codes

2025-1-29

dependency

```
rm(list=c())
Rcpp::sourceCpp("base_randomization.cpp")
source("simulation.R")
library(parallel)
library(Rcpp)
library(RcppArmadillo)
library(ggplot2)
library(tidyr)
```

```
##
## Attaching package: 'tidyr'

## The following object is masked _by_ '.GlobalEnv':
##
##     extract
```

```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(patchwork)
library(latex2exp)
```

Main Text

Table 1

```
true_tau=true_values(model2,"RAR")[1]
true_bound=true_values(model2,"RAR")[2]
n=5e2
repli_num=1e4
extract2 (experiment2(model2, n,"CR",repli = repli_num) )
```

```
## [1]  0.250 16.819  0.001  0.274
```

```
true_bound=true_values(model2,"RAR",TB=100)[2]
extract2 (experiment2(model2, n,"RAR", target="New", TB=100,repli = repli_num) )
```

```
## [1]  0.249 14.722 -0.013  0.246
```

```
true_bound=true_values(model2,"RAR",TB=15)[2]
extract2 (experiment2(model2, n,"RAR", target="New", TB=15,repli = repli_num) )
```

```
## [1]  0.249 14.570 -0.004  0.248
```

```
true_bound=true_values(model2,"RAR",TB=14)[2]
extract2 (experiment2(model2, n,"RAR", target="New", TB=14,repli = repli_num) )
```

```
## [1]  0.252 13.959  0.014  0.256
```

```
true_bound=true_values(model2,"RAR",TB=13)[2]
extract2 (experiment2(model2, n,"RAR", target="New", TB=13,repli = repli_num) )
```

```
## [1]  0.271 13.011  0.019  0.276
```

Table 2

```
true_tau=true_values(model2,"CARA")[1]
true_bound=true_values(model2,"CARA")[2]
n=5e2
repli_num=1e4
extract (experiment(model2, n,"CR",repli = repli_num) )
```

```
## [1]  0.135 11.778 19.746 18.919 -0.004  0.271 -0.003  0.170
```

```
true_bound=true_values(model2,"CARA",TB=100)[2]
extract (experiment(model2, n,"CARA", target="New", TB=100,repli = repli_num) )
```

```
## [1]  0.135  8.573 23.536 16.063  1.408  0.450 -0.011  0.135
```

```
true_bound=true_values(model2,"CARA",TB=18)[2]
extract (experiment(model2, n,"CARA", target="New", TB=18,repli = repli_num) )
```

```
## [1]  0.152  8.573 18.017 16.074  0.025  0.296 -0.009  0.155
```

```
true_bound=true_values(model2,"CARA",TB=17)[2]
extract (experiment(model2, n,"CARA", target="New", TB=17,repli = repli_num) )
```

```
## [1]  0.160  8.573 17.025 16.045 -0.291  0.288 -0.005  0.163
```

```
true_bound=true_values(model2,"CARA",TB=16)[2]
extract (experiment(model2, n,"CARA", target="New", TB=16,repli = repli_num) )
```

```
## [1]  0.174  8.573 16.034 15.852 -0.675  0.289  0.004  0.182
```

Supplementary Material

Section S2.1

Table S1

```
true_tau=true_values(model1,"RAR")[1]
true_bound=true_values(model1,"RAR")[2]
n=500
extract2 (experiment2(model1, n,"CR"),5 )
```

```
## [1]  0.00170  0.63352 -0.00040  0.00173
```

```
true_bound=true_values(model1,"RAR",TB=1)[2]
extract2 (experiment2(model1, n,"RAR", target="New", TB=1) ,5)
```

```
## [1] 0.00170 0.62237 0.00045 0.00170
```

```
true_bound=true_values(model1,"RAR",TB=0.65)[2]
extract2 (experiment2(model1, n,"RAR", target="New", TB=0.65),5 )
```

```
## [1] 0.00170 0.62120 0.00093 0.00168
```

```
true_bound=true_values(model1,"RAR",TB=0.6)[2]
extract2 (experiment2(model1, n,"RAR", target="New", TB=0.6) ,5)
```

```
## [1] 0.00175 0.59912 0.00538 0.00173
```

```
true_bound=true_values(model1,"RAR",TB=0.55)[2]
extract2 (experiment2(model1, n,"RAR", target="New", TB=0.55) ,5)
```

```
## [1] 0.00253 0.56704 0.00466 0.00241
```

Table S2

```
true_tau=true_values(model1,"CARA")[1]
true_bound=true_values(model1,"CARA")[2]
n=500
extract.binary (experiment(model1, n,"CR"),5 )
```

```
## [1] 0.00159 0.70012 0.49938 0.00066 0.00173 0.00055 0.00167
```

```
true_bound=true_values(model1,"CARA",TB=1)[2]
extract.binary (experiment(model1, n,"CARA", target="New", TB=1),5 )
```

```
## [1]  0.00159  0.64510  0.50039 -0.02991  0.00158  0.00144  0.00163
```

```
true_bound=true_values(model1,"CARA",TB=0.65)[2]
extract.binary (experiment(model1, n,"CARA", target="New", TB=0.65),5 )
```

```
## [1]  0.00159  0.63652  0.50042 -0.03566  0.00202  0.00219  0.00160
```

```
true_bound=true_values(model1,"CARA",TB=0.6)[2]
extract.binary (experiment(model1, n,"CARA", target="New", TB=0.6),5 )
```

```
## [1]  0.00166  0.60183  0.50037 -0.06644  0.00315  0.00265  0.00168
```

```
true_bound=true_values(model1,"CARA",TB=0.55)[2]
extract.binary (experiment(model1, n,"CARA", target="New", TB=0.55),5 )
```

```
## [1]  0.00209  0.57711  0.50033 -0.10026  0.00301 -0.00034  0.00204
```

