How Much Do Effects Vary Across Sites?

Evidence From Existing Multisite Randomized Trials

Stanford Workshop

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Outline

- Why do Effects Vary and Why Should we Care?
- Cross-site Distribution of Effects Defined
- Data
- Estimation
- Empirical Results
- Discussion
  - Implications for designing studies
  - When to expect a lot of x-site impact variation

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Why do effects vary: The three C's

1. **Treatment Contrast**
    1. Program Group: the services received by the program group
    2. Control Group: the counterfactual services received

2. **Client Characteristics**

3. **Program Context**

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Why are about cross-site impact variation?

- Overall average impacts can mask heterogeneity in impacts across sites

- This information…
  - has substantive implications
  - is necessary for planning multi-site experiments

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Site-level distribution of impacts

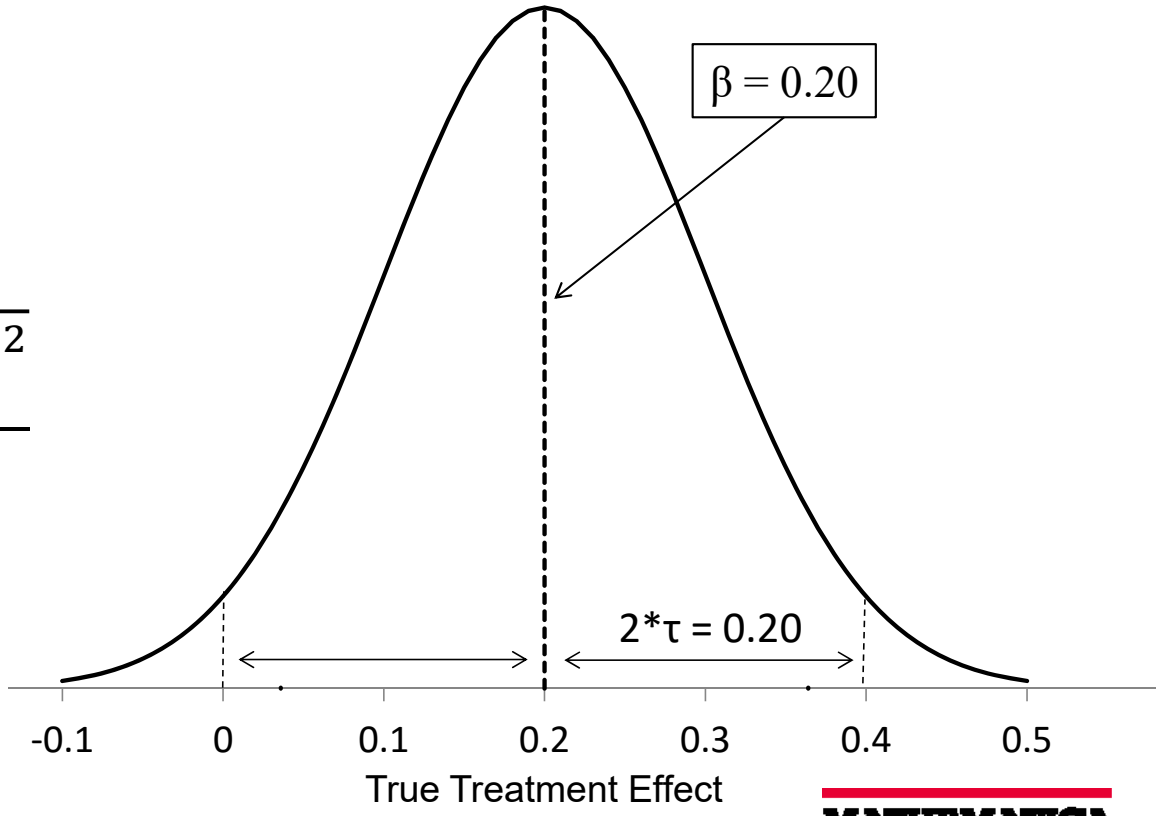
Let:

B_j = True average treatment effect at site *j*

Then:

$$\beta \equiv \lim_{J^* \to \infty} \frac{\sum_{j=1}^{J^*} B_j}{J^*}$$

$$\tau \equiv \lim_{J^* \to \infty} \sqrt{\frac{\sum_{j=1}^{J^*} (B_j - \beta)^2}{J^*}}$$



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Data

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Data from large multi-site RCTs

