Studying Variation in the Effect of Program Participation

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Outline

1. Pervasiveness of
   - Multi-site trials
   - Non-compliance

2. Instrumental variables in a single-site study
   - Under homogeneity of impact
   - Under heterogeneity of impact
   - Examples

3. Instrumental variables in multi-site studies:
   - Method 1 Combine 2 ITT Analyses
   - Method 2: Two-stage generalized least squares
   - Method 2= “Between-Site Regression!”

4. Design Considerations

5. Modeling Program Participation and Program Impact on Participants

1. Pervasiveness of Multi-Site Trials

Since 2002, IES has funded 175 group-randomized trials

Vast majority are multi-site trials (Spybrook, 2013)

Other recent examples

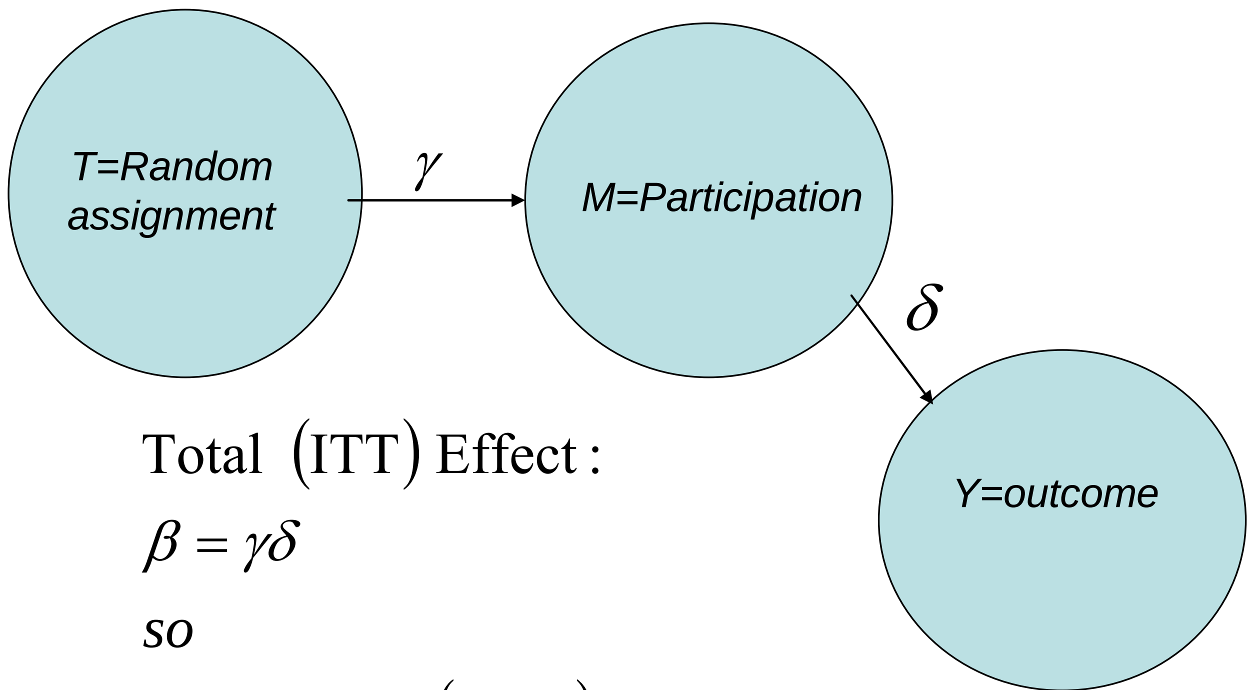
* National Head Start Evaluation (US Dept of HHS, 2010)
* Moving to Opportunity (Sonbanmatsu, Kling, Duncan, Brooks Gunn, 2006)
* School-based lottery studies (Abdulkadiroglu, Angrist, Dynarski, Kane, and Pathak, 2009).
* Tennessee STAR (Finn and Achilles, 1990)
* Ending Social Promotion (Jacob and Lefgren, 2009)
* Double-Dose Algebra (Nomi and Allensworth, 2009)
* Welfare to Work (Bloom, Hill, Riccio, 2003)
* Small Schools of Choice (MDRC)

Some Recent MS Trials

Study	Levels	Assigned Units	Sites	Fixed or Random sites
National Head Start Eval.	2	Children	198 Program Sites	Random
Moving to Opportunity	2	Families	5 cities	Fixed
Boston Charter School Lotteries	2	Children	Lottery pools	Random
Tennessee STAR	3	Teachers	79 Schools	Random
4 R's	3	Classrooms	18 Schools	Random
Double-Dose Algebra	2	Children	60 Schools	Random

2. Estimating the Impact of Program Participation in a One- Site Study

Figure 1: Conventional Instrumental Variable Model (Homogeneous Treatment Effects)



Total (ITT) Effect:

