

Replication Document for the Main Results in “Precise Unbiased Estimation in Randomized Experiments using Auxiliary Observational Data”

1 Preliminaries

This document will reproduce all of the tables and figures from the manuscript. The tables and figures will appear in the compiled version of this PDF, as well as in stand-alone files to be incorporated into the main manuscript.

```
opts_chunk$set(message=FALSE,warning=FALSE,error=FALSE,echo=TRUE,cache=TRUE,dev='tikz')
```

```
set.seed(613)
```

```
library(scales)
#library(tidyverse)
library(dplyr)
library(ggplot2)
library(tibble)
library(purrr)
library(tidyr)
library(loop.estimator)
library(kableExtra)
library(xtable)
library(knitr)
library(tikzDevice)
library(estimatr)
library(forcats)

## specialized versions of the LOOP estimator
source('code/loop_ols.R')
source('code/loop_ext.R')
## functions for estimating effects
source('code/analysisFunctions.r')
```

Names of covariates for within-sample covariate adjustment:

```
covNames <- c(
  "Prior.Problem.Count",
  "Prior.Percent.Correct",
  "Prior.Assignments.Assigned",
  "Prior.Percent.Completion",
  "Prior.Class.Percent.Completion",
  "Prior.Homework.Assigned",
  "Prior.Homework.Percent.Completion",
  "Prior.Class.Homework.Percent.Completion",
  "male",
  "unknownGender")#)
```

2 Data

Here we load in the data for estimating effects and standard errors using several different methods discussed in the manuscript. Note that the predictions from the model fit in the remnant are already part of the datasets (which are themselves part of the GitHub repository) under the column name `p_complete`.

Load in and clean the data:

```
source('code/dataPrep.r')
```

Replicating Table ?? from the manuscript:

```
source('code/covTable.r')
print(covTable, add.to.row=ATR)
```

2.1 Imputing Missing Covariates

To impute missing covariate values, when possible we imputed the classroom mean covariate value for students working on that skill builder. When there were no other available values for a covariate for students in the same classroom working on the same skill builder, we imputed with the global mean of students working on that skill builder. Since covariates are all pre-treatment and the imputation did not depend on treatment status, the imputed covariates are themselves covariates, measured for all subjects. Therefore, we need not correct for the imputation scheme in our treatment effect estimation.

| | Mean | SD | % Missing |
|-----------------------------------|-----------|-------------|--------------|
| Problem Count | 603.11 | 784.29 | 2 |
| Percent Correct | 0.68 | 0.13 | 2 |
| Assignments Assigned | 103.92 | 412.15 | 13 |
| Percent Completion | 0.89 | 0.21 | 13 |
| Class Percent Completion | 0.90 | 0.13 | 22 |
| Homework Assigned | 25.82 | 29.87 | 50 |
| Homework Percent Completion | 0.93 | 0.16 | 59 |
| Class Homework Percent Completion | 0.93 | 0.09 | 56 |
| Guessed Gender | Male: 36% | Female: 36% | Unknown: 28% |

Table 1: Pooled summary statistics for aggregate prior ASSISTments performance used as within-sample covariates.

```
### first fill in with class/problem_set mean
### if that doesn't work, fill in with problem_set mean
dat <- dat%>%
  group_by(Class.ID,problem_set)%>%
  mutate(across(all_of(covNames),~ifelse(is.finite(.),,mean(.,na.rm=TRUE))))%>%
  group_by(problem_set)%>%
  mutate(across(all_of(covNames),~ifelse(is.finite(.),,mean(.,na.rm=TRUE))))%>%
  ungroup()

stopifnot(all(sapply(covNames,function(x) mean(is.finite(dat[[x]]))==1))
```

3 Estimate Effects

Here we estimate effects of treatment for each of the 33 skill builders in the dataset. The functions for estimating effects are all found in the file `code/analysisFunctions.r`. This includes the function `full()` which estimates all five treatment effects discussed in the paper.

```
fullres <- sapply(levels(dat$problem_set),full,dat=dat,covNames=covNames,simplify=FALSE)

### name the problem sets based on the SE from the simple difference estimator
rnk <- rank(sapply(fullres,function(x) x['simpDiff','se']))
names(fullres) <- as.character(rnk)

for(i in 1:length(fullres))
  attr(fullres[[i]],'psid') <- levels(dat$problem_set)[i]
```

```
save(fullres,file='results/fullres.RData')

dat$ps <- rnk[as.character(dat$problem_set)]
```