Early Childhood-Element. School	Middle School-High School	Post-secondary Education	Labor Market Programs
Head Start Program *(Abt)*	Charter Middle Schools (*Mathematica)*	Learning Communities *(MDRC)*	Job Corps *(Mathematica)*
After School – Reading Program *(MDRC)*	Teach for America – Math *(Mathematica)*	Performance-based Scholarships *(MDRC)*	Welfare-to-Work Programs *(MDRC)*
After School – Math Program *(MDRC)*	Enhanced Reading Opportunity *(MDRC)*		
Teach for America – Pooled (i3, National) *(Mathematica)*	Small Schools of Choice *(MDRC)*		
Tennessee STAR	Career Academies *(MDRC)*		
	Early College H.S. *(Abt)*		

Estimation Model

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Estimation Model

Level 1 (clients):

$$Y_{ij} = \sum_{r=1}^{R} \alpha_r \, RA\_Block_{rij} + B_j T_{ij} + \sum_{l=1}^{L} \gamma_l X_{lij} + e_{ij}$$

Level 2 (sites):

$$B_j = \beta + b_j$$

$\hat{\beta}$, an estimate of the treatment effect for the average site

Where:

$$e_{ij} \sim N\left(0, \sigma^2_{|\boldsymbol{X}\boldsymbol{\alpha}}(T_{ij})\right)$$

$$b_j \sim N(0, \tau^2)$$

$$Cov(e_{ij}, b_j) = 0$$

$\hat{\tau}$, an estimate of the cross-site standard deviation of site-average treatment effects

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Results

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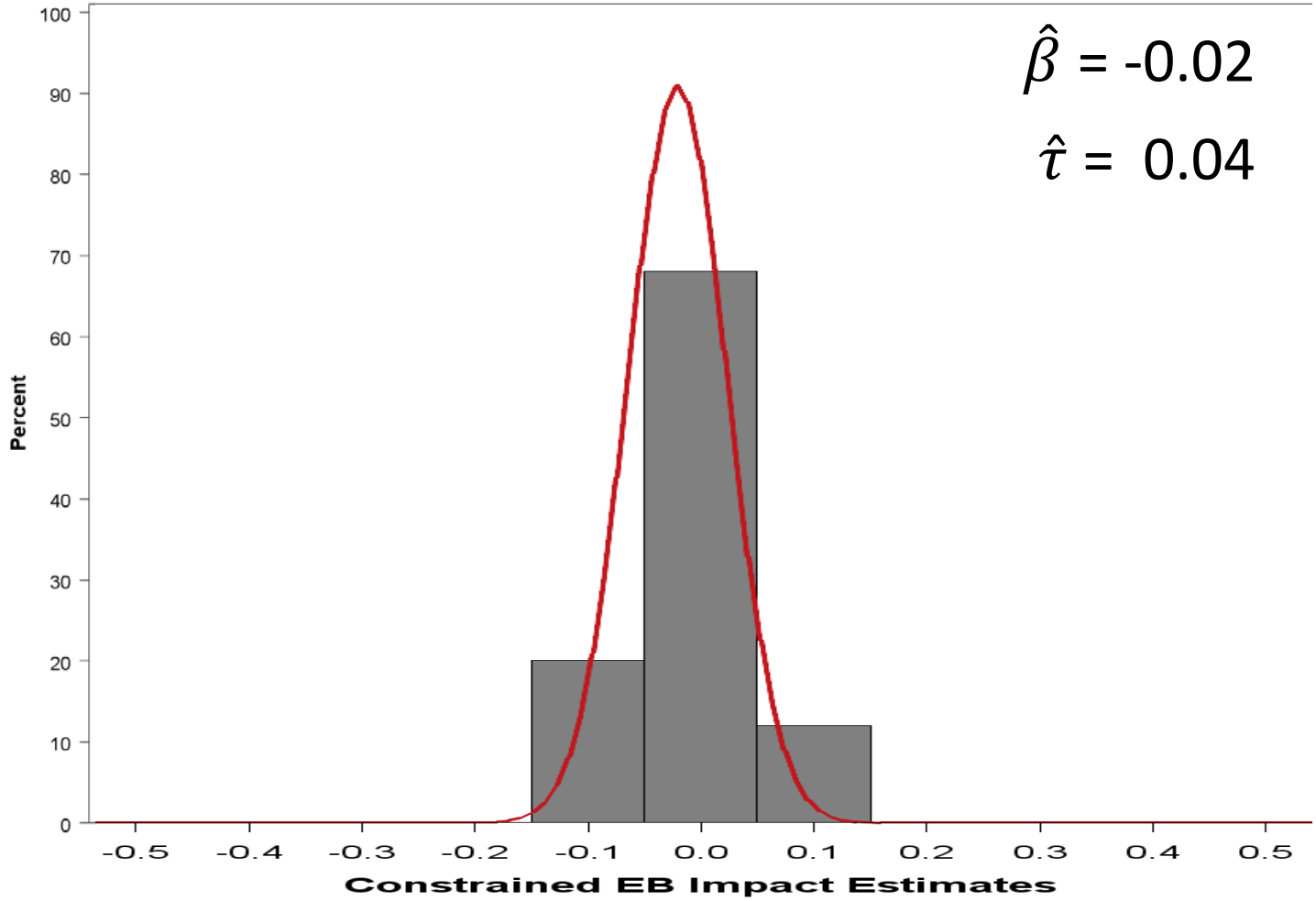
Selected Results