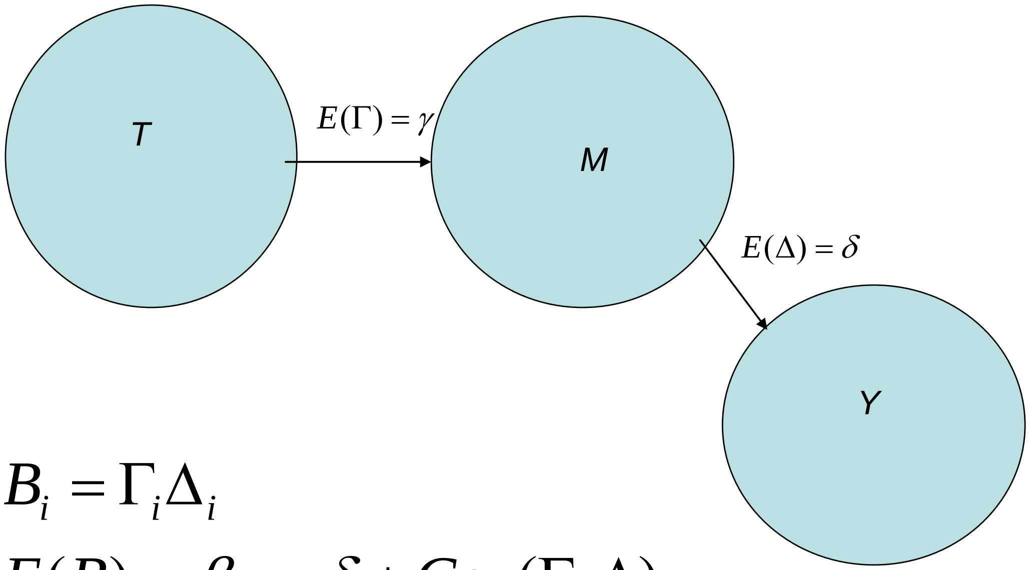
$$\beta = \gamma\delta$$

so

$$\delta = \beta / \gamma \qquad (\gamma \neq 0)$$

Single site, heterogeneous treatment effects

Person-specific Causal Model



$$B_i = \Gamma_i \Delta_i$$

$$E(B) = \beta = \gamma\delta + Cov(\Gamma, \Delta)$$

“No Compliance-Covariance” Assumption is Strong!

$$E(B) = \beta = \gamma\delta + Cov(\Gamma, \Delta)$$

$$= \gamma\delta \qquad if\ Cov(\Gamma, \Delta) = 0$$

$$= \delta / \gamma \qquad if\ \ \gamma \neq 0$$

Alternative Approach for binary M

"Local Average Treatment Effect" (LATE)

or

"Complier Average Treatment Effect"

(Bloom, 1984; Angrist, Imbens, and Rubin, 1996)

Principal Stratification

Stratum	M(1)	M(0)	Γ=M(1)-M(0)	Y(M(1))-Y(M(0))	Fraction of pop	Average Effect
Compliers	1	0	1	Y(1)=Y(0)	$\gamma_{compliers}$	$\delta_{compliers}$
Always-takers	1	1	0	Y(1)-Y(1)=0	γ_{always}	0
Never-takers	0	0	0	Y(0)-Y(0)=0	γ_{never}	0
Defiers	0	1	-1	Y(0)-Y(1)	0	0

Complier-average treatment effect
("Local average treatment effect")

$$E(B) = \beta = \delta_{compliers}\gamma_{compliers} + 0 * \gamma_{always} + 0 * \gamma_{never}$$

$$= \delta_{compliers}\gamma_{compliers} \equiv \delta\gamma$$

so

$$\beta / \gamma = \delta$$

$$Note\ \beta = E(Y \mid T = 1) - E(Y \mid T = 0) = \text{"}ITT\ on\ Y\text{"}$$

$$\gamma = E(M \mid T = 1) - E(M \mid T = 0) = \text{"}ITT\ on\ M\text{"}$$

$if\ \ T\ \ is\ randomized$

In Sum

We can estimate the Population-Average Effect of Participating if we assume $\mathrm{Cov}(\Gamma,\Delta)=0$

We can estimate LATE if we assume $\Pr(\Gamma\geq 0)=1$

The latter is a weaker assumption, but does not eliminate the selection problem!

Multiple Sites

How do we take this to multiple sites to

- * Estimate average Impact of Program Participation
- * Estimate variation in the Impact of Program Participation

- * Two methods using simulated data:

  "Small Schools of Choice" Design (J=200, 80<n<120)

$$(true\ values: \delta = 1.194, \quad \tau_{\delta}^{2} = 0.430)$$

Method 1: Combine 2 ITT analyses

Step 1: Estimate the Impact of Treatment Assignment on the Outcome

$$Y_{ij} - \overline{Y}_{\cdot j} = B_j (T_{ij} - \overline{T}_{\cdot j}) + e_{ij} - \overline{e}_{\cdot j}$$

$$E(B) = \beta, \;\; Var(B) = \tau_B^2$$

Results

$$\hat{\beta} = 0.770, \quad se = 0.53$$

$$\hat{\tau}_B^2 = 0.249 \; \left(= .499^2\right)$$

95% plausible value interval for B_j

$$= .770 \pm 1.96 * .499 = (-.21, \; 1.75)$$

Step 2: Estimate the Impact of Treatment Assignment on Program Participation

$$M_{ij} - \overline{M}._j = G_j(T_{ij} - \overline{T}._j) + \nu_{ij} - \overline{\nu}._j$$

$$E(G) = \gamma, \quad Var(G) = \tau_G^2$$

Results

$$\hat{\gamma} = 0.703$$

$$\hat{\tau}_G^2 = 0.0061 \ \left(= .078^2\right)$$

95% plausible value interval for G_j

$$= (.55,\ 86)$$

Step 3: Combine Results

$$\delta = \beta / \gamma$$

$$\textit{In our case } \hat{\delta} = \hat{\beta} / \hat{\gamma} = .770 / .703 = 1.095$$

$$\tau_D^2 = \frac{\tau_\beta^2 - \delta^2 \tau_\gamma^2}{\gamma^2 + \tau_\gamma^2} \quad \left(if \;\; G \perp D \right)$$