Replicate Table ?? (Now in an appendix, I think). The numbering of the experiments derives from the estimated standard errors, so this comes after effect estimation.

```
source('code/psTable.r')

kbl(tab,

      booktabs=FALSE,
      col.names=rep(c("",rep(c("Trt","Ctl"),2)),2),
      caption="Sample sizes and \\% homework completion by treatment group in each
      label="info")%>%
kable_styling()%>%
column_spec(5,border_right=TRUE)%>%
add_header_above(rep(c("Experiment"=1,"n"=2,"% Complete"=2),2))
```

4 Figures

The following code creates a dataset called `comparisons` that includes the sampling variance ratios comparing each method to the others, for each problem set. It also produces a table (which is not in the manuscript) giving the estimated standard error for each method and each experiment.

```
source('code/figurePrep.r')

pwidePrint <- pwide
names(pwidePrint)[-1] <- paste0('$',methodName[names(pwidePrint)[-1]],'$')
kable(pwidePrint,row.names=FALSE,caption="Estimated standard error for the ATE in each s
```

Figure ??, comparing $\hat{\tau}^{DM}$, $\hat{\tau}^{RE}$, and $\hat{\tau}^{SS}[x^r, LS]$:

```
p <- comparisons%>%
  filter(method1%in%c('ReLOOP', 'Rebar'),method2%in%c('ReLOOPEN', 'Rebar', 'SimpleDifferen
  ggplot(aes(ssMult))+#,fill=exGroup))+
  geom_dotplot( method="histodot", binwidth = .05 ) +
  labs( x = "Relative Ratio of Sample Variances", y="" ) +
```

Table 2: Sample sizes and % homework completion by treatment group in each of the 33 A/B tests.

| Experiment | n | | % Complete | | Experiment | n | | % Complete | |
|------------|-----|-----|------------|-----|------------|-----|-----|------------|-----|
| | Trt | Ctl | Trt | Ctl | | Trt | Ctl | Trt | Ctl |
| 1 | 956 | 961 | 93 | 93 | 18 | 188 | 193 | 89 | 85 |
| 2 | 330 | 365 | 98 | 96 | 19 | 199 | 213 | 89 | 82 |
| 3 | 680 | 650 | 86 | 88 | 20 | 264 | 281 | 81 | 79 |
| 4 | 943 | 921 | 70 | 68 | 21 | 242 | 266 | 81 | 76 |
| 5 | 931 | 900 | 61 | 64 | 22 | 215 | 211 | 82 | 82 |
| 6 | 355 | 349 | 88 | 88 | 23 | 281 | 234 | 73 | 69 |
| 7 | 492 | 463 | 79 | 81 | 24 | 269 | 288 | 65 | 59 |
| 8 | 231 | 197 | 92 | 91 | 25 | 224 | 233 | 73 | 74 |
| 9 | 367 | 387 | 83 | 82 | 26 | 270 | 253 | 63 | 61 |
| 10 | 617 | 587 | 67 | 62 | 27 | 228 | 244 | 68 | 64 |
| 11 | 338 | 289 | 88 | 84 | 28 | 201 | 228 | 73 | 69 |
| 12 | 478 | 476 | 76 | 73 | 29 | 238 | 259 | 44 | 54 |
| 13 | 193 | 209 | 93 | 89 | 30 | 74 | 92 | 91 | 84 |
| 14 | 404 | 451 | 73 | 69 | 31 | 69 | 67 | 91 | 87 |
| 15 | 265 | 275 | 85 | 84 | 32 | 76 | 81 | 62 | 70 |
| 16 | 165 | 170 | 92 | 89 | 33 | 15 | 11 | 73 | 55 |
| 17 | 259 | 246 | 82 | 85 | NA | NA | NA | NA | NA |