Intervention	$\hat{\beta}$ - mean	$\hat{\tau}$ - s.d.	
Head Start Impact Study (ES - Read)	0.20***	0.30***	Early Childhood-Elementary
After School Reading (ES - Read)	-0.02	0.04	
After School Math (ES - Math)	0.07***	0.00	
Teach for America - Pooled (ES - Math)	0.10**	0.05*	
Tennessee STAR (ES - Read)	0.15***	0.23***	
Charter Middle Schools (ES - Read)	-0.07	0.16***	Middle-High School
Enhanced Reading Opp's (ES - Read)	0.07***	0.08**	
Teach for America - Math (ES - Math)	0.08***	0.10***	
Small High Schools of Choice (% on track)	10.3 ***	15.3 ***	
Career Academies (avg yearly $, yrs 1-4)	1,883.00***	0.0	
Early College High School (% on track)	3.4 *	8.2 ***	
Learning Communities (credits, 1.5yrs)	0.4	0.0	Post-secondary
Perform-based Scholarship (credits, 3yrs)	1.8 **	1.3 *	
Job Corps (avg yearly $, yr 4)	1,415.00***	1,687.00**	Labor
Welfare-to-Work (avg yearly $, yrs 1-2)	670.00***	601.00***	

*p<.10 **p<.05 ***p<.01

Consistent zero average impact across sites

Afterschool Reading Program – Reading, yr 1



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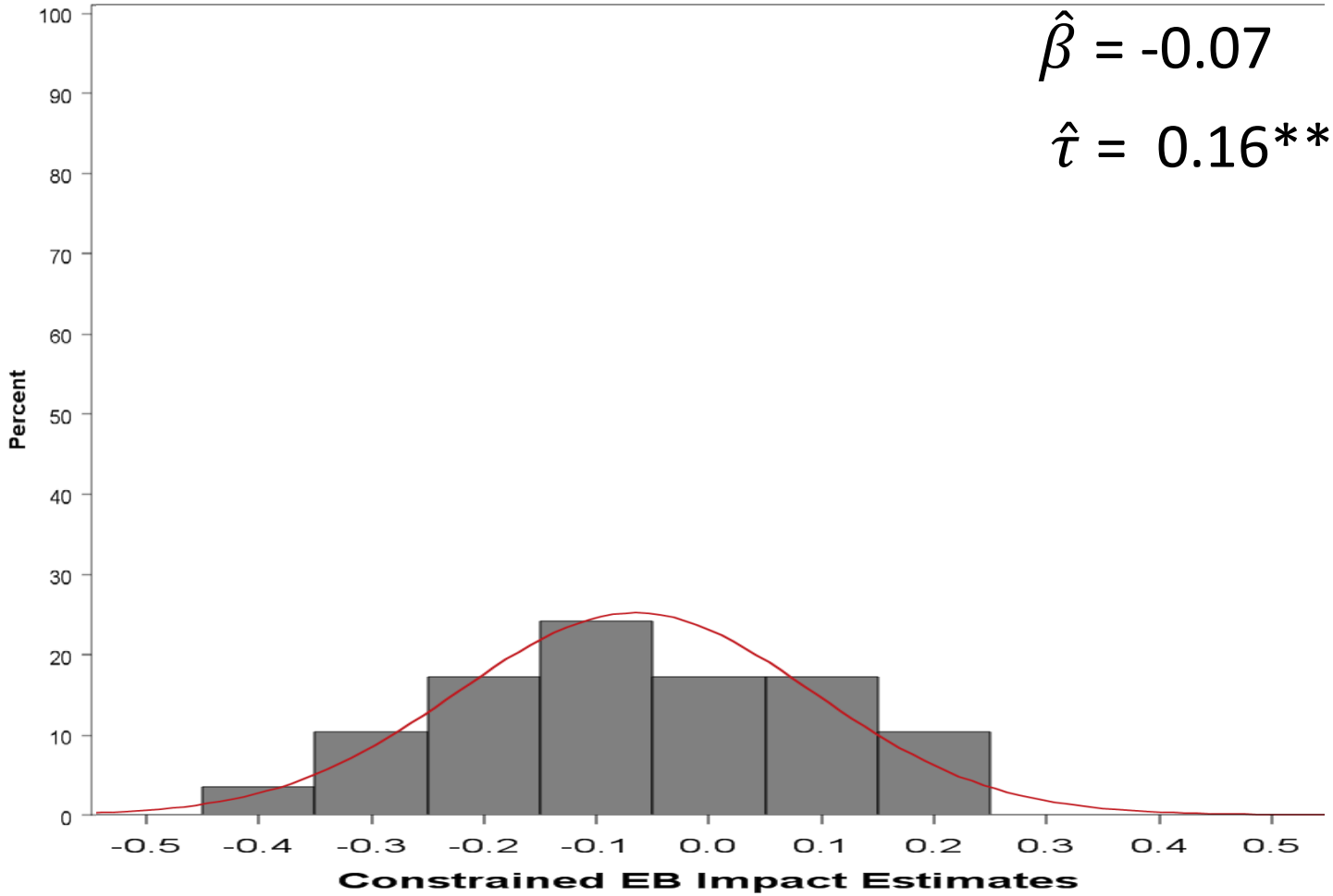
Near zero average impact with a lot of cross-site variation