In our case

$$\hat{\tau}_D^2 = \frac{(.249) - (1.095^2) * (.078^2)}{(.078^2) + (.703^2)} = .483$$

$$95\% \, PV \;\; (D) = 1.095 \pm 1.96 * \sqrt{.483} = (-.267, \; 1.248)$$

In sum

True Values

$$True\ values: \delta = 1.19, \quad \tau_{\delta}^{2} = 0.430$$

Our estimates

$$\hat{\delta} = 1.10, \qquad \hat{\tau}_{\delta}^{2} = 0.487$$

Method 2: Two-Stage Generalized Least Squares: Theoretical Model

$$\text{Stage 1:} \qquad M_{ij} - \overline{M}_{\cdot j} = G_j (T_{ij} - \overline{T}_{\cdot j}) + \nu_{ij} - \overline{\nu}_{\cdot j}$$

$$E(G) = \gamma, \ \ Var(G) = \tau_G^2$$

$$\text{Stage 2:} \qquad Y_{ij} - \overline{Y}_{\cdot j} = D_j (M_{ij} - \overline{M}_{\cdot j}) + \varepsilon_{ij} - \overline{\varepsilon}_{\cdot j}$$

$$E(D) = \delta, \ \ Var(D) = \tau_D^2$$

Method 2 in Practice

$$1.\ Compute:\ \hat{M}_{ij} - \overline{M}._j = \hat{G}_{OLS}(T_{ij} - \overline{T}._j)$$

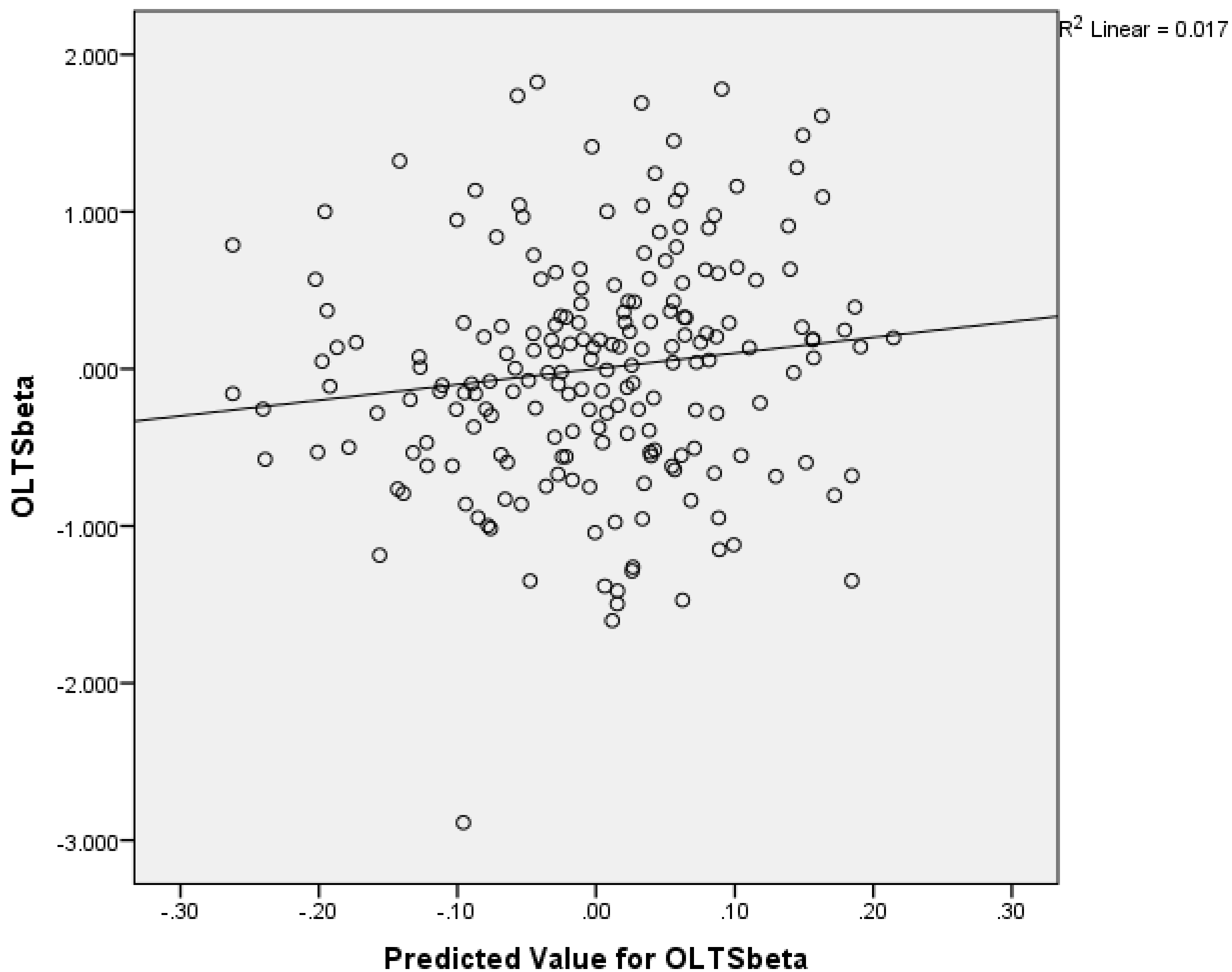
$$2.\ Do\ \ HLM:\quad Y_{ij} - \overline{Y}._j = D_j(\hat{M}_{ij} - \overline{M}._j) + \varepsilon^*_{ij} - \overline{\varepsilon}^*_{ij}$$

