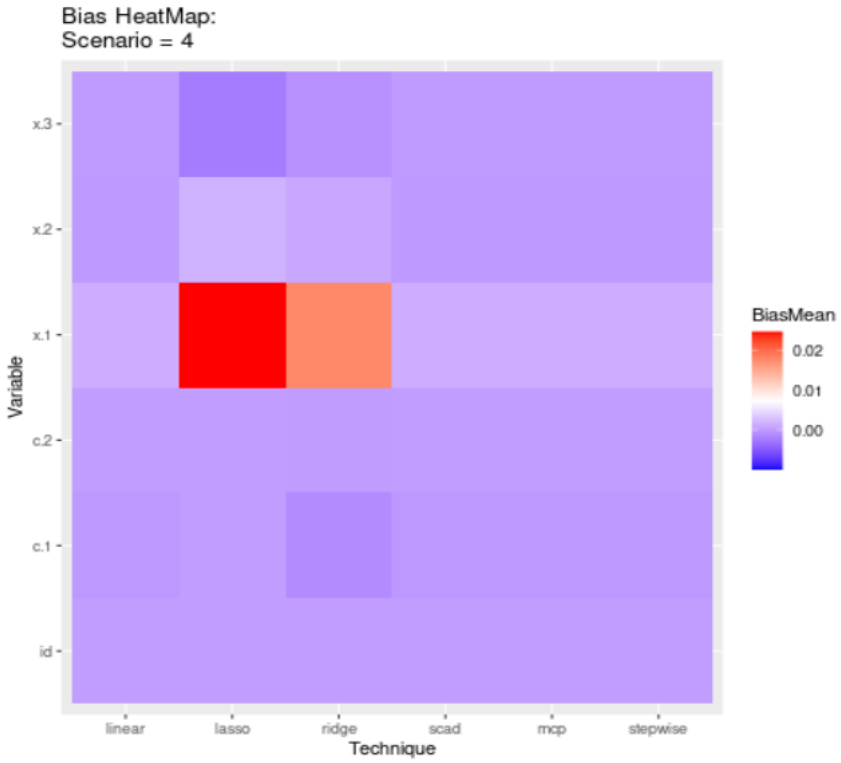

Synthetic Data Causal DAG - Scenario 3
c.1
c.2
x.1
x.2
x.3
y


Synthetic Data Correlation Plot - Scenario 3 - Trial 1
y
x.3
x.2
x.1
c.2
c.1
id
id
c.1
c.2
x.1
x.2
x.3
y
Corr
1.0
0.5
0.0
-0.5
-1.0


Bias HeatMap:
Scenario = 3
x.3
x.2
x.1
c.2
c.1
id
Variable
linear
lasso
ridge
scad
mcp
stepwise
Technique
BiasMean
0.02
0.01
0.00


Synthetic Data Causal DAG - Scenario 4
c.1
c.2
x.1
x.2
x.3
y


Synthetic Data Correlation Plot - Scenario 4 - Trial 1
y
x.3
x.2
x.1
c.2
c.1
id
id
c.1
c.2
x.1
x.2
x.3
y
Corr
1.0
0.5
0.0
-0.5
-1.0



[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]]
```

```
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	-0.0000011	0.0000100	-0.0000011	0.0000100

c.1	0	0.0002129	0.0117545	0.0002129	0.0117545
c.2	0	-0.0002393	0.0117414	-0.0002393	0.0117414
x.1	1	1.0001656	0.0040014	0.0001656	0.0040014
x.2	1	1.0001770	0.0121616	0.0001770	0.0121616
x.3	1	1.0002186	0.0085538	0.0002186	0.0085538

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	-0.0000004	0.0000106	-0.0000004	0.0000106
c.1	0	-0.0007450	0.0195969	-0.0007450	0.0195969
c.2	0	0.0002019	0.0121621	0.0002019	0.0121621
x.1	1	0.9999631	0.0040065	-0.0000369	0.0040065
x.2	1	1.0008361	0.0301511	0.0008361	0.0301511
x.3	1	0.9996116	0.0082889	-0.0003884	0.0082889

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000000	0.0000036	0.0000000	0.0000036
c.1	0	-0.0001543	0.0042633	-0.0001543	0.0042633
c.2	0	-0.0001884	0.0040704	-0.0001884	0.0040704
x.1	1	0.9998780	0.0096482	-0.0001220	0.0096482
x.2	1	1.0001174	0.0096590	0.0001174	0.0096590
x.3	1	0.9999004	0.0029243	-0.0000996	0.0029243