Charter Middle School – Reading



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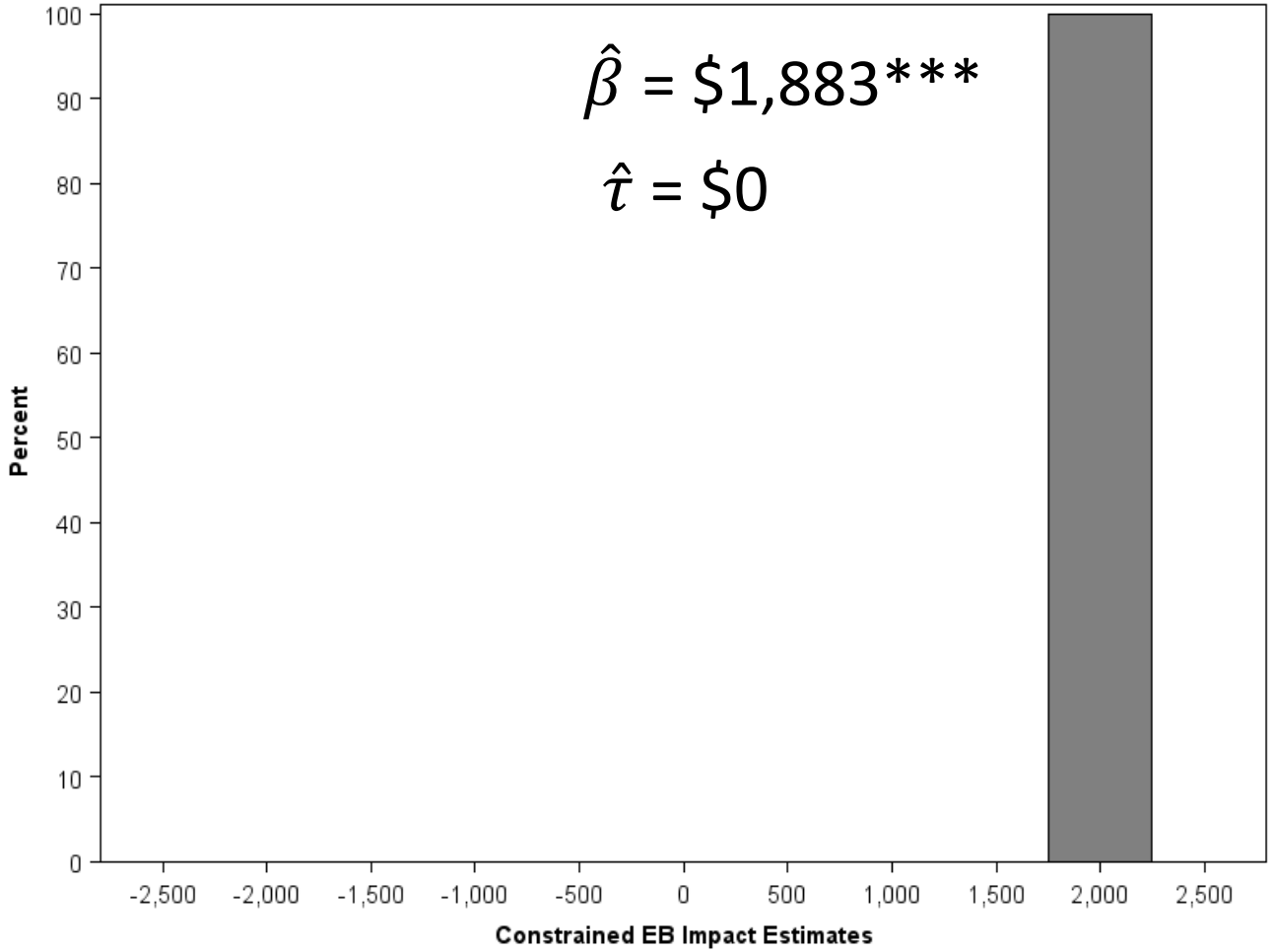
Consistent positive impacts across sites