$$E(D) = \delta,\ \ Var(D) = \tau^2_D$$

3. Recompute variances using original M

$$Y_{ij} - \overline{Y}._j = \hat{D}_j(M_{ij} - \overline{M}._j) + \varepsilon^*_{ij} - \overline{\varepsilon}^*_{ij}$$

$$E(D) = \hat{\delta},\ \ Var(D) = \tau^2_D$$


R2 Linear = 0.017
2.000
1.000
.000
-1.000
-2.000
-3.000
OLTSbeta
-.30
-.20
-.10
.00
.10
.20
.30
Predicted Value for OLTSbeta

Method 2="Between Site Regression!"

$$B_j = D_j G_j$$
$$= \delta G_j + (D_j - \delta) G_j$$

from which.....

$$\hat{B}_j = \delta \hat{G}_j + (D_j - \delta)\hat{G}_j + \overline{\varepsilon}_j^E - \overline{\varepsilon}_j^C$$

Requires $E[\hat{G}_j (D_j - \delta)] = 0$

Results

$$\hat{\delta} = 1.095, \quad se = 0.0730$$

$$\hat{\tau}_{\delta}^{2} = .4856$$
$$= .6968^{2}$$

$$95\%\ CI = (.316, .746)$$
$$= (.562^{2}, .863^{2})$$

Envisioning Variation: LATE Effect

“Head Start” Design (J=200, 10<n<20)

“Small Schools of Choice” Design (J=200, 80<n<120)

“Welfare to Work” Design (J=60, 200<n<1400)

Program Participation Model ("LATE")

$Participation\ \ model:$

$$M_{ij} - \overline{M}_{j} = G_j (T_{ij} - T._{j}) + v_{ij} - \overline{v}._{j}$$

$$E(G) = \gamma, \qquad Var(G) = \tau_{\gamma}^{2}$$

$Impact\ \ Model:$

$$Y_{ij} - \overline{Y}._{j} = D_j (M_{ij} - \overline{M}._{j}) + \varepsilon_{ij} - \overline{\varepsilon}._{j}$$

$$D_j \sim N(\delta, \tau_{\delta}^{2})$$

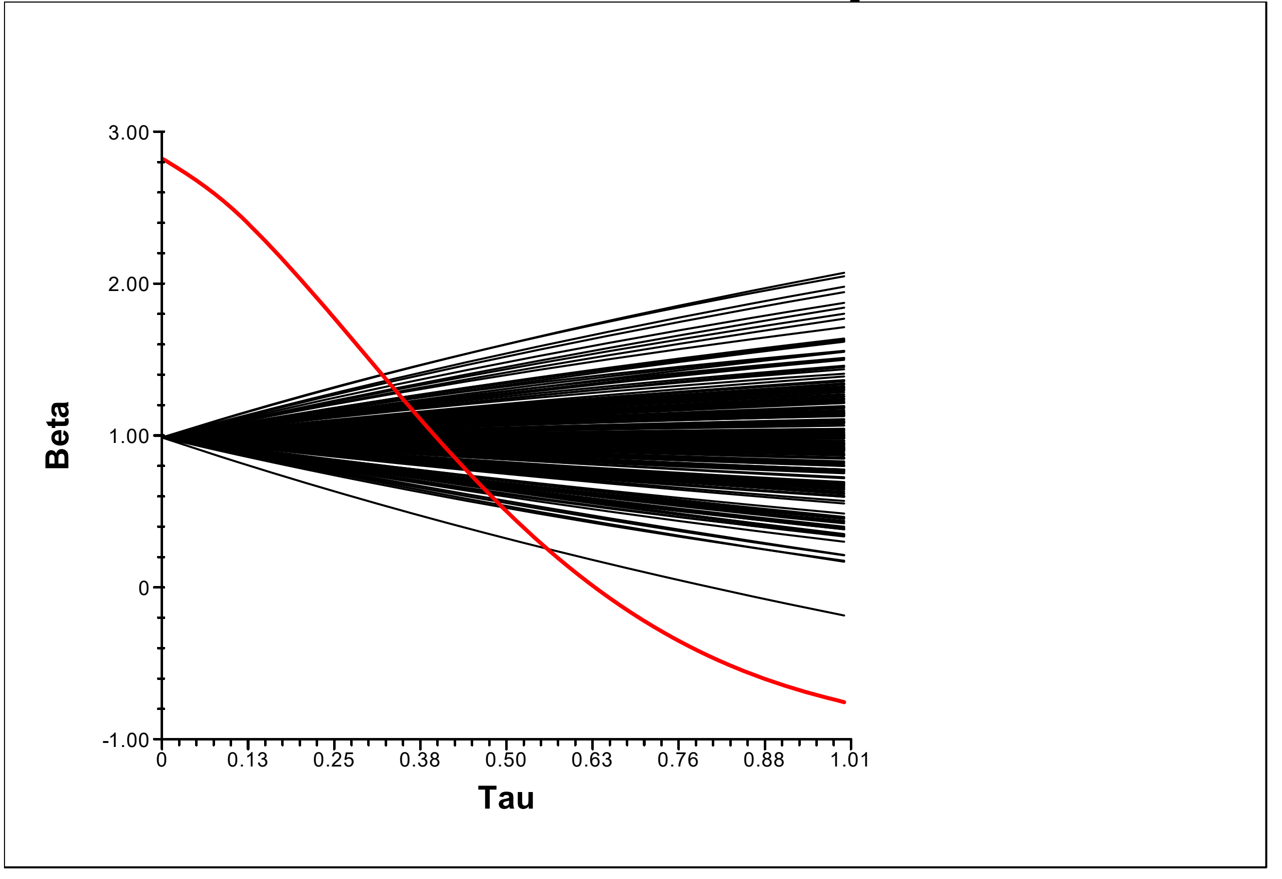
$HS: \quad \hat{\delta} = 0.986 \qquad \hat{\tau}_{\delta}^{2} = 0$

