How to ensure that policy experiments are credible and actionable

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Overall

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3.
4.
5.

1. A proposed research integrity process
2. Standard Operating Procedures

The Current DRAFT OES Process

1. **Project Initiation**: early ideas about the project are discussed to ensure general feasibility, proper planning, and wise investment of team resources prior to formally initiating a project and committing to a collaboration with agency partners
2. **Design Review**: the project design is peer reviewed and then presented to the team, to ensure a sound design that effectively addresses research objectives before we invest resources in fielding a study
3. **Analysis Plan Commitment**: an analysis plan (also known as a "pre-analysis plan" or "pre-specification plan") is finalized, date-stamped, and posted publicly on our website before data are received and analyzed
4. **Findings Review**: an initial analysis of results is presented to the team, to ensure that tentative findings are consistent with a sound analysis of the data, that important limitations on the study's findings have been identified, and that alternative explanations have been addressed to the greatest extent possible
5. **Reanalysis**: an internal replication of the initial analysis, to ensure that results and conclusions are sound, reliable, and reproducible
6. **Pre-Publication Review**: to ensure OES maintains transparency, retains materials necessary for reproducibility, and meets all legal and administrative requirements in disseminating knowledge for the whole of government and the public

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Current DRAFT OES SOP Principles

1. Collaborate. Serve the agency partner. Practice humility and listening.
2. Work in public as much as possible. (Post code, Post pre-analysis plans, Post results)
3. Randomization is a reasoned basis for statistical inference (i.e. p-values should refer to distributions generated by design). (Ramdom sampling, likelihood functions, Bayesian posterior (likelihood+prior) are all reasoned bases as well. But we can much more easily test hypotheses about alternative randomizations than we can justify the other claims.)

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Example 1: Randomization Assessment

Setup an experiment:

```
set.seed(20180225)
N <- 50
K <- 30
Xdat <- as.data.frame(replicate(K,rnorm(N)))
names(Xdat) <- paste0("X",1:K)
y0 <- Xdat$X1+Xdat$X2+rchisq(N,df=1)
y1 <- y0 + rnorm(N,mean=0,sd=sd(y0))## No treatment effect but different variance
Z <- complete_ra(N,m=15) ## very simple randomization
Y <- Z*y1 + (1-Z) * y0 ## randomization reveals a potential outcome
dat <- data.frame(cbind(Xdat,Y=Y,Z=Z,y0=y0,y1=y1))
```

Example 1: Randomization Assessment

Hansen and Bowers (2008) developed an omnibus balance test that refers to a Normal distribution that approximates the randomization-based reference distribution in large-samples. (see the help page for `balanceTest` for `strata()` and `cluster()` arguments for block and/or clustered designs)

```
balfmla <- reformulate(names(Xdat),response="Z")
## See balanceTest help for block and cluster randomized designs
randTest1 <- balanceTest(balfmla,data=dat,report="all",p.adjust.method="none")
signif(randTest1$results[,"p",],3)[1:5]
```

```
    X1     X2     X3     X4     X5
0.1430 0.0924 0.3980 0.5700 0.7510
```

```
randTest1$overall[1,]
```

```
chisquare        df   p.value
  34.0239   30.0000    0.2799
```

```
sum(randTest1$results[,"p",]<.05,na.rm=TRUE) ## How many false positives
```

```
[1] 3
```

Example 1: Randomization Assessment

A common approach with two problems (separation/problems in high dimensions and not-randomization based reference distribution)

```
balfmla <- reformulate(names(Xdat),response="Z")
## See balanceTest help for block and cluster randomized designs
glm1 <- glm(balfmla,data=dat,family=binomial())
```

```
Warning: glm.fit: algorithm did not converge
```

```
Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```
glm0 <- glm(Z~1,data=dat,family=binomial())
anova(glm0,glm1,test="Chisq")
```

```
Analysis of Deviance Table

Model 1: Z ~ 1
Model 2: Z ~ X1 + X2 + X3 + X4 + X5 + X6 + X7 + X8 + X9 + X10 + X11 +
    X12 + X13 + X14 + X15 + X16 + X17 + X18 + X19 + X20 + X21 +
    X22 + X23 + X24 + X25 + X26 + X27 + X28 + X29 + X30
  Resid. Df Resid. Dev Df Deviance Pr(>Chi)
1        49       61.1
2        19        0.0 30     61.1  0.00068 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Example 1: Randomization Assessment

Which to use? How should we choose? (One idea: False Positive Rate)