Career Academies – Average yearly earnings, yrs 1-4



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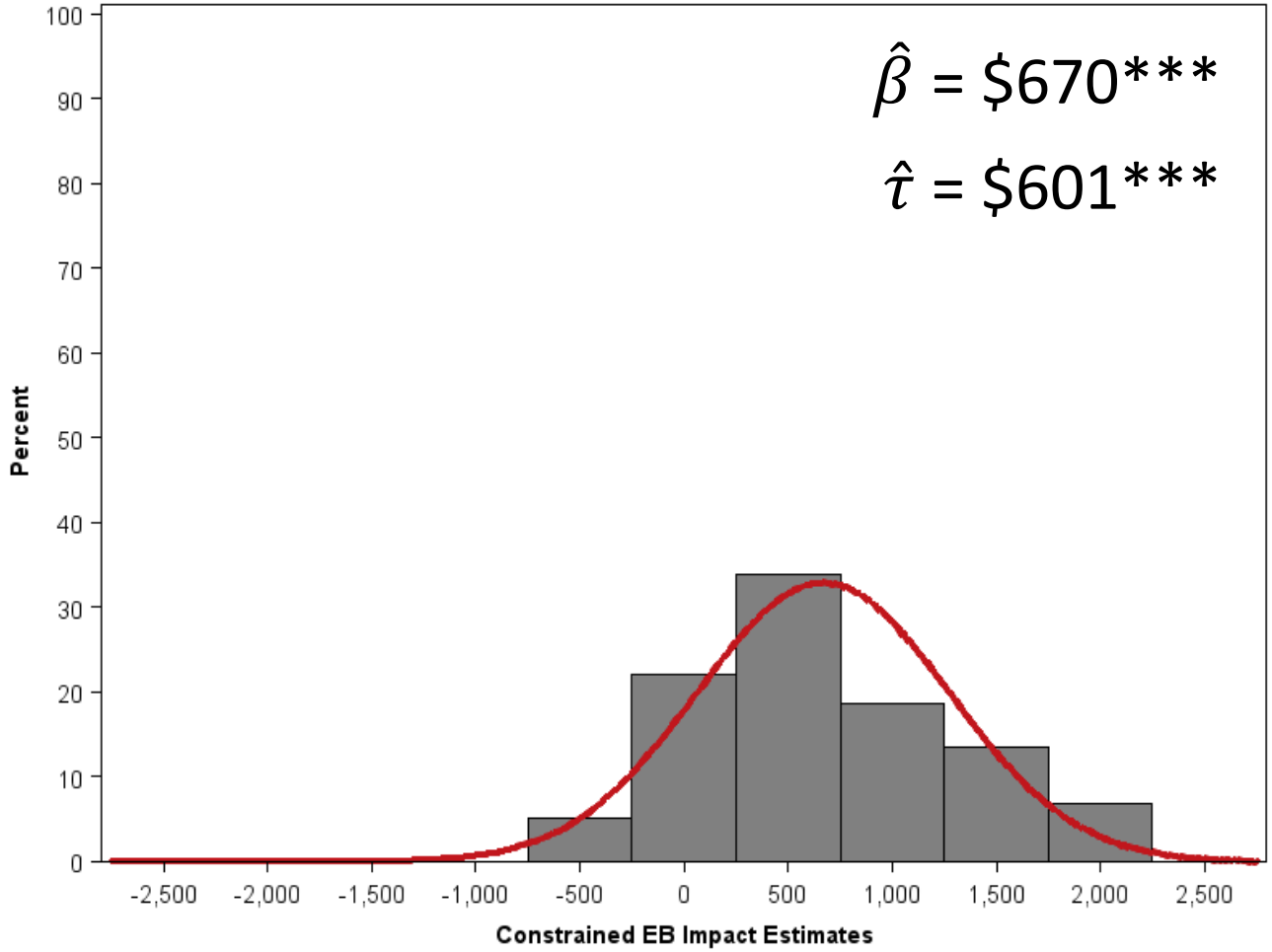
Large average impacts with a lot of cross-site variation