Table 3: Estimated standard error for the ATE in each skill builder, using each method discussed in the manuscript

| experiment | $\hat{\tau}^{\text{SS}}[\tilde{\mathbf{x}}, \text{EN}]$ | $\hat{\tau}^{\text{SS}}[x^r, \text{LS}]$ | $\hat{\tau}^{\text{SS}}[\mathbf{x}, \text{RF}]$ | $\hat{\tau}^{\text{RE}}$ | $\hat{\tau}^{\text{DM}}$ |
|------------|---|--|---|--------------------------|--------------------------|
| 1 | 0.010 | 0.011 | 0.011 | 0.011 | 0.012 |
| 10 | 0.021 | 0.024 | 0.021 | 0.024 | 0.028 |
| 11 | 0.026 | 0.027 | 0.026 | 0.028 | 0.028 |
| 12 | 0.022 | 0.026 | 0.022 | 0.026 | 0.028 |
| 13 | 0.029 | 0.029 | 0.030 | 0.032 | 0.029 |
| 14 | 0.028 | 0.029 | 0.030 | 0.029 | 0.031 |
| 15 | 0.028 | 0.029 | 0.029 | 0.029 | 0.031 |
| 16 | 0.031 | 0.031 | 0.031 | 0.031 | 0.032 |
| 17 | 0.031 | 0.032 | 0.031 | 0.032 | 0.033 |
| 18 | 0.032 | 0.032 | 0.033 | 0.033 | 0.034 |
| 19 | 0.035 | 0.034 | 0.037 | 0.038 | 0.034 |
| 2 | 0.013 | 0.012 | 0.013 | 0.017 | 0.013 |
| 20 | 0.032 | 0.033 | 0.033 | 0.034 | 0.034 |
| 21 | 0.034 | 0.034 | 0.035 | 0.034 | 0.036 |
| 22 | 0.035 | 0.036 | 0.034 | 0.036 | 0.037 |
| 23 | 0.033 | 0.038 | 0.035 | 0.038 | 0.040 |
| 24 | 0.030 | 0.040 | 0.029 | 0.041 | 0.041 |
| 25 | 0.038 | 0.040 | 0.038 | 0.040 | 0.041 |
| 26 | 0.031 | 0.034 | 0.030 | 0.035 | 0.042 |
| 27 | 0.038 | 0.040 | 0.038 | 0.040 | 0.044 |
| 28 | 0.043 | 0.044 | 0.043 | 0.046 | 0.044 |
| 29 | 0.045 | 0.045 | 0.047 | 0.047 | 0.045 |
| 3 | 0.016 | 0.018 | 0.016 | 0.018 | 0.018 |
| 30 | 0.050 | 0.050 | 0.054 | 0.050 | 0.052 |
| 31 | 0.049 | 0.049 | 0.050 | 0.051 | 0.054 |
| 32 | 0.063 | 0.068 | 0.060 | 0.067 | 0.076 |
| 33 | 0.129 | 0.136 | 0.153 | 0.145 | 0.197 |
| 4 | 0.017 | 0.019 | 0.017 | 0.020 | 0.021 |
| 5 | 0.019 | 0.019 | 0.019 | 0.019 | 0.023 |
| 6 | 0.019 | 0.022 | 0.019 | 0.021 | 0.025 |
| 7 | 0.019 | 0.022 | 0.019 | 0.022 | 0.026 |
| 8 | 0.026 | 0.026 | 0.028 | 0.027 | 0.027 |
| 9 | 0.025 | 0.027 | 0.025 | 0.028 | 0.027 |