Section 2.2

Table S3

```
n=500
repli_num=1e4

true_tau=true_values(model2,"RAR")[1]
true_bound=true_values(model2,"RAR")[2]

extract2 (experiment2(model2, n,"CR",repli=repli_num) )
```

```
## [1]  0.249 16.819 -0.005  0.274
```

```
extract2 (experiment2(model2, n,"BCD",repli=repli_num) )
```

```
## [1]  0.249 16.820 -0.006  0.267
```

```
extract2 (experiment2(model2, n,"RAR", target="Neyman",repli=repli_num, TB=100) )
```

```
## [1]  0.249 14.722 -0.019  0.246
```

```
extract2 (experiment2(model2, n,"RAR", target="BandBis",repli=repli_num,TB=30) )
```

```
## [1]  0.249 19.435  0.003  0.367
```

```
extract2 (experiment2(model2, n,"RAR", target="RSIHR",repli=repli_num,TB=30) )
```

```
## [1]  0.249 13.324 -0.028  0.267
```

```
extract2 (experiment2(model2, n,"RAR", target="Bayesian",repli=repli_num,n0=100, TB=30) )
```

```
## [1]  0.249 12.607  0.003  0.288
```

Table S4

```
n=500
repli_num=1e4

true_tau=true_values(model2,"CARA")[1]
true_bound=true_values(model2,"CARA")[2]
extract (experiment(model2, n,"CR",repli=repli_num) )
```

```
## [1]  0.135 11.778 19.746 18.919 -0.004  0.271 -0.003  0.170
```

```
extract (experiment(model2, n,"MIN",repli=repli_num) )
```

```
## [1]  0.135 11.787 19.757 18.919 -0.006  0.176 -0.005  0.175
```

```
extract (experiment(model2, n,"CARA", target="Neyman",repli=repli_num, TB=100) )
```

```
## [1]  0.135  8.573 23.536 16.063  1.408  0.450 -0.011  0.135
```

```
extract (experiment(model2, n,"CARA", target="BandBis",repli=repli_num,TB=30) )
```

```
## [1]  0.135 16.168 22.519 20.044 -0.714  0.294  0.005  0.191
```

```
extract (experiment(model2, n,"CARA", target="RSIHR",repli=repli_num,TB=30) )
```

```
## [1]  0.135  5.057 22.330 15.737  2.463  0.395 -0.023  0.141
```

```
extract (experiment(model2, n,"CARA", target="Bayesian",repli=repli_num,n0=33,TB=30) )
```

```
## [1]  0.135  6.222 15.399 16.289  0.005  0.223 -0.013  0.183
```

```
extract (experiment(model2, n,"CADBCD", target="Neyman",TB=100,
                    repli=repli_num, n0=30,gamma=2) )
```

```
## [1]  0.135  8.773 22.861 16.378  1.233  0.498 -0.008  0.140
```

```
extract (experiment(model2, n,"CADBCD", target="BandBis",TB=30,repli=repli_num,
                    n0=30,gamma=2) )
```

```
## [1]  0.135 15.993 22.492 20.123 -0.592  0.410  0.011  0.196
```

```
extract (experiment(model2, n,"CADBCD", target="RSIHR",TB=30,repli=repli_num, n0=30,gamma=2) )
```

```
## [1]  0.135  5.675 21.367 16.020  2.009  0.429 -0.014  0.143
```

```
extract (experiment(model2, n,"CADBCD", target="Bayesian",TB=30,n0=100,repli=repli_num,gamma=2) )
```

```
## [1]  0.135  6.253 15.419 16.215 -0.007  0.288 -0.011  0.196
```

Table S5

```
n=2e3
repli_num=1e4

true_tau=true_values(model2,"CARA")[1]
true_bound=true_values(model2,"CARA")[2]
extract (experiment(model2, n,"CR",repli=repli_num) ,round_num = 4)
```

```
## [1]  0.0339 11.7874 19.7567 18.9202 -0.0075  0.0678 -0.0064  0.0418
```

```
extract (experiment(model2, n,"MIN",repli=repli_num) ,round_num = 4)
```

```
## [1]  0.0339 11.7859 19.7568 18.9208 -0.0079  0.0421 -0.0078  0.0421
```

```
extract (experiment(model2, n,"CARA", target="Neyman",repli=repli_num, TB=100) ,round_num = 4)
```

```
## [1]  0.0339  8.6210 23.4984 16.0960  1.3810  0.1217 -0.0080  0.0336
```

```
extract (experiment(model2, n,"CARA", target="BandBis",repli=repli_num,TB=30) ,round_num = 4)
```

```
## [1]  0.0339 16.1928 22.5410 20.0524 -0.7244  0.0764 -0.0024  0.0493
```

```
extract (experiment(model2, n,"CARA", target="RSIHR",repli=repli_num,TB=30) ,round_num = 4)
```

```
## [1]  0.0339  5.0282 22.2962 15.7484  2.4695  0.1104 -0.0121  0.0351
```

```
extract (experiment(model2, n,"CARA", target="Bayesian",repli=repli_num,n0=133,TB=30) ,round_num = 4)
```

```
## [1]  0.0339  6.2348 15.4100 16.1786 -0.0018  0.0586 -0.0033  0.0466
```

```
extract (experiment(model2, n,"CADBCD", target="Neyman",TB=100,
                    repli=repli_num, n0=30) ,round_num = 4)
```

```
## [1]  0.0339  8.6669 23.3314 16.1721  1.3383  0.1479 -0.0090  0.0338
```

```
extract (experiment(model2, n,"CADBCD", target="BandBis",TB=30,repli=repli_num,
                    n0=30) ,round_num = 4)
```

```
## [1]  0.0339 16.1521 22.5299 20.0741 -0.6987  0.1041 -0.0046  0.0489
```

```
extract (experiment(model2, n,"CADBCD", target="RSIHR",TB=30,repli=repli_num, n0=30) ,round_num = 4)
```

```
## [1]  0.0339  5.2004 22.0493 15.8204  2.3461  0.1244 -0.0122  0.0352
```

```
extract (experiment(model2, n,"CADBCD",target="Bayesian",TB=30,n0=400,repli=repli_num,gamma=2),round_nu
```