```
newExp <- function(N){ complete_ra(N,m=15) }

getPvalues <- function(){
  dat$newZ <- newExp(N)
  newfmla <- reformulate(names(Xdat),response="newZ")

  bt1 <- balanceTest(newfmla,data=dat,report="all",p.adjust.method="none")
  btp<-bt1$overall[1,"p.value"]

  theglm1 <- glm(newfmla,data=dat,family=binomial())
  theglm0 <- glm(newZ~1,data=dat,family=binomial())
  theanova <- anova(theglm0,theglm1,test="Chisq")
  anovap <- theanova[2,"Pr(>Chi)"]

  return(c(btp = btp, anovap = anovap))
}
```

```
theps <- replicate(1000,getPvalues())
theps[,1:5]
```

```
            [,1]      [,2]      [,3]      [,4]      [,5]
btp    0.1384167 0.2308195 0.5880233 0.2045699 0.1915891
anovap 0.0006787 0.0006787 0.0006787 0.0006787 0.0006787
```

Example 1: Randomization Assessment

```
apply(theps,1,function(x){ mean(x<=.05) })
```

```
  btp anovap
    0     NA
```

Example 2: Pre-registration

We pre-register that we will look at the effect of the treatment moderated by X1:

```
lm1 <- lm(Y~Z*X1,data=dat)
lm1ci <- coefci(lm1,vcov=vcovHC(lm1,type="HC2"))
lm1p <- coeftest(lm1,vcov=vcovHC(lm1,type="HC2"))[4,4]
```

vs we hunt for a statistically significant moderating effect:

```
theres <- sapply(dat[,names(Xdat)],function(thex){
                  thelm<-lm(Y~Z*thex,data=dat)
                  lm1p <- coeftest(thelm,vcov=vcovHC(thelm,type="HC2"))[4,4]
})
anx <- names(theres[theres==min(theres)])
afmla <- as.formula(paste0("Y~Z*",anx))
alm <- lm(afmla,data=dat)
almp <- coeftest(alm,vcov=vcovHC(alm,type="HC2"))[4,4]
```

Example 2: Pre-registration

How often will we make a false positive error in each case?

```
preRegProcedure <- function(newZ){
  lm1 <- lm(Y~newZ*X1,data=dat)
  lm1p <- coeftest(lm1,vcov=vcovHC(lm1,type="HC2"))[4,4]
  return(lm1p)
}
```

```
pHuntProcedure <- function(newZ){
  theres <- sapply(dat[,names(Xdat)],function(thex){
                    thelm<-lm(Y~newZ*thex,data=dat)
                    lm1p <- coeftest(thelm,vcov=vcovHC(thelm,type="HC2"))[4,4]
                    return(lm1p)
})
  anx <- names(theres[theres==min(theres)])
  afmla <- as.formula(paste0("Y~newZ*",anx))
  alm <- lm(afmla,data=dat)
  almp <- coeftest(alm,vcov=vcovHC(alm,type="HC2"))[4,4]
  return(almp)
}