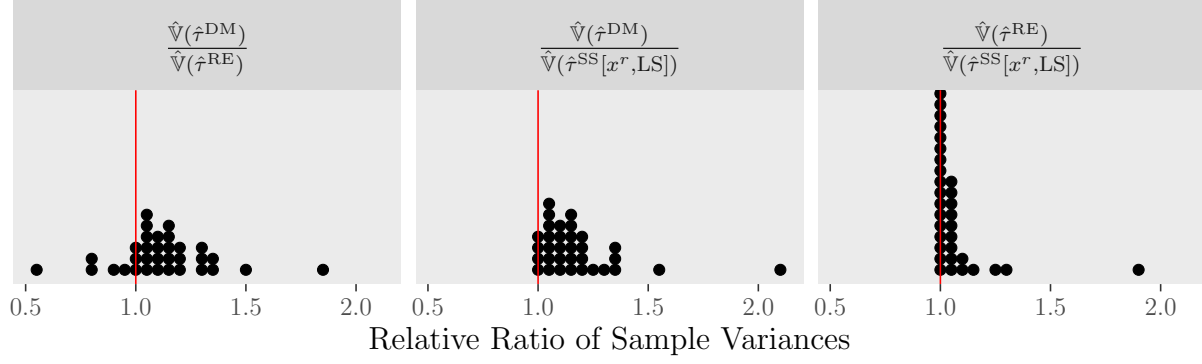


Figure 1: A dotplot showing sample size multipliers (i.e. sampling variance ratios) comparing $\hat{\tau}^{DM}$, $\hat{\tau}^{RE}$, and $\hat{\tau}^{SS}[x^r, LS]$ on the 33 ASSISTments TestBed experiments.

```
geom_vline( xintercept = 1, col="red" ) +
facet_wrap(~comp,nrow=1)+
theme(legend.position = "none",
      panel.grid = element_blank(),
      axis.title.y = element_blank(),
      axis.text.y= element_blank(),
      axis.ticks.y = element_blank(),
      text=element_text(size=12),
      strip.text=element_text(size=12,lineheight=0.5))

tikz('figure/fig4.tex',width=6.4,height=2,standAlone=FALSE)
print(p)
dev.off()

## tikz output
##          2
```

Figure ??, comparing $\hat{\tau}^{DM}$, $\hat{\tau}^{SS}[x^r, LS]$, $\hat{\tau}^{SS}[x, RF]$, and $\hat{\tau}^{SS}[\tilde{x}, EN]$:

```
p <- comparisons%>%
  filter((method1%in%c('ReLOOPEN')&method2%in%c('Loop', 'ReLOOP', 'SimpleDifference')))%>%
  mutate(comp=factor(comp,levels=unique(as.character(comp))))%>%
ggplot(aes(ssMult))+#, fill=exGroup))+
  geom_dotplot( method="histodot", binwidth = .05 ) +
  labs( x = "Relative Ratio of Sample Variances", y="" ) +
  geom_vline( xintercept = 1, col="red" ) +
```

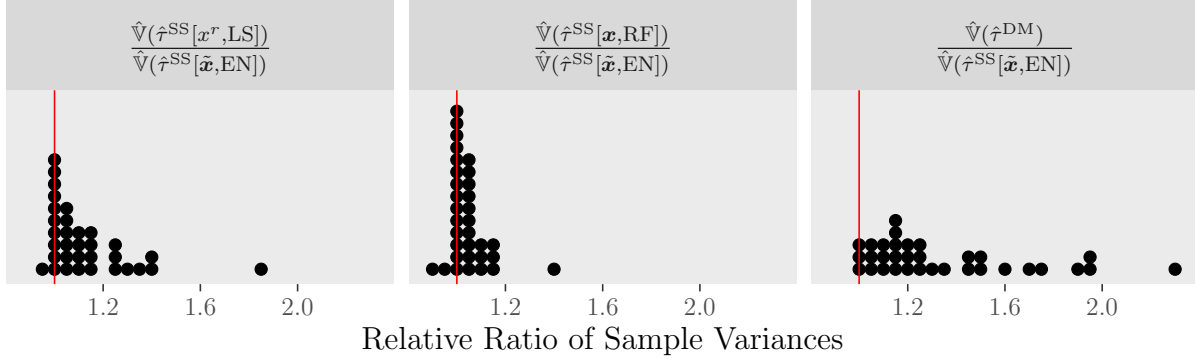


Figure 2: A dotplot showing sample size multipliers (i.e. sampling variance ratios) comparing $\hat{\tau}^{SS}[\tilde{x}, EN]$ to $\hat{\tau}^{SS}[x^r, LS]$, $\hat{\tau}^{SS}[\mathbf{x}; RF]$, and $\hat{\tau}^{DM}$, respectively, on the 33 ASSISTments TestBed experiments.

```
facet_wrap(~comp, nrow=1)+
theme(legend.position = "none",
      panel.grid = element_blank(),
      axis.title.y = element_blank(),
      axis.text.y= element_blank(),
      axis.ticks.y = element_blank(),
      text=element_text(size=12),
      strip.text=element_text(size=12, lineheight=0.5))
#print(p)

tikz('figure/fig5alt.tex', width=6.4, height=2, standalone=FALSE)
print(p)

dev.off()

## tikz output
##          2
```

The following code reproduces some of the numbers in the manuscript text describing the results:

```
compTab <- comparisons%>%group_by(method1, method2)%>%
  summarize(
    worse=sum(ssMult<0.975),
    equal=sum(abs(ssMult-1)<0.025),
```



```

better=sum(ssMult>1.025),
best=max(ssMult),
bestPS=experiment[which.max(ssMult)],
best2=sort(ssMult,decreasing=TRUE)[2],
best2ps=experiment[rank(ssMult)==32],
worst=min(ssMult),
worstPS=experiment[which.min(ssMult)]
)%>%ungroup()%>%
mutate(across(starts_with('method'),~paste0('$',methodName[as.character(.)],'$'))
compTab%>%select(method1:bestPS)%>%kable(escape = FALSE)