Welfare to Work – Average yearly earnings, yrs 1-2



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Discussion

Minimum Detectable Effect Size (MDES)

$$MDES_Z = M_{J-1}\sqrt{\left(\frac{1}{J}\right)\left(\tau_Z^2 + \frac{(1-\rho_C)\left(1-R^2_{(within)}\right)}{n\bar{T}(1-\bar{T})}\right)}$$

?

Where:

M_{J-1} = a multiplier that rapidly approaches 2.8 as J increases (for a 2-tail test at the 0.05 significance level with 80 percent power)

J = number of sites

n = number of individuals per site (assumed constant across sites)

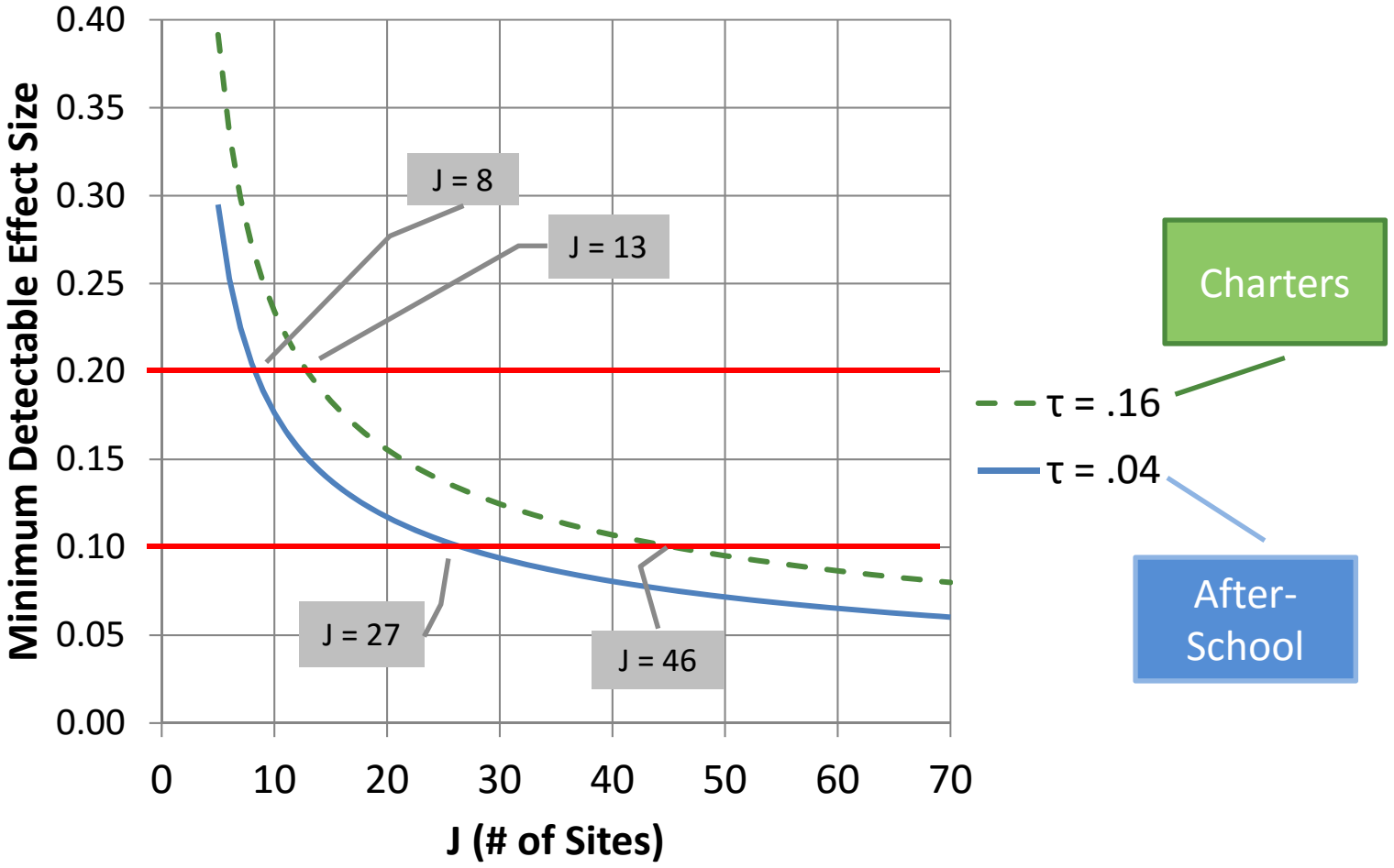
$\bar{T}$ = proportion of individuals randomized to treatment