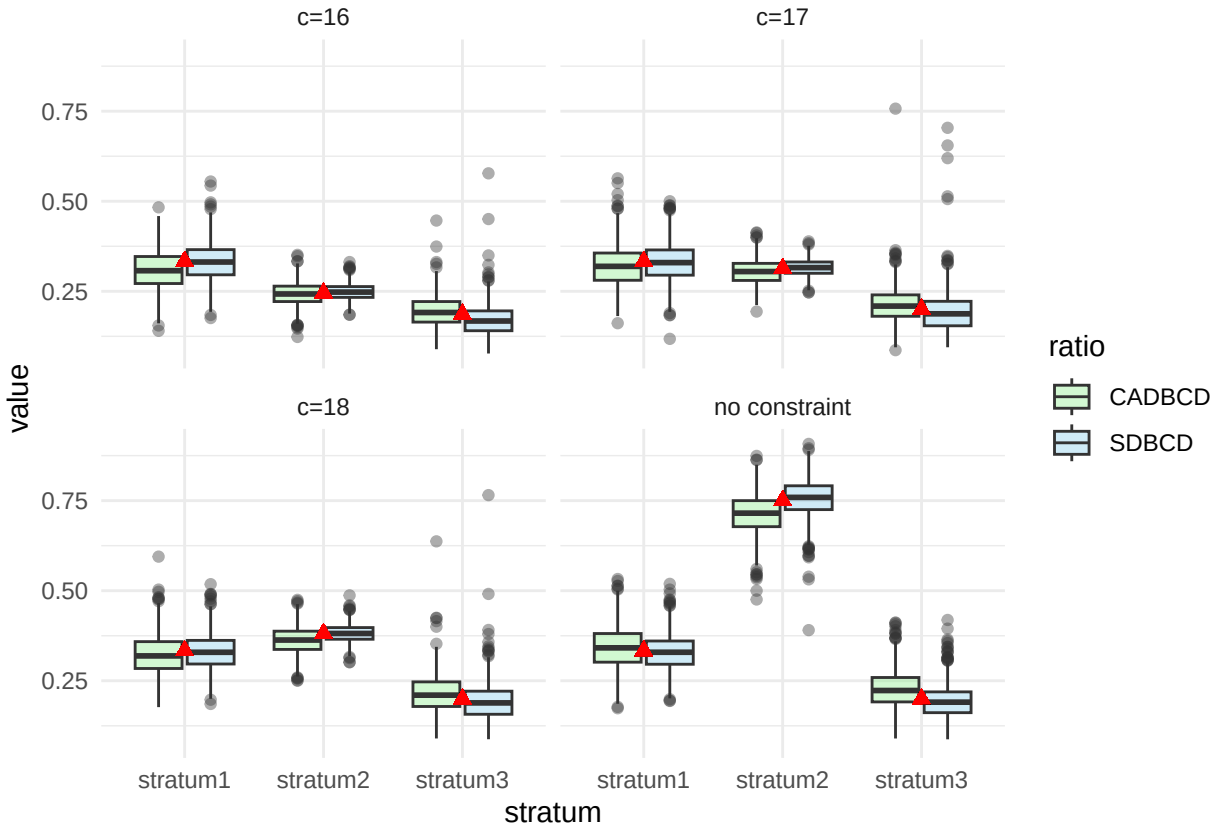
```
## [1]  0.0339  6.2503 15.4203 16.1901 -0.0038  0.0722 -0.0050  0.0483
```