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000000	0.0000034	0.0000000	0.0000034
c.1	0	-0.0002936	0.0055875	-0.0002936	0.0055875
c.2	0	0.0000298	0.0040775	0.0000298	0.0040775
x.1	1	1.0012182	0.0345646	0.0012182	0.0345646
x.2	1	0.9997414	0.0099956	-0.0002586	0.0099956
x.3	1	0.9998706	0.0029080	-0.0001294	0.0029080

lasso Parameter Estimates for each Scenario

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	0.9993537	0.0039984	-0.0006463	0.0039984
x.2	1	1.0080034	0.0057127	0.0080034	0.0057127
x.3	1	0.9900547	0.0075045	-0.0099453	0.0075045

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	0.9997636	0.0039793	-0.0002364	0.0039793
x.2	1	1.0080124	0.0152011	0.0080124	0.0152011
x.3	1	0.9975099	0.0051734	-0.0024901	0.0051734

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	1.0021411	0.0087217	0.0021411	0.0087217
x.2	1	1.0010291	0.0095383	0.0010291	0.0095383
x.3	1	0.9997391	0.0010508	-0.0002609	0.0010508

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	1.0245645	0.0195765	0.0245645	0.0195765
x.2	1	1.0015753	0.0096212	0.0015753	0.0096212
x.3	1	0.9975124	0.0019617	-0.0024876	0.0019617

ridge Parameter Estimates for each Scenario

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	-0.0000019	0.0000050	-0.0000019	0.0000050
c.1	0	-0.0025215	0.0042511	-0.0025215	0.0042511
c.2	0	-0.0012241	0.0059777	-0.0012241	0.0059777

x.1	1	0.9999139	0.0040065	-0.0000861	0.0040065
x.2	1	1.0060417	0.0062380	0.0060417	0.0062380
x.3	1	0.9949545	0.0074977	-0.0050455	0.0074977

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	-0.0000002	0.0000046	-0.0000002	0.0000046
c.1	0	-0.0012550	0.0032062	-0.0012550	0.0032062
c.2	0	0.0002097	0.0051850	0.0002097	0.0051850
x.1	1	0.9999710	0.0039891	-0.0000290	0.0039891
x.2	1	1.0042959	0.0166092	0.0042959	0.0166092
x.3	1	0.9994085	0.0052551	-0.0005915	0.0052551

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000001	0.0000021	0.0000001	0.0000021
c.1	0	-0.0000690	0.0016544	-0.0000690	0.0016544
c.2	0	-0.0000788	0.0022554	-0.0000788	0.0022554
x.1	1	0.9999817	0.0092871	-0.0000183	0.0092871
x.2	1	1.0001626	0.0096083	0.0001626	0.0096083
x.3	1	1.0000219	0.0013895	0.0000219	0.0013895

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	-0.0000002	0.0000020	-0.0000002	0.0000020
c.1	0	-0.0013143	0.0012355	-0.0013143	0.0012355
c.2	0	-0.0000246	0.0021487	-0.0000246	0.0021487
x.1	1	1.0176987	0.0210977	0.0176987	0.0210977
x.2	1	1.0007667	0.0097467	0.0007667	0.0097467
x.3	1	0.9991319	0.0019547	-0.0008681	0.0019547

scad Parameter Estimates for each Scenario

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	-0.0000011	0.0000100	-0.0000011	0.0000100
c.1	0	0.0002130	0.0117532	0.0002130	0.0117532
c.2	0	-0.0002429	0.0117399	-0.0002429	0.0117399
x.1	1	1.0001655	0.0040014	0.0001655	0.0040014

|x.2 | 1| 1.0001770| 0.0121616| 0.0001770| 0.0121616|
|x.3 | 1| 1.0002186| 0.0085538| 0.0002186| 0.0085538|

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	-0.0000004	0.0000106	-0.0000004	0.0000106
c.1	0	-0.0007377	0.0195930	-0.0007377	0.0195930
c.2	0	0.0001988	0.0121611	0.0001988	0.0121611
x.1	1	0.9999631	0.0040065	-0.0000369	0.0040065
x.2	1	1.0008273	0.0301436	0.0008273	0.0301436
x.3	1	0.9996116	0.0082889	-0.0003884	0.0082889

