

Augmented Panel Data Models with Staggered Adoption

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Summary

- Often, jurisdictions adopt policies over time
- Differences in Differences (DiD) is a workhorse, but parallel trends isn't always reasonable
- Synthetic Control Method (SCM) is more flexible, but designed for a single treatment time
- We extend SCM to staggered adoption setting, partially pool across times, and combine with DiD

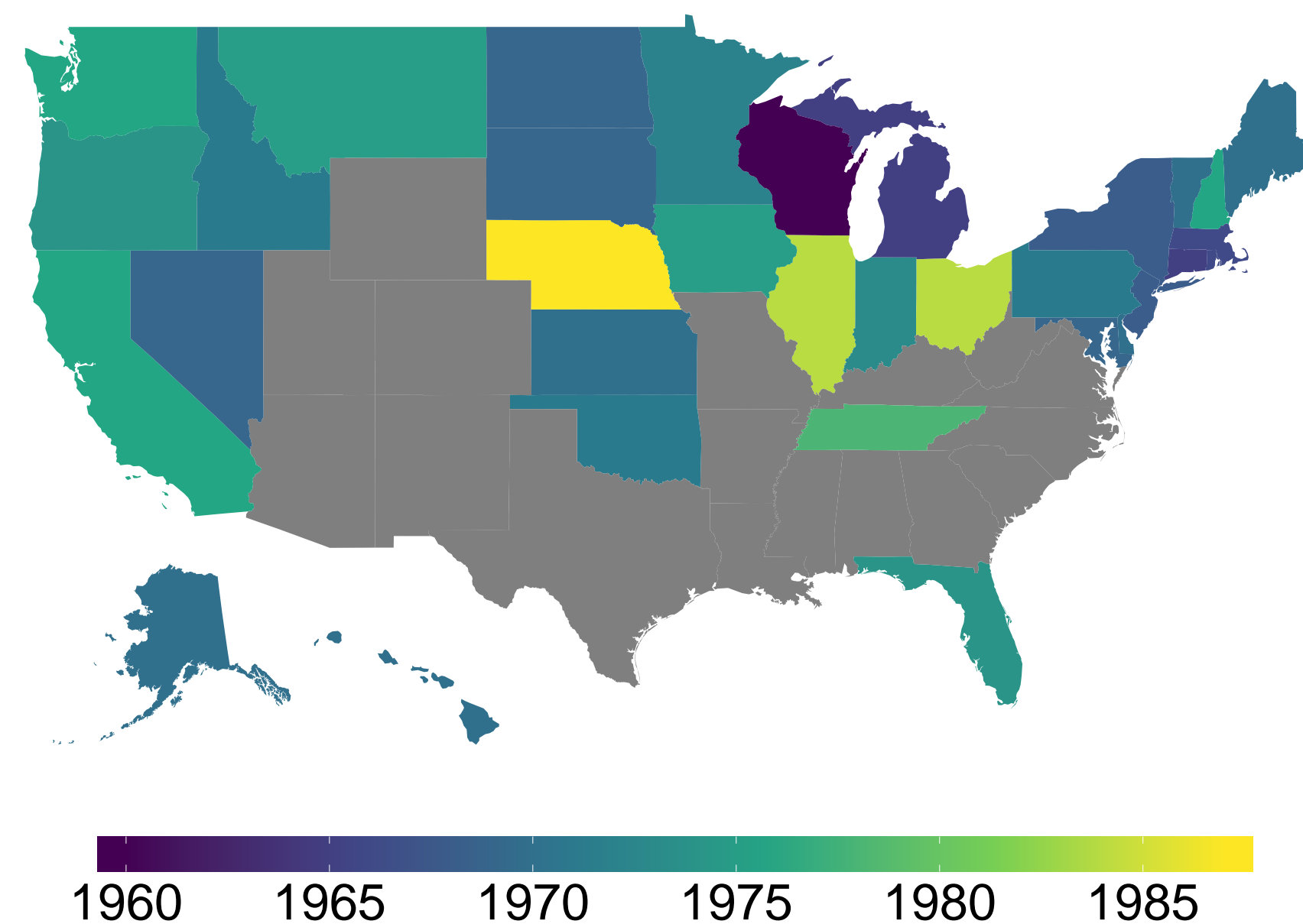
Mandatory Collective Bargaining

Do public sector unions influence public spending?