Section S2.3

Figure S1

```
set.seed(123456)
repli_num=1e3

true_pi=oracle(model2(1e7),"New",100)$target_alloc_strata
data1 <- data.frame(
  stratum = rep(paste0("stratum",c(1:3,1:3)), each = repli_num),
  ratio = rep(c("SDBCD", "CADBCD"), each = 3*repli_num),
  value = c(t(replicate(repli_num,compare_alloc(model2(500),n0=10,target="New",TB=100)))),
  true_pi = rep(c(true_pi,true_pi),each=repli_num)
)
true_pi=oracle(model2(1e7),"New",18)$target_alloc_strata
data2 <- data.frame(
  stratum = rep(paste0("stratum",c(1:3,1:3)), each = repli_num),
  ratio = rep(c("SDBCD", "CADBCD"), each = 3*repli_num),
  value = c(t(replicate(repli_num,compare_alloc(model2(500),n0=10,target="New",TB=18)))),
  true_pi = rep(c(true_pi,true_pi),each=repli_num)
)
```

```r
true_pi=oracle(model2(1e7),"New",17)$target_alloc_strata
data3 <- data.frame(
  stratum = rep(paste0("stratum",c(1:3,1:3)), each = repli_num),
  ratio = rep(c("SDBCD", "CADBCD"), each = 3*repli_num),
  value = c(t(replicate(repli_num,compare_alloc(model2(500),n0=10,target="New",TB=17)))),
  true_pi = rep(c(true_pi,true_pi),each=repli_num)
)
true_pi=oracle(model2(1e7),"New",16)$target_alloc_strata
data4 <- data.frame(
  stratum = rep(paste0("stratum",c(1:3,1:3)), each = repli_num),
  ratio = rep(c("SDBCD", "CADBCD"), each = 3*repli_num),
  value = c(t(replicate(repli_num,compare_alloc(model2(500),n0=10,target="New",TB=16)))),
  true_pi = rep(c(true_pi,true_pi),each=repli_num)
)
data_combined <- bind_rows(data1, data2, data3, data4)
data_combined$dataset <- rep(c("no constraint",paste0("c=",18:16)), each = 6*repli_num)


ggplot(data_combined, aes(y = value, x = stratum, fill = ratio)) +
  geom_boxplot(alpha = 0.4)+#, outlier.shape = NA) +  # Transparent boxplot
  geom_point(data = data_combined, aes(x = stratum, y = true_pi), shape = 17, color = "red", size = 2, s
  #labs(title = "Covariate Imbalance Comparison by Randomization",
  #     x = "Covariate Imbalance", y = "") +
  facet_wrap(.~dataset,ncol=2,nrow=2) +
  theme_minimal() +
  scale_fill_manual(values = c("lightgreen", "skyblue", "darkblue", "black")) +  # Color for randomizat
  theme(legend.position = "right")
```



Section S2.4

Figure S2

```
repli_num=1e3
n=500

set.seed(123456)
true_pi=oracle2(model2(1e7),"New",100)$target_alloc
df1 <- data.frame(
  value=c(t(replicate(repli_num,burn_in_test(model2(500),10,"New","RAR",100)))),
                              true_pi = rep(c(true_pi,true_pi),each=repli_num),
            probability = rep(c("all-sample estimate", "burn-in estimate"), each = repli_num)
)
true_pi=oracle2(model2(1e7),"New",15)$target_alloc
df2 <- data.frame(
  value=c(t(replicate(repli_num,burn_in_test(model2(500),10,"New","RAR",15)))),
                              true_pi = rep(c(true_pi,true_pi),each=repli_num),
            probability = rep(c("all-sample estimate", "burn-in estimate"), each = repli_num)
)
true_pi=oracle2(model2(1e7),"New",14)$target_alloc
df3 <- data.frame(
  value=c(t(replicate(repli_num,burn_in_test(model2(500),10,"New","RAR",14)))),
                              true_pi = rep(c(true_pi,true_pi),each=repli_num),
```

```
            probability = rep(c("all-sample estimate", "burn-in estimate"), each = repli_num)
)
true_pi=oracle2(model2(1e7),"New",13)$target_alloc
df4 <- data.frame(
  value=c(t(replicate(repli_num,burn_in_test(model2(500),10,"New","RAR",13)))),
                              true_pi = rep(c(true_pi,true_pi),each=repli_num),
            probability = rep(c("all-sample estimate", "burn-in estimate"), each = repli_num)
)
df_combined <- bind_rows(df1, df2, df3, df4)
df_combined$dataset <- rep(c("no constraint", "c=15","c=14","c=13"), each = 2*repli_num)
ggplot(df_combined, aes(x = probability, y = value, fill = probability)) +
  geom_boxplot(alpha = 0.4)+#,outlier.shape = NA) +  #
  geom_point(data = df_combined, aes(x=probability, y = true_pi), shape = 17, color = "red", size = 3, s
  labs(x="")+
  facet_wrap(.~dataset,ncol=2,nrow=2) +
  theme_minimal() +
  scale_fill_manual(values = c("lightgreen", "skyblue", "darkblue", "black")) +  # Color for randomizat
  theme(legend.position = "right")
```