$SSC \quad \hat{\delta} = 1.095, \quad \hat{\tau}_{\delta}^{2} = 0.487$

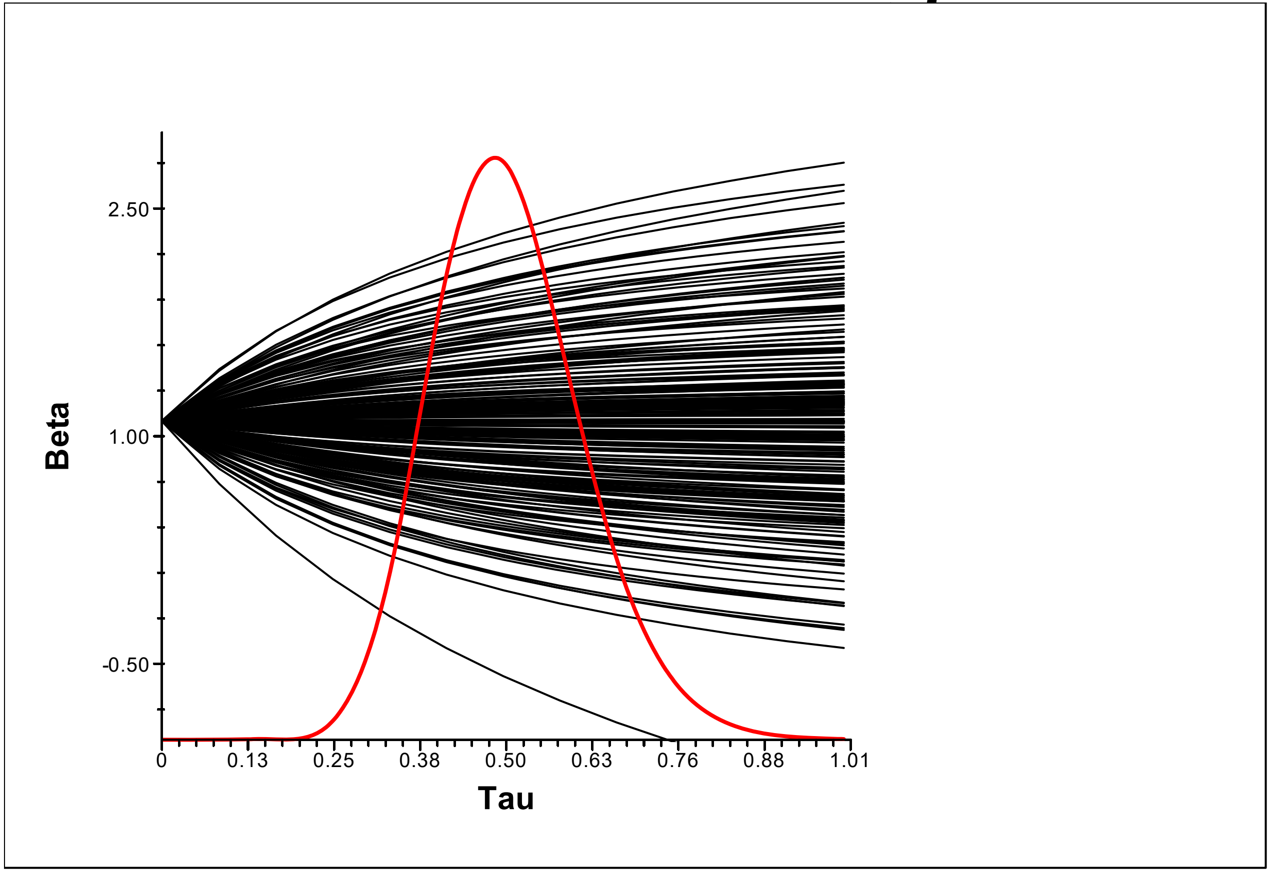
$WtW: \ \hat{\delta} = 1.007, \quad \hat{\tau}_{\delta}^{2} = 0.280$