```

| method1 | method2 | worse | equal | better | best | bestPS |
|--|--|-------|-------|--------|----------|--------|
| $\hat{\tau}^{SS}[\tilde{\mathbf{x}}, \text{EN}]$ | $\hat{\tau}^{SS}[x^r, \text{LS}]$ | 1 | 10 | 22 | 1.844856 | 24 |
| $\hat{\tau}^{SS}[\tilde{\mathbf{x}}, \text{EN}]$ | $\hat{\tau}^{SS}[\mathbf{x}, \text{RF}]$ | 2 | 14 | 17 | 1.400882 | 33 |
| $\hat{\tau}^{SS}[\tilde{\mathbf{x}}, \text{EN}]$ | $\hat{\tau}^{\text{RE}}$ | 1 | 2 | 30 | 1.905476 | 24 |
| $\hat{\tau}^{SS}[\tilde{\mathbf{x}}, \text{EN}]$ | $\hat{\tau}^{\text{DM}}$ | 0 | 3 | 30 | 2.314750 | 33 |
| $\hat{\tau}^{SS}[x^r, \text{LS}]$ | $\hat{\tau}^{SS}[\mathbf{x}, \text{RF}]$ | 18 | 3 | 12 | 1.266307 | 33 |
| $\hat{\tau}^{SS}[x^r, \text{LS}]$ | $\hat{\tau}^{\text{RE}}$ | 0 | 18 | 15 | 1.898485 | 2 |
| $\hat{\tau}^{SS}[x^r, \text{LS}]$ | $\hat{\tau}^{\text{DM}}$ | 0 | 4 | 29 | 2.092385 | 33 |
| $\hat{\tau}^{SS}[\mathbf{x}, \text{RF}]$ | $\hat{\tau}^{\text{RE}}$ | 5 | 4 | 24 | 1.926845 | 24 |
| $\hat{\tau}^{SS}[\mathbf{x}, \text{RF}]$ | $\hat{\tau}^{\text{DM}}$ | 5 | 1 | 27 | 1.957049 | 26 |
| $\hat{\tau}^{\text{RE}}$ | $\hat{\tau}^{\text{DM}}$ | 5 | 3 | 25 | 1.848485 | 33 |

```

compTab%>%select(method1,method2,best2:worstPS)%>%kable(escape=FALSE)

```

| method1 | method2 | best2 | best2ps | worst | worstPS |
|--|--|----------|---------|-----------|---------|
| $\hat{\tau}^{SS}[\tilde{\mathbf{x}}, \text{EN}]$ | $\hat{\tau}^{SS}[x^r, \text{LS}]$ | 1.417204 | 12 | 0.9680705 | 2 |
| $\hat{\tau}^{SS}[\tilde{\mathbf{x}}, \text{EN}]$ | $\hat{\tau}^{SS}[\mathbf{x}, \text{RF}]$ | 1.142609 | 30 | 0.9088411 | 32 |
| $\hat{\tau}^{SS}[\tilde{\mathbf{x}}, \text{EN}]$ | $\hat{\tau}^{\text{RE}}$ | 1.837867 | 2 | 0.9692726 | 30 |
| $\hat{\tau}^{SS}[\tilde{\mathbf{x}}, \text{EN}]$ | $\hat{\tau}^{\text{DM}}$ | 1.933998 | 26 | 0.9893321 | 13 |
| $\hat{\tau}^{SS}[x^r, \text{LS}]$ | $\hat{\tau}^{SS}[\mathbf{x}, \text{RF}]$ | 1.150106 | 30 | 0.5360364 | 24 |
| $\hat{\tau}^{SS}[x^r, \text{LS}]$ | $\hat{\tau}^{\text{RE}}$ | 1.277514 | 13 | 0.9756321 | 30 |
| $\hat{\tau}^{SS}[x^r, \text{LS}]$ | $\hat{\tau}^{\text{DM}}$ | 1.563645 | 26 | 0.9931606 | 28 |
| $\hat{\tau}^{SS}[\mathbf{x}, \text{RF}]$ | $\hat{\tau}^{\text{RE}}$ | 1.832200 | 2 | 0.8482977 | 30 |
| $\hat{\tau}^{SS}[\mathbf{x}, \text{RF}]$ | $\hat{\tau}^{\text{DM}}$ | 1.949483 | 24 | 0.8744120 | 19 |
| $\hat{\tau}^{\text{RE}}$ | $\hat{\tau}^{\text{DM}}$ | 1.515003 | 26 | 0.5588199 | 2 |