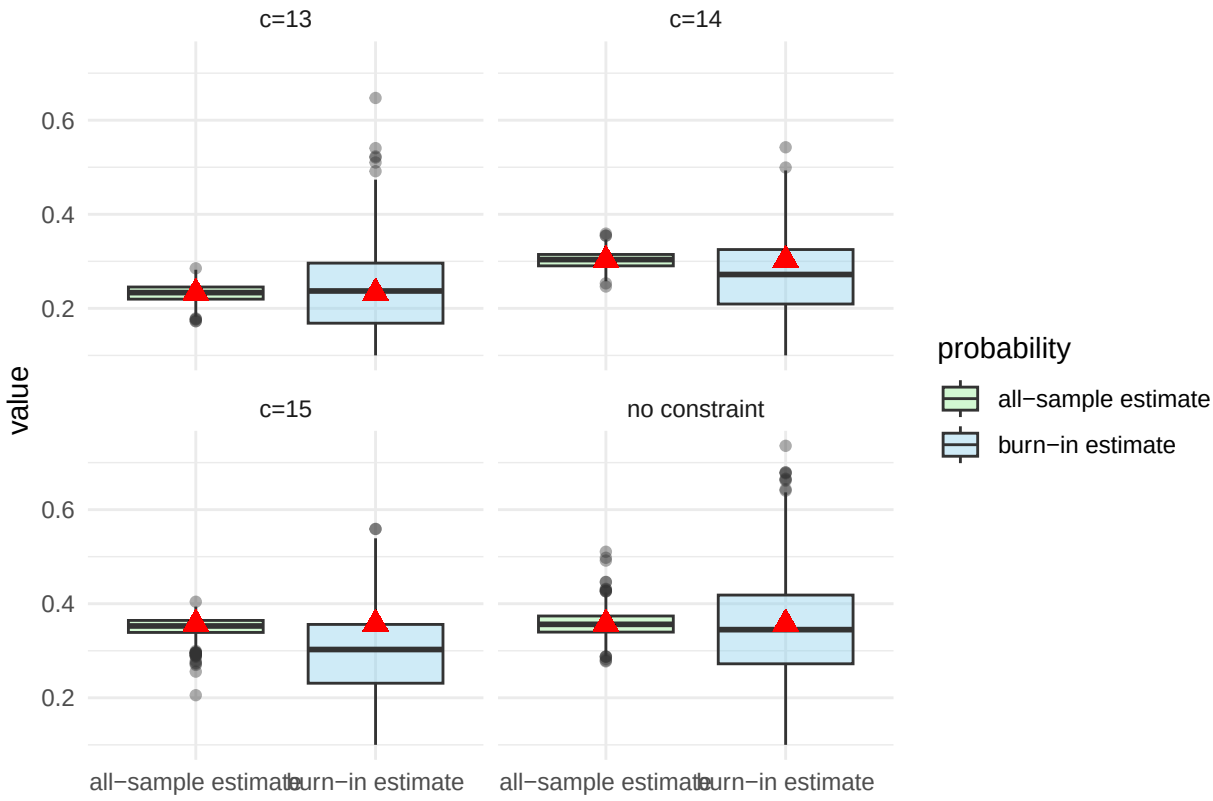
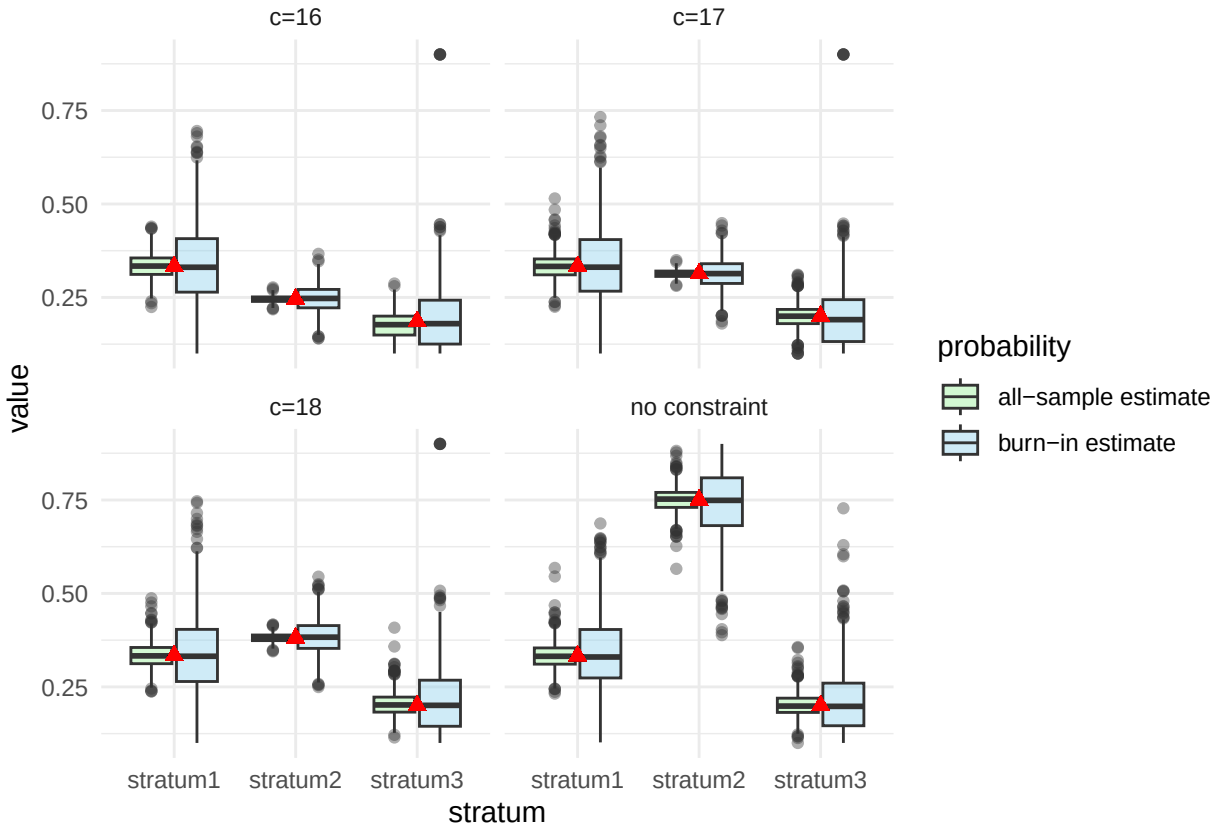