$(true\ values: \delta = 1.194, \ \ \tau_{\delta}^{2} = 0.430)$

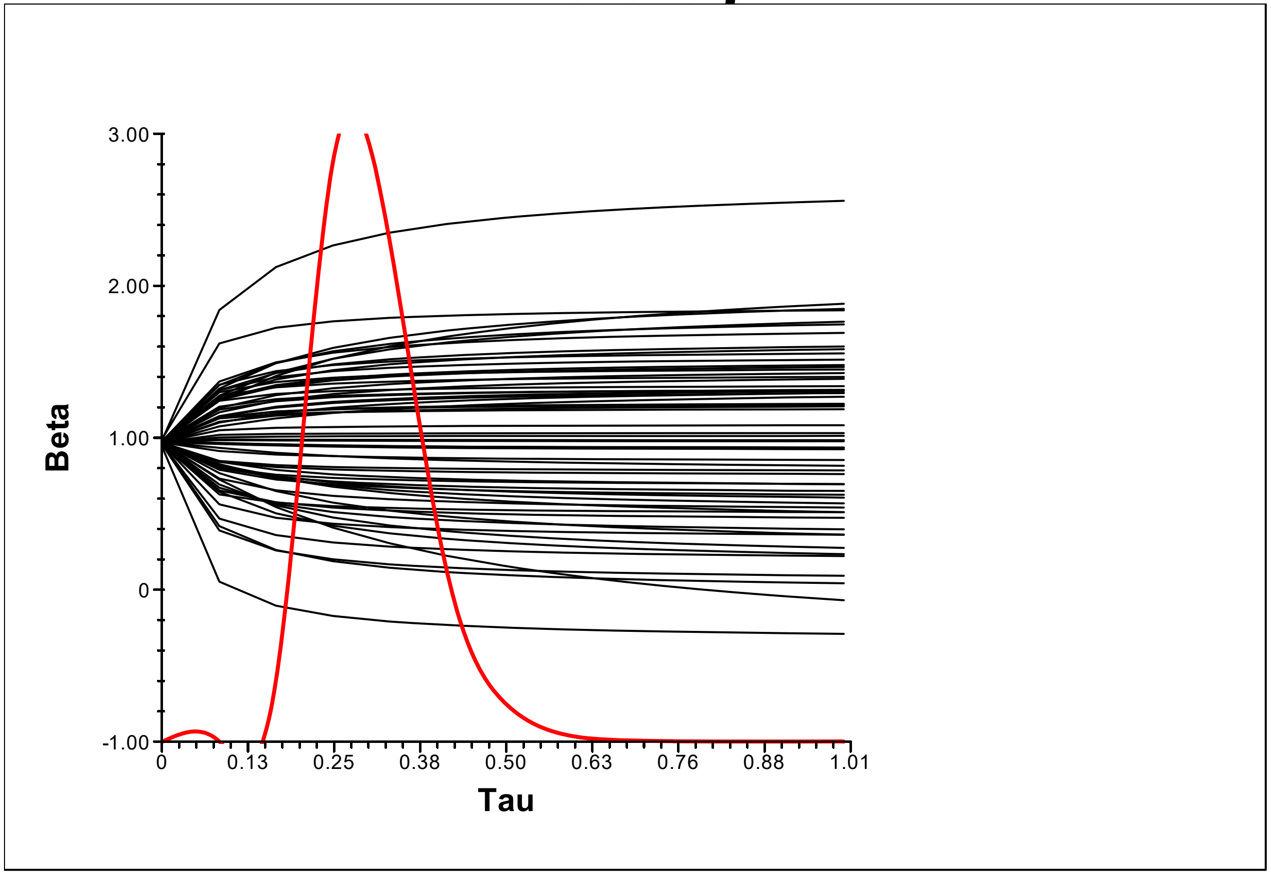
Profile Likelihood for LATE: "HS" Design