4.1 Comparing Sample Splitting to ANCOVA Estimators

The following creates the figures in 4.3 (plus some others)

This estimates the effects and their SEs:

```
ols <- sapply(levels(dat$problem_set),full,dat=dat,covNames=covNames,simplify=FALSE,
              methods=c('reloopLin','reloopPoor','reloopPlusLin','reloopPlusPoor','
save(ols,file='results/ols.RData')
```

```
source('code/olsFigurePrep.r')
```

```
pLin1 <- comparisonsLin%>%
  mutate(comp=factor(comp,levels=unique(as.character(comp))))%>%
ggplot(aes(ssMult))+#,fill=exGroup))+
  geom_dotplot( method="histodot", binwidth = .05 ) +
  labs( x = "Relative Ratio of Sample Variances", y="" ) +
  geom_vline( xintercept = 1, col="red" ) +
  facet_wrap(~comp)+#,nrow=1)+
  theme(legend.position = "none",
        panel.grid = element_blank(),
        axis.title.y = element_blank(),
        axis.text.y= element_blank(),
        axis.ticks.y = element_blank(),
        text=element_text(size=12),
        strip.text=element_text(size=12,lineheight=0.5))

tikz('figure/appendixLin.tex',width=6.4,height=4,standAlone=FALSE,packages= c(getOption
print(pLin1)
dev.off()

## tikz output
##          2

### compare Lin to Reloop

pLin2 <- comparisonsReloopLin%>%
  mutate(comp=factor(comp,levels=unique(as.character(comp))))%>%
ggplot(aes(ssMult))+#,fill=exGroup))+
  geom_dotplot( method="histodot", binwidth = .02 ) +
  labs( x = "Relative Ratio of Sample Variances (Log 10 Scaled)", y="" ) +
  geom_vline( xintercept = 1, col="red" ) +
  facet_wrap(~comp,nrow=1)+
  theme(legend.position = "none",
        panel.grid = element_blank(),
```

```

axis.title.y = element_blank(),
axis.text.y= element_blank(),
axis.ticks.y = element_blank(),
text=element_text(size=12),
strip.text=element_text(size=12,lineheight=0.5))+
scale_x_continuous(trans="log10")

tikz('figure/appendixLinReLoop.tex',width=4,height=2,standAlone=FALSE,packages= c(getOpt
print(pLin2)
dev.off()

## tikz output
##          2

```

```

p0ls1 <- comparisonsPoor%>%
  mutate(comp=factor(comp,levels=unique(as.character(comp))))%>%
ggplot(aes(ssMult))+#,fill=exGroup))+
  geom_dotplot( method="histodot", binwidth = .05 ) +
  labs( x = "Relative Ratio of Sample Variances (Log 10 Scaled)", y="" ) +
  geom_vline( xintercept = 1, col="red" ) +
  facet_wrap(~comp)+#,nrow=1)+
  theme(legend.position = "none",
        panel.grid = element_blank(),
        axis.title.y = element_blank(),
        axis.text.y= element_blank(),
        axis.ticks.y = element_blank(),
        text=element_text(size=12),
        strip.text=element_text(size=12,lineheight=0.5))

tikz('figure/appendixPoor.tex',width=6.4,height=4,standAlone=FALSE,packages= c(getOption
print(p0ls1)
dev.off()

## tikz output
##          2

```

```

p0ls2 <- comparisonsReLoopPoor%>%
  mutate(comp=factor(comp,levels=unique(as.character(comp))))%>%
ggplot(aes(ssMult))+#,fill=exGroup))+
  geom_dotplot( method="histodot", binwidth = .02 ) +
  labs( x = "Relative Ratio of Sample Variances", y="" ) +