Figure S3

```
set.seed(123456)
repli_num=1e3
```

```r
true_pi=oracle(model2(1e7),"New",100)$target_alloc_strata
data1 <- data.frame(
  stratum = rep(paste0("stratum",c(1:3,1:3)), each = repli_num),
  probability = rep(c("all-sample estimate", "burn-in estimate"), each = 3*repli_num),
  value = c(t(replicate(repli_num,burn_in_test(model2(500),10,"New","CARA",100)))),
  true_pi = rep(c(true_pi,true_pi),each=repli_num)
)
true_pi=oracle(model2(1e7),"New",18)$target_alloc_strata
data2 <- data.frame(
  stratum = rep(paste0("stratum",c(1:3,1:3)), each = repli_num),
  probability = rep(c("all-sample estimate", "burn-in estimate"), each = 3*repli_num),
  value = c(t(replicate(repli_num,burn_in_test(model2(500),10,"New","CARA",18)))),
  true_pi = rep(c(true_pi,true_pi),each=repli_num)
)
true_pi=oracle(model2(1e7),"New",17)$target_alloc_strata
data3 <- data.frame(
  stratum = rep(paste0("stratum",c(1:3,1:3)), each = repli_num),
  probability = rep(c("all-sample estimate", "burn-in estimate"), each = 3*repli_num),
  value = c(t(replicate(repli_num,burn_in_test(model2(500),10,"New","CARA",17)))),
  true_pi = rep(c(true_pi,true_pi),each=repli_num)
)
true_pi=oracle(model2(1e7),"New",16)$target_alloc_strata
data4 <- data.frame(
  stratum = rep(paste0("stratum",c(1:3,1:3)), each = repli_num),
  probability = rep(c("all-sample estimate", "burn-in estimate"), each = 3*repli_num),
  value = c(t(replicate(repli_num,burn_in_test(model2(500),10,"New","CARA",16)))),
  true_pi = rep(c(true_pi,true_pi),each=repli_num)
)
data_combined <- bind_rows(data1, data2, data3, data4)
data_combined$dataset <- rep(c("no constraint",paste0("c=",18:16)), each = 6*repli_num)


ggplot(data_combined, aes(y = value, x = stratum, fill = probability)) +
  geom_boxplot(alpha = 0.4)+#, outlier.shape = NA) +  # Transparent boxplot
  geom_point(data = data_combined, aes(x = stratum, y = true_pi), shape = 17, color = "red", size = 2, s
  #labs(title = "Covariate Imbalance Comparison by Randomization",
  #     x = "Covariate Imbalance", y = "") +
  facet_wrap(.~dataset,ncol=2,nrow=2) +
  theme_minimal() +
  scale_fill_manual(values = c("lightgreen", "skyblue", "darkblue", "black")) +  # Color for randomizat
  theme(legend.position = "right")
```



Section S2.5

Figure S4

```
n=5e2
repli_num=1e4


df <- data.frame(
 p_cr=(experiment2(model2, n,"CR",repli = repli_num) )$did,

 p_100=(experiment2(model2, n,"RAR", target="New", TB=100,repli = repli_num) )$did,

 p_15=(experiment2(model2, n,"RAR", target="New", TB=15,repli = repli_num) )$did,

 p_14=(experiment2(model2, n,"RAR", target="New", TB=14,repli = repli_num) )$did,

 p_13=(experiment2(model2, n,"RAR", target="New", TB=13,repli = repli_num) )$did
)
colnames(df) <- c("CR", "No Constraint", "c=15", "c=14",
                  "c=13")
df_long <- df %>%
  pivot_longer(cols = everything(), names_to = "Variable", values_to = "Value")
```

```r
df_long$Variable <- factor(df_long$Variable,
                           levels = c("CR", "No Constraint", "c=15", "c=14","c=13"))

boxplot <- ggplot(df_long, aes(x = Variable, y = Value)) +
  geom_boxplot()+#alpha = 0.4, outlier.shape = NA) +
  theme_minimal() +
  labs(title = "", x = "Randomization", y = "Estimate")

#
print(boxplot)
```