τ_Z = cross-site standard deviation of site-average program effects on the z-score metric

ρ_C = intra-class correlation for control group outcomes (i.e., the proportion of total outcome variance explained by site indicators)

$R^2_{(within)}$ = proportion of within-site outcome variance explained by our baseline covariates

(MDES) by (# of Sites) by (Tau)



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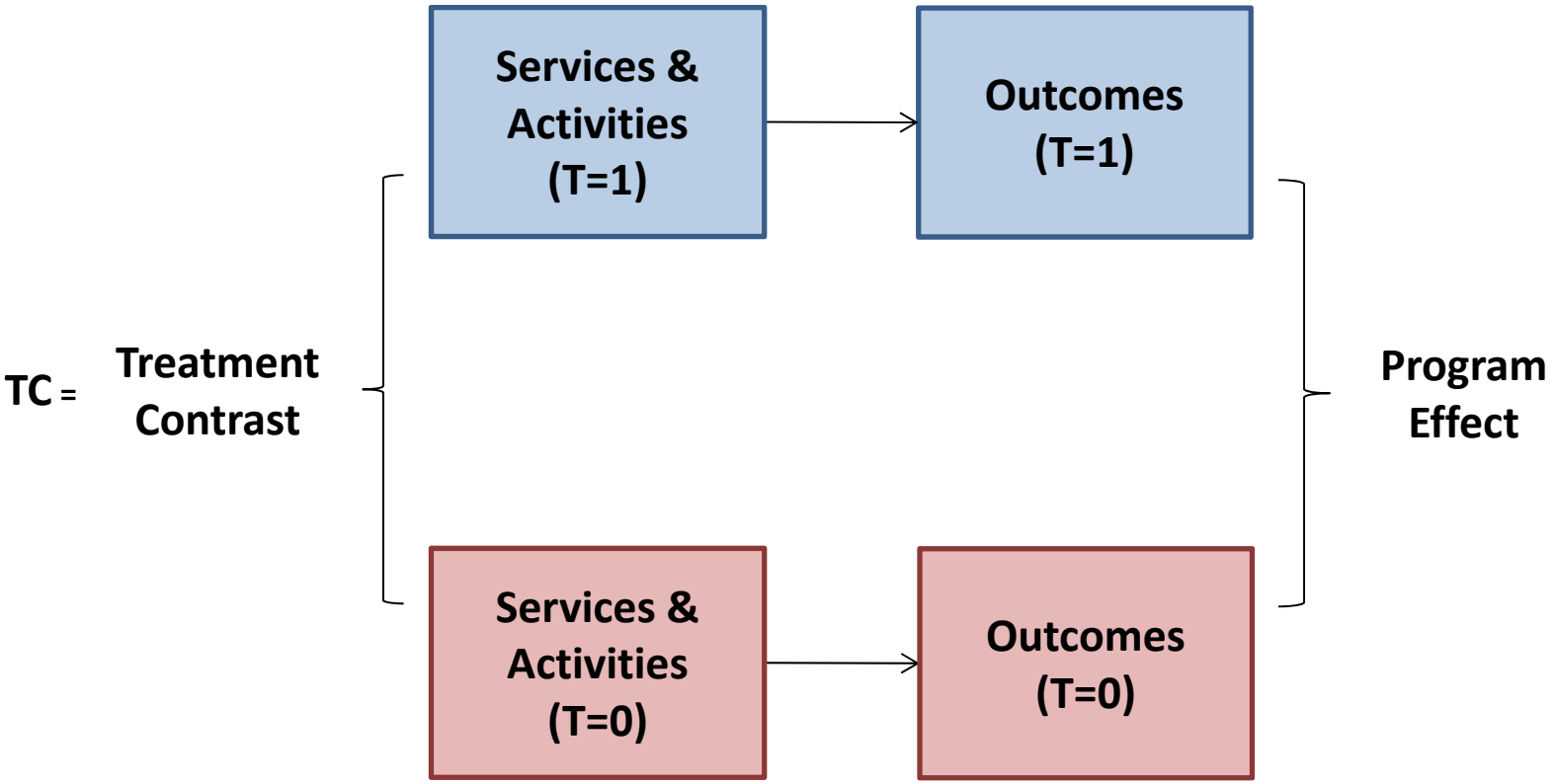
Assuming: R^2 = 0.50, σ_Z^2 = 1, n = 75 and $\bar{T}$ = 0.5

Slide 18

mjw6 Check this...
Mike Weiss, 7/11/2016

When do effects vary across sites a little vs. a lot?