```

```

geom_vline( xintercept = 1, col="red" ) +
facet_wrap(~comp,nrow=1)+
theme(legend.position = "none",
      panel.grid = element_blank(),
      axis.title.y = element_blank(),
      axis.text.y= element_blank(),
      axis.ticks.y = element_blank(),
      text=element_text(size=12),
      strip.text=element_text(size=12,lineheight=0.5))

tikz('figure/appendixOlsReloop.tex',width=4,height=2,standAlone=FALSE,packages= c(getOpt
print(pOls2)
dev.off()

## tikz output
##          2

#### this one actually made it into the manuscript:

pOls3 <- ggplot(newcomp,aes(ssMult))+#,fill=exGroup))+
  geom_dotplot( method="histodot", binwidth = .01 ) +
  labs( x = "Relative Ratio of Sample Variances", y="" ) +
  geom_vline( xintercept = 1, col="red" ) +
  facet_wrap(~comp,nrow=3)+
  theme(legend.position = "none",
        panel.grid = element_blank(),
        axis.title.y = element_blank(),
        axis.text.y= element_blank(),
        axis.ticks.y = element_blank(),
        text=element_text(size=12),
        strip.text=element_text(size=12,lineheight=0.5))+
  scale_x_continuous(trans="log10",breaks=c(0.85,1,1.2,1.4,1.7,2,2.5))

tikz('figure/OlsReloop.tex',width=5,height=6,standAlone=FALSE,packages= c(getOption('til
print(pOls3)
dev.off()

## tikz output
##          2

```

```

sessionInfo()

## R version 4.2.2 (2022-10-31)
## Platform: x86_64-pc-linux-gnu (64-bit)
## Running under: Debian GNU/Linux 11 (bullseye)
##
## Matrix products: default
## BLAS:   /usr/lib/x86_64-linux-gnu/blas/libblas.so.3.9.0
## LAPACK: /usr/lib/x86_64-linux-gnu/lapack/liblapack.so.3.9.0
##
## locale:
##  [1] LC_CTYPE=en_US.UTF-8      LC_NUMERIC=C
##  [3] LC_TIME=en_US.UTF-8      LC_COLLATE=en_US.UTF-8
##  [5] LC_MONETARY=en_US.UTF-8  LC_MESSAGES=en_US.UTF-8
##  [7] LC_PAPER=en_US.UTF-8     LC_NAME=C
##  [9] LC_ADDRESS=C             LC_TELEPHONE=C
## [11] LC_MEASUREMENT=en_US.UTF-8 LC_IDENTIFICATION=C
##
## attached base packages:
## [1] stats      graphics  grDevices  utils      datasets  methods    base
##
## other attached packages:
##  [1] forcats_0.5.2      tidyr_1.2.0        purrr_0.3.4
##  [4] tibble_3.1.8       kableExtra_1.3.4   ggplot2_3.4.1
##  [7] dplyr_1.0.10       estimatr_1.0.0     tikzDevice_0.12.3.1
## [10] knitr_1.40         xtable_1.8-4       loop.estimator_1.0.0
## [13] scales_1.2.1       languageserver_0.3.15 httpgd_1.3.1
##
## loaded via a namespace (and not attached):
##  [1] Rcpp_1.0.10        svglite_2.1.0      ps_1.7.1
##  [4] assertthat_0.2.1   digest_0.6.29      utf8_1.2.2
##  [7] R6_2.5.1           evaluate_0.16      httr_1.4.5
## [10] highr_0.9          pillar_1.8.1       rlang_1.0.6
## [13] rstudioapi_0.14    callr_3.7.3        rmarkdown_2.16
## [16] labeling_0.4.2     webshot_0.5.4      stringr_1.4.1
## [19] munsell_0.5.0      compiler_4.2.2     xfun_0.32
## [22] pkgconfig_2.0.3    systemfonts_1.0.4  htmltools_0.5.3
## [25] tidyselect_1.1.2   codetools_0.2-18   randomForest_4.7-1.1
## [28] fansi_1.0.3        viridisLite_0.4.1  withr_2.5.0
## [31] later_1.3.0        grid_4.2.2         jsonlite_1.8.0
## [34] gtable_0.3.0       lifecycle_1.0.3    DBI_1.1.3
## [37] magrittr_2.0.3     cli_3.6.0          stringi_1.7.12

```

```
## [40] farver_2.1.1      xml2_1.3.3      ellipsis_0.3.2
## [43] generics_0.1.3    vctrs_0.5.2     Formula_1.2-4
## [46] tools_4.2.2       glue_1.6.2      processx_3.7.0
## [49] parallel_4.2.2    fastmap_1.1.0   colorspace_2.0-3
## [52] filehash_2.4-3    rvest_1.0.3
```

```
enddocument ‘
```