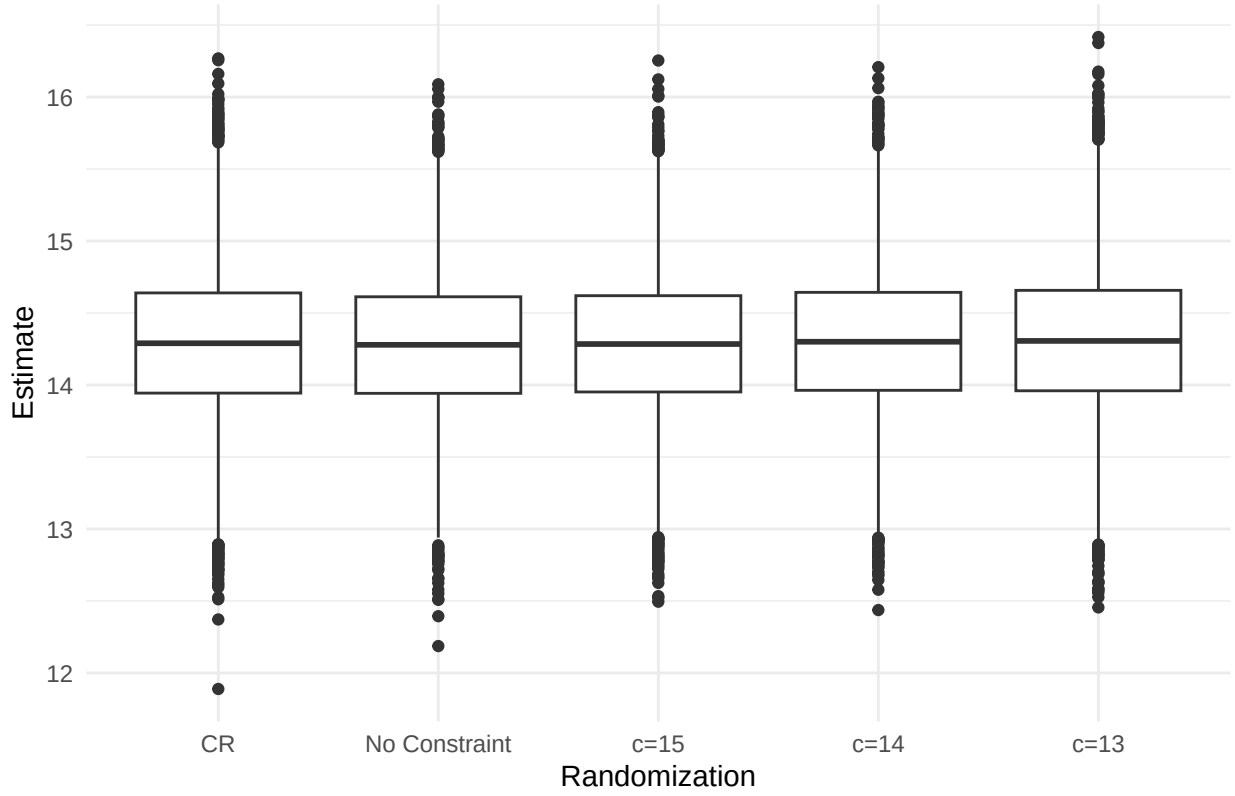


Figure S5(a)

```r
n=5e2
repli_num=1e3

df <- data.frame(
 p_cr=(experiment(model2, n,"CR",repli = repli_num) )$did,


 p_100=(experiment(model2, n,"CARA", target="New", TB=100,repli = repli_num) )$did,

 p_18=(experiment(model2, n,"CARA", target="New", TB=18,repli = repli_num) )$did,
```

```
 p_17=(experiment(model2, n,"CARA", target="New", TB=17,repli = repli_num) )$did,

 p_16=(experiment(model2, n,"CARA", target="New", TB=16,repli = repli_num) )$did
)
colnames(df) <- c("CR", "No Constraint", "c=18", "c=17",
                  "c=16")

df_long <- df %>%
  pivot_longer(cols = everything(), names_to = "Variable", values_to = "Value")

df_long$Variable <- factor(df_long$Variable,
                           levels = c("CR", "No Constraint", "c=18", "c=17","c=16"))

ggplot(df_long, aes(x = Variable, y = Value)) +
  geom_boxplot()+#alpha = 0.4, outlier.shape = NA) +
  theme_minimal() +
  labs(title = "", x = "Randomization", y = "Estimatie")
```