Hypothesis: When the site-average TCs varies a lot across sites, so will treatment effects

When do effects vary across sites a little vs. a lot?

$$\overline{TC_j} \equiv \bar{S}_{j|T=1} - \bar{S}_{j|T=0}$$

Hypothesis:

As $Var(\overline{TC})$ increases, so does τ

$$Var(\overline{TC}) = Var(\bar{S}_{T=1}) + Var(\bar{S}_{T=0}) - 2Cov(\bar{S}_{T=1}, \bar{S}_{T=0})$$

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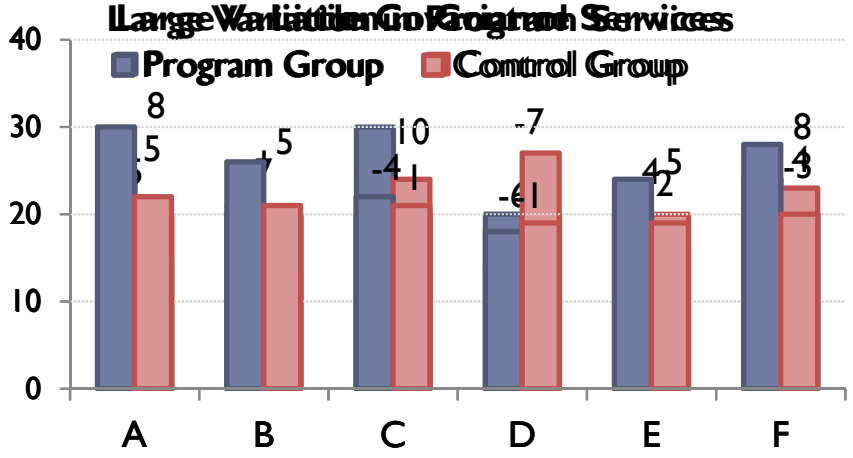
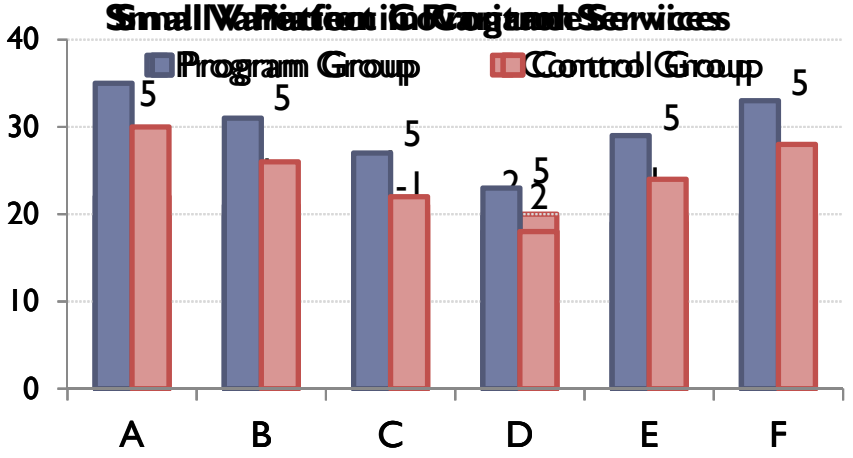
When to expect a large Var($\overline{TC}$) (and τ)

$$Var(\overline{TC}) = Var(\bar{S}_{T=1}) + Var(\bar{S}_{T=0}) - 2Cov(\bar{S}_{T=1}, \bar{S}_{T=0})$$

- Low specificity of the program model
- A high proportion of formal education is altered by the intervention
- When treatment and control group members from the same "site" are served in a different setting for a high proportion of their formal education experience





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What about Client Characteristics?

- For many characteristics (e.g., prior achievement) most variation is *within* sites

- We suspect cross-site impact variation driven by cross-site variation in client characteristics may be hard to predict

What about Context?

- We suspect contextual moderation often occurs through the treatment contrast

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QUESTIONS?

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