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000000	0.0000036	0.0000000	0.0000036
c.1	0	-0.0001537	0.0042628	-0.0001537	0.0042628
c.2	0	-0.0001877	0.0040699	-0.0001877	0.0040699
x.1	1	0.9998774	0.0096476	-0.0001226	0.0096476
x.2	1	1.0001172	0.0096591	0.0001172	0.0096591
x.3	1	0.9999004	0.0029243	-0.0000996	0.0029243

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000000	0.0000034	0.0000000	0.0000034
c.1	0	-0.0002964	0.0055867	-0.0002964	0.0055867
c.2	0	0.0000305	0.0040771	0.0000305	0.0040771
x.1	1	1.0012299	0.0345665	0.0012299	0.0345665
x.2	1	0.9997415	0.0099962	-0.0002585	0.0099962
x.3	1	0.9998706	0.0029081	-0.0001294	0.0029081

mcp Parameter Estimates for each Scenario

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	-0.0000011	0.0000100	-0.0000011	0.0000100
c.1	0	0.0002130	0.0117532	0.0002130	0.0117532
c.2	0	-0.0002429	0.0117399	-0.0002429	0.0117399
x.1	1	1.0001655	0.0040014	0.0001655	0.0040014
x.2	1	1.0001770	0.0121616	0.0001770	0.0121616

|x.3 | 1| 1.0002186| 0.0085538| 0.0002186| 0.0085538|

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	-0.0000004	0.0000106	-0.0000004	0.0000106
c.1	0	-0.0007377	0.0195930	-0.0007377	0.0195930
c.2	0	0.0001988	0.0121611	0.0001988	0.0121611
x.1	1	0.9999631	0.0040065	-0.0000369	0.0040065
x.2	1	1.0008273	0.0301436	0.0008273	0.0301436
x.3	1	0.9996116	0.0082889	-0.0003884	0.0082889

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000000	0.0000036	0.0000000	0.0000036
c.1	0	-0.0001537	0.0042628	-0.0001537	0.0042628
c.2	0	-0.0001877	0.0040699	-0.0001877	0.0040699
x.1	1	0.9998774	0.0096476	-0.0001226	0.0096476
x.2	1	1.0001172	0.0096591	0.0001172	0.0096591
x.3	1	0.9999004	0.0029243	-0.0000996	0.0029243

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000000	0.0000034	0.0000000	0.0000034
c.1	0	-0.0002964	0.0055867	-0.0002964	0.0055867
c.2	0	0.0000305	0.0040771	0.0000305	0.0040771
x.1	1	1.0012299	0.0345665	0.0012299	0.0345665
x.2	1	0.9997415	0.0099962	-0.0002585	0.0099962
x.3	1	0.9998706	0.0029081	-0.0001294	0.0029081

stepwise Parameter Estimates for each Scenario

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	-0.0000011	0.0000100	-0.0000011	0.0000100
c.1	0	0.0002129	0.0117545	0.0002129	0.0117545
c.2	0	-0.0002393	0.0117414	-0.0002393	0.0117414
x.1	1	1.0001656	0.0040014	0.0001656	0.0040014
x.2	1	1.0001770	0.0121616	0.0001770	0.0121616
x.3	1	1.0002186	0.0085538	0.0002186	0.0085538

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	-0.0000004	0.0000106	-0.0000004	0.0000106
c.1	0	-0.0007450	0.0195969	-0.0007450	0.0195969
c.2	0	0.0002019	0.0121621	0.0002019	0.0121621
x.1	1	0.9999631	0.0040065	-0.0000369	0.0040065
x.2	1	1.0008361	0.0301511	0.0008361	0.0301511
x.3	1	0.9996116	0.0082889	-0.0003884	0.0082889

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000000	0.0000036	0.0000000	0.0000036
c.1	0	-0.0001543	0.0042633	-0.0001543	0.0042633
c.2	0	-0.0001884	0.0040704	-0.0001884	0.0040704
x.1	1	0.9998780	0.0096482	-0.0001220	0.0096482
x.2	1	1.0001174	0.0096590	0.0001174	0.0096590
x.3	1	0.9999004	0.0029243	-0.0000996	0.0029243

Variable	True	Mean	SD	BiasMean	BiasSD
id	0	0.0000000	0.0000034	0.0000000	0.0000034
c.1	0	-0.0002936	0.0055875	-0.0002936	0.0055875
c.2	0	0.0000298	0.0040775	0.0000298	0.0040775
x.1	1	1.0012182	0.0345646	0.0012182	0.0345646
x.2	1	0.9997414	0.0099956	-0.0002586	0.0099956
x.3	1	0.9998706	0.0029080	-0.0001294	0.0029080

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