assessPs <- function(newZ){
  preRegP <- preRegProcedure(newZ = newZ)
  pHuntP <- pHuntProcedure(newZ = newZ)
  return(c(preregp=preRegP, phuntp = pHuntP))
}
```

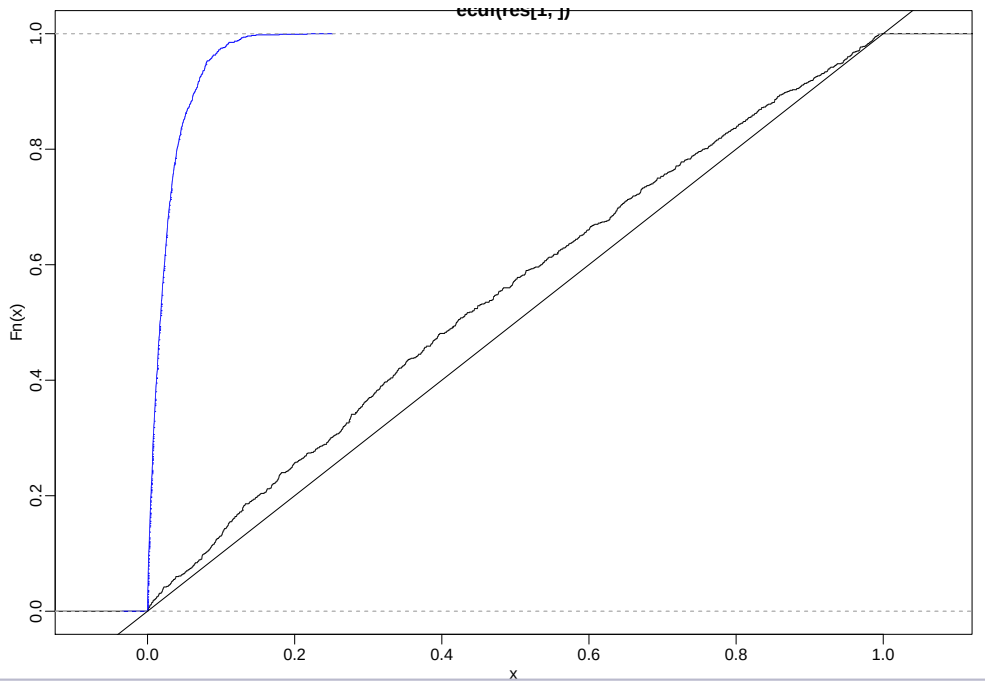
Example 2: Pre-registration

Notice that we could have similar kinds of issues with covariance adjustment and not moderating effects.

```
res <- replicate(1000,assessPs(newZ=complete_ra(N=50,m=15)))
apply(res,1,function(x){ mean(x <=.05) })
```

```
preregp  phuntp
  0.065   0.852
```

```
plot(ecdf(res[1,]))
plot(ecdf(res[2,]),add=TRUE,col="blue")
abline(0,1)
```



Example 3: Covariance Adjustment Avoiding Bias

We often use OLS to estimate the ATE using β_1 (below).

$$Y_i = \beta_0 + \beta_1 Z_i$$

$$\hat{\beta}_1 = Y|\bar{Z} = 1 - Y|\bar{Z} = 0 = \frac{\text{cov(Y,Z)}}{\text{var(Z)}}$$

.

And we know:

$$E_R(\hat{\beta}_1) = \beta_1 \equiv \text{ATE}$$

.

Example 3: Covariance Adjustment Avoiding Bias

Now, what about when we have a covariate X_i and we use it as would be normal in the analysis of non-experimental data:

$$Y_i = \beta_0 + \beta_1 Z_i + \beta_2 X_i$$

What is β_1 in this case? Well, we all know the matrix representation here $(X^T X)^{-1} X^T y$, but here is the scalar formula for this case:

$$\hat{\beta}_1 = \frac{var(X)cov(Z, Y) - cov(X, Z)cov(X, Y)}{var(Z)var(X) - cov(Z, X)^2}$$

In very large experiments $cov(X, Z) \approx 0$ however in any given finite sized experiment $cov(X, Z) \neq 0$ so this does not reduce to the unbiased estimator of the bivariate case. Is it itself unbiased?

References