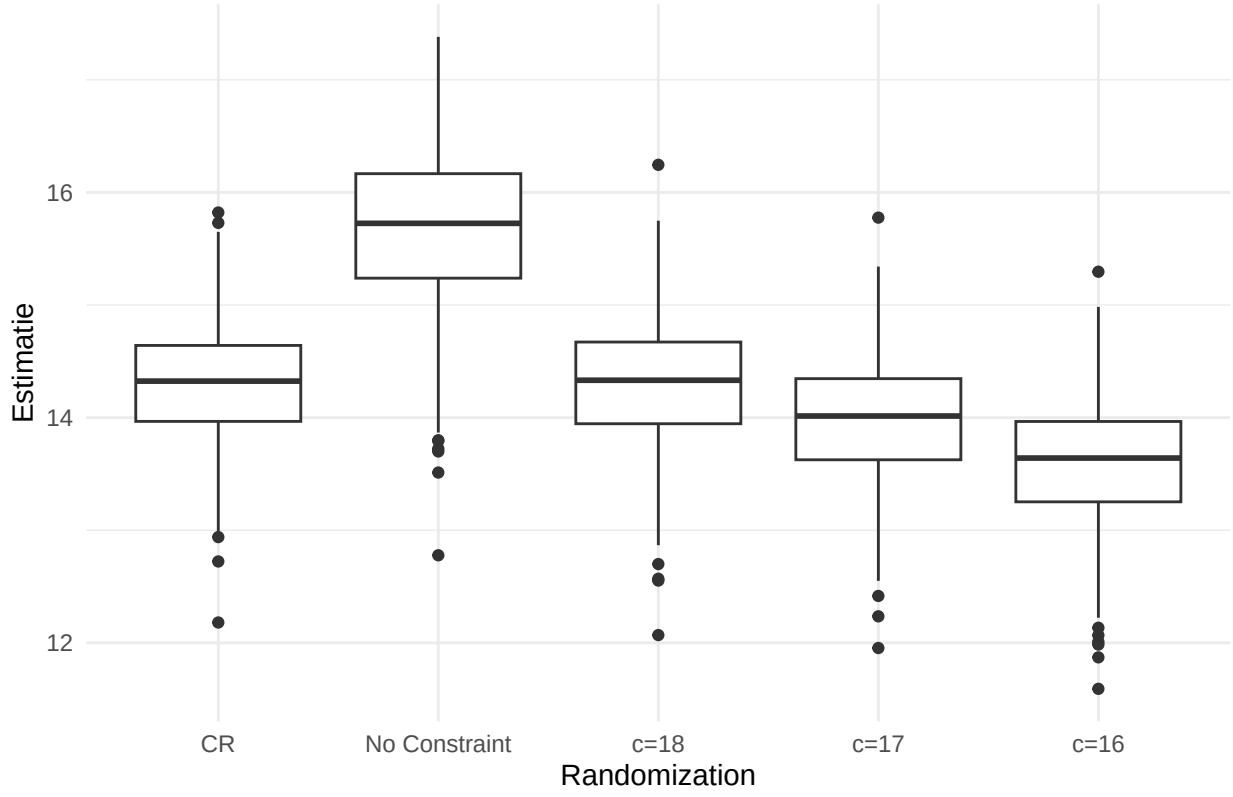
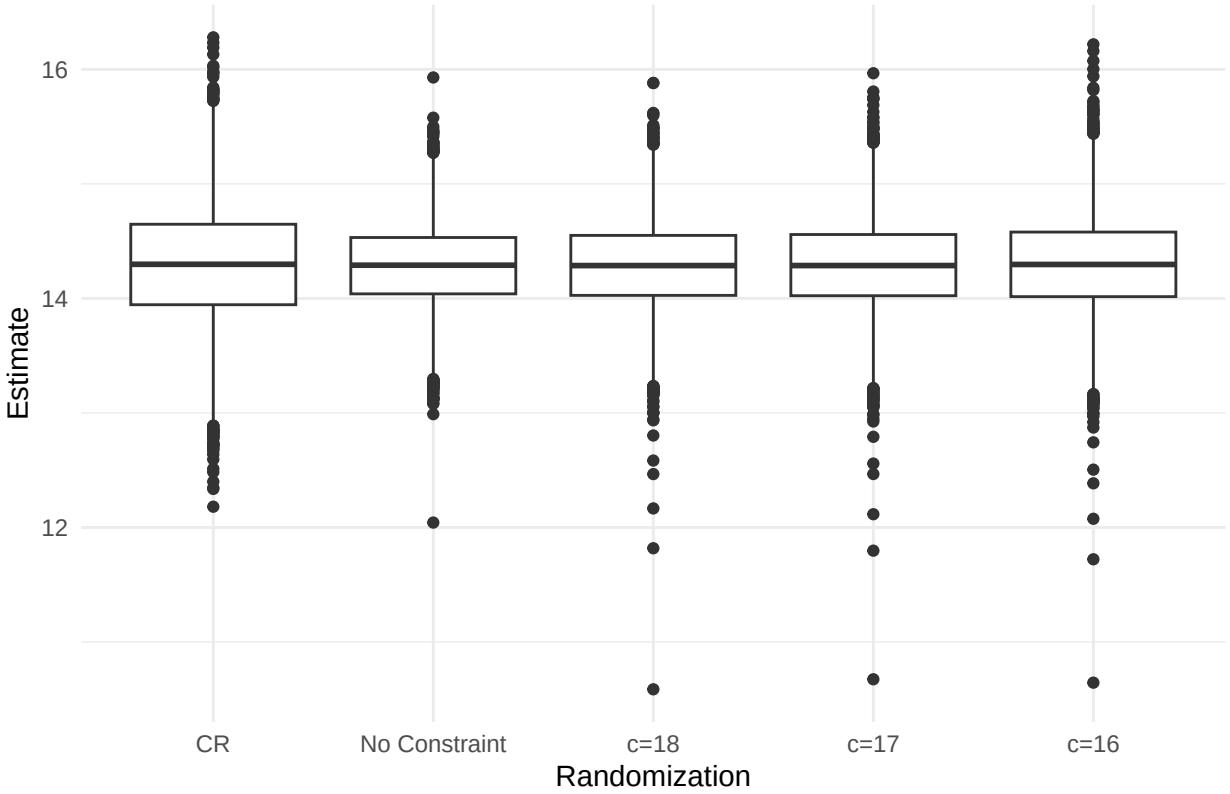


Figure S5(b)

```
n=5e2
repli_num=1e4
```

```r
df <- data.frame(
 p_cr=(experiment(model2, n,"CR",repli = repli_num) )$did,


 p_100=(experiment(model2, n,"CARA", target="New", TB=100,repli = repli_num) )$sdid,

 p_18=(experiment(model2, n,"CARA", target="New", TB=18,repli = repli_num) )$sdid,

 p_17=(experiment(model2, n,"CARA", target="New", TB=17,repli = repli_num) )$sdid,

 p_16=(experiment(model2, n,"CARA", target="New", TB=16,repli = repli_num) )$sdid
)
colnames(df) <- c("CR", "No Constraint", "c=18", "c=17",
                  "c=16")

df_long <- df %>%
  pivot_longer(cols = everything(), names_to = "Variable", values_to = "Value")

df_long$Variable <- factor(df_long$Variable,
                           levels = c("CR", "No Constraint", "c=18", "c=17","c=16"))

boxplot <- ggplot(df_long, aes(x = Variable, y = Value)) +
  geom_boxplot()+#alpha = 0.4, outlier.shape = NA) +
  theme_minimal() +
  labs(title = "", x = "Randomization", y = "Estimate")

#
print(boxplot)
```


16
14
12
Estimate
CR
No Constraint
c=18
c=17
c=16
Randomization