Profile Likelihood for LATE: "SSOC" Design

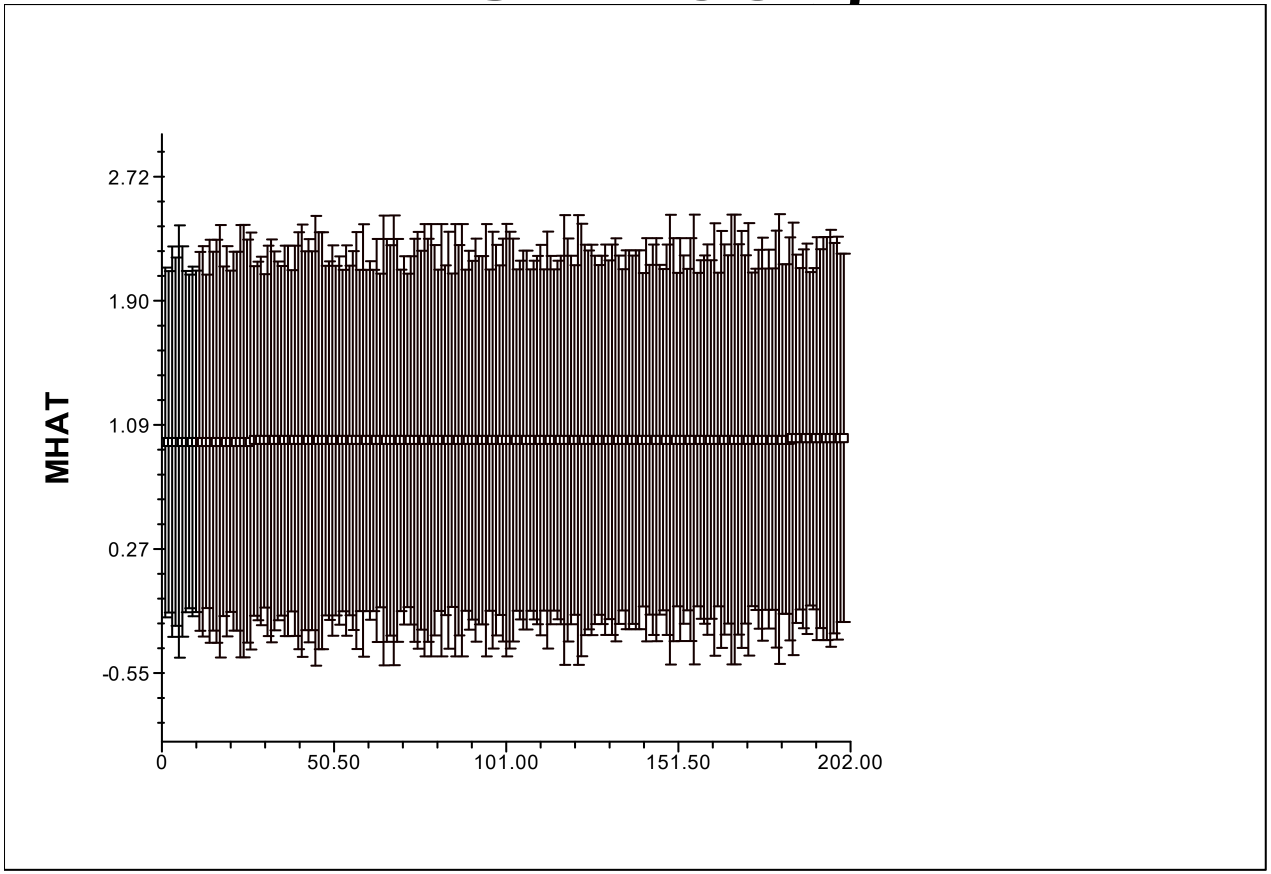


Profile Likelihood for LATE: “WtW” Design

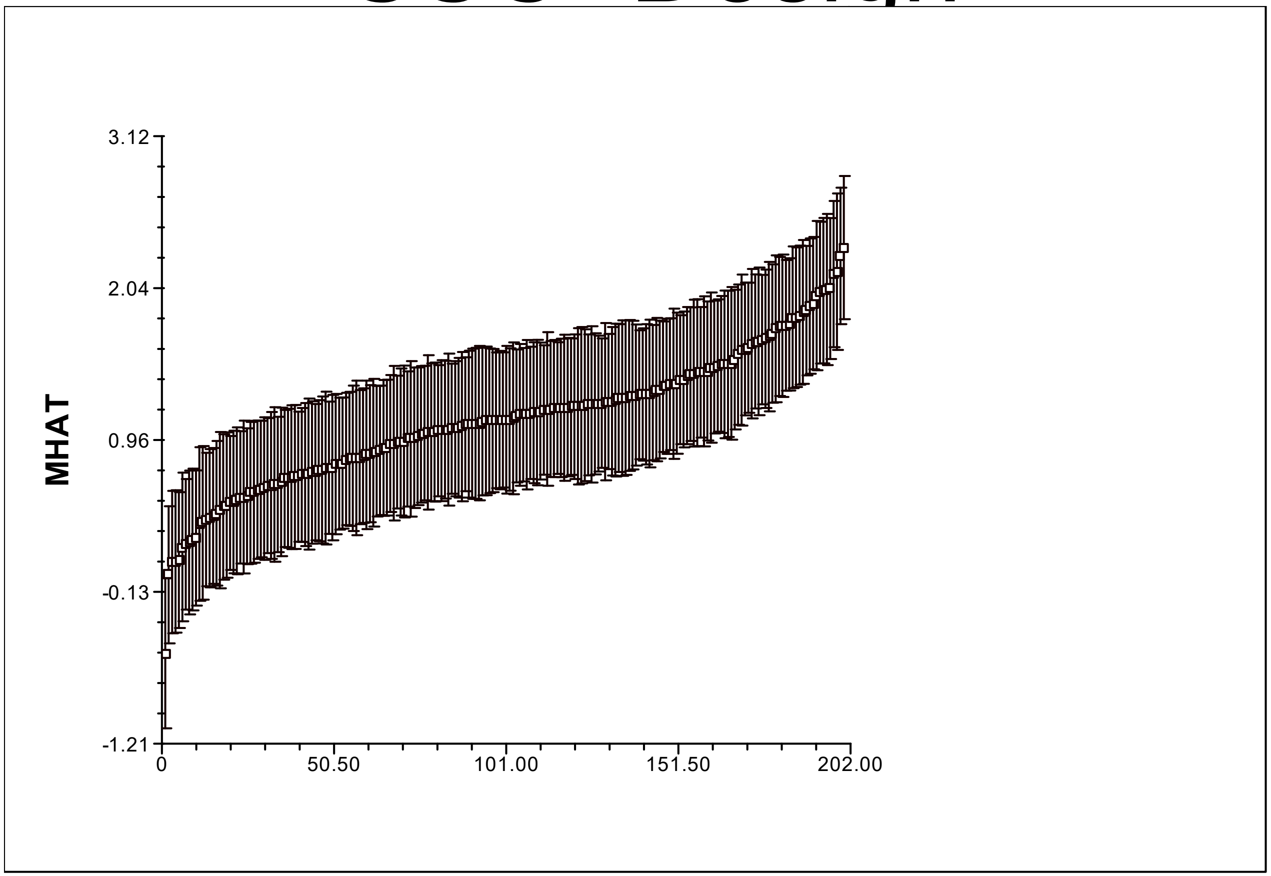


Posterior intervals for site-specific LATE Effects

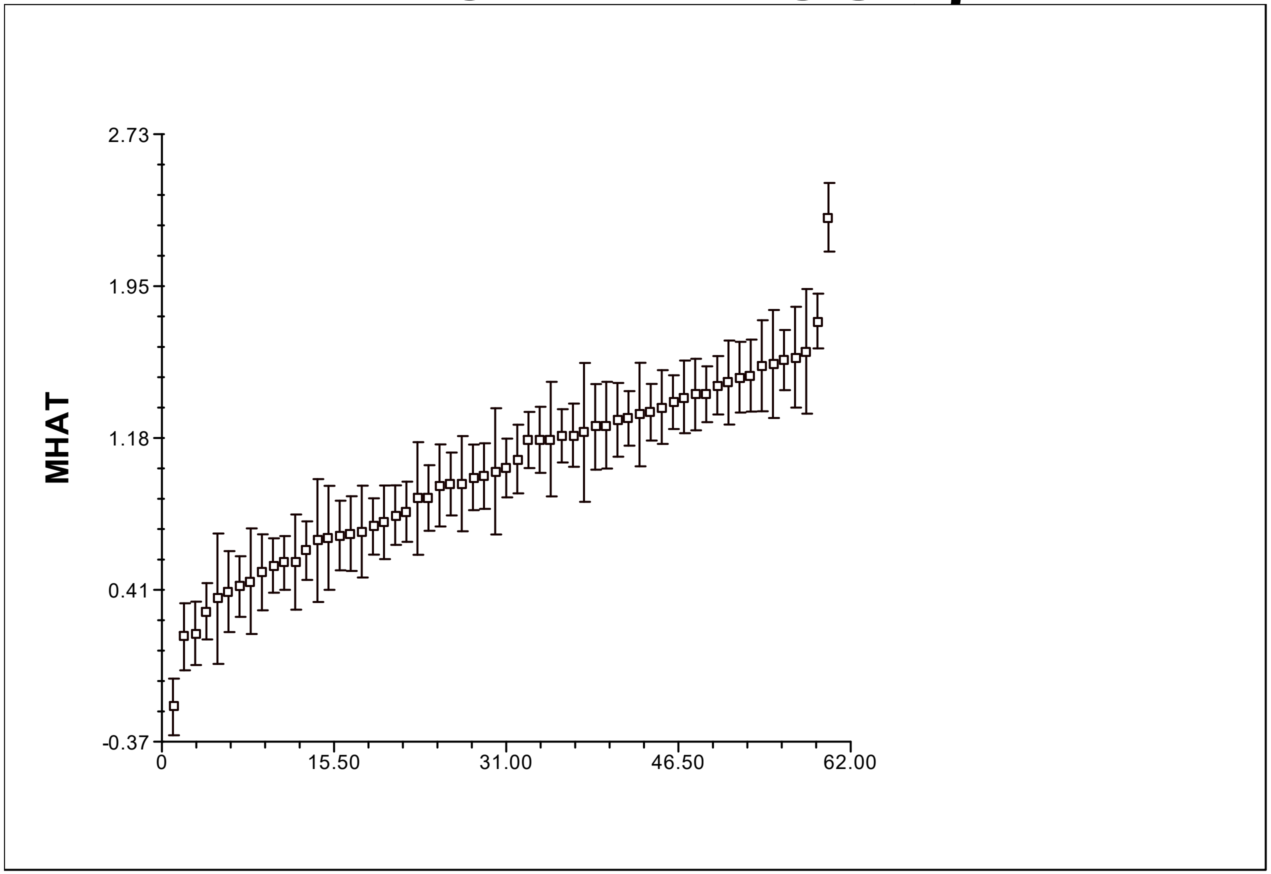
Posterior Intervals for LATE: "HS" Design



Posterior Intervals for LATE: "SSC" Design



Posterior Intervals for LATE: “W to W” Design



Moving Toward Explanation
modeling participation, modeling impact

$$B_j = G_j D_j$$

Total Impact of Assignment=
Impact of Assignment on Participation * Impact of participation on Outcome

Within site:

Which persons are most likely to participate?
Which persons are most likely to benefit from participation?

Between Sites:

How do we improve site-average participation rate?
How do we enhance average benefit of participating?

Models are needed at both levels because sites vary not only in organizational effectiveness but also in client composition