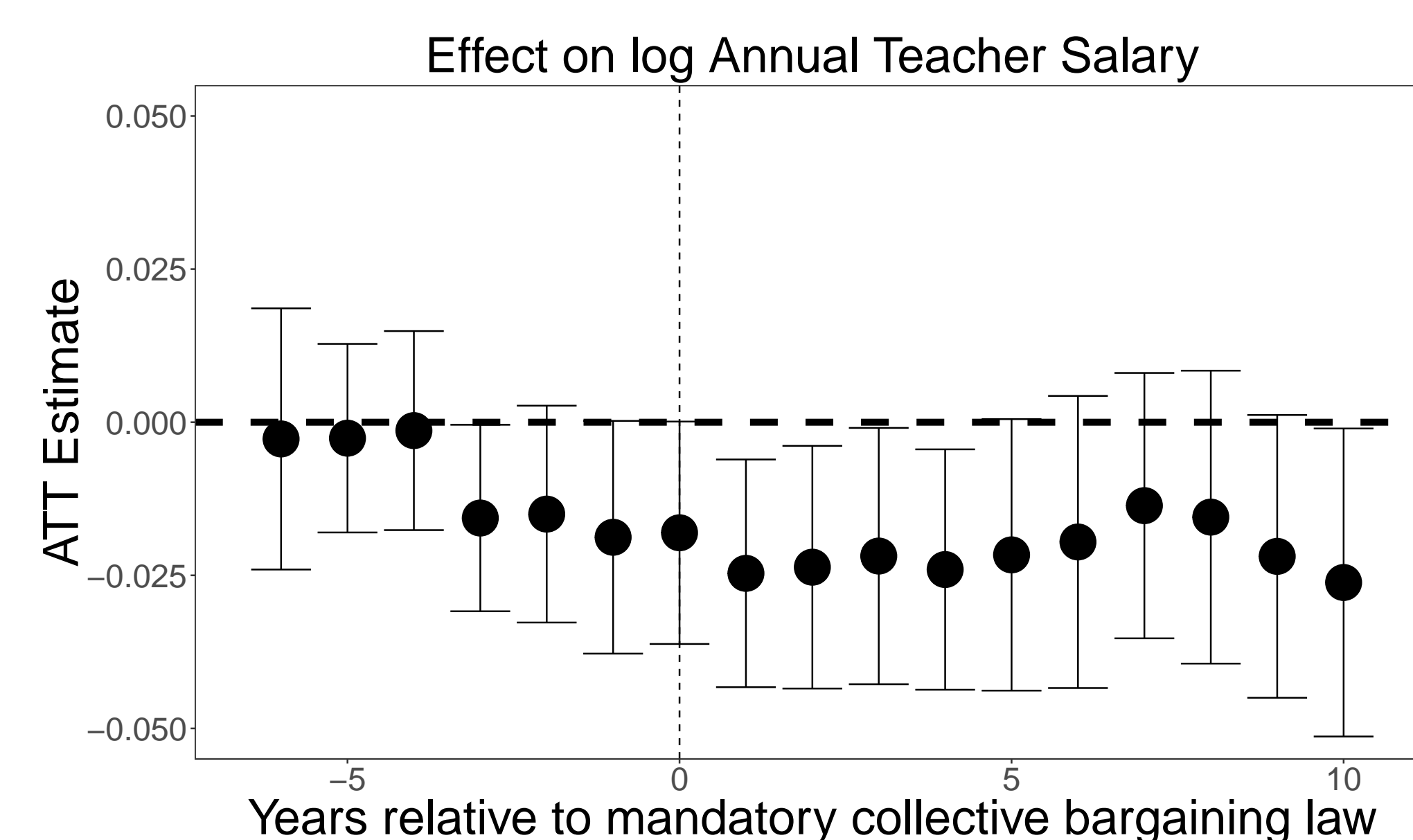
Data: Mandatory collective bargaining laws [1]

- Study period: 1959 to 1997
- 33 states mandate bargaining with public unions
- 10 states allow but do not require, 7 prohibit
- Evaluate effect on average teacher salaries

Year of Mandatory Collective Bargaining Law



Non-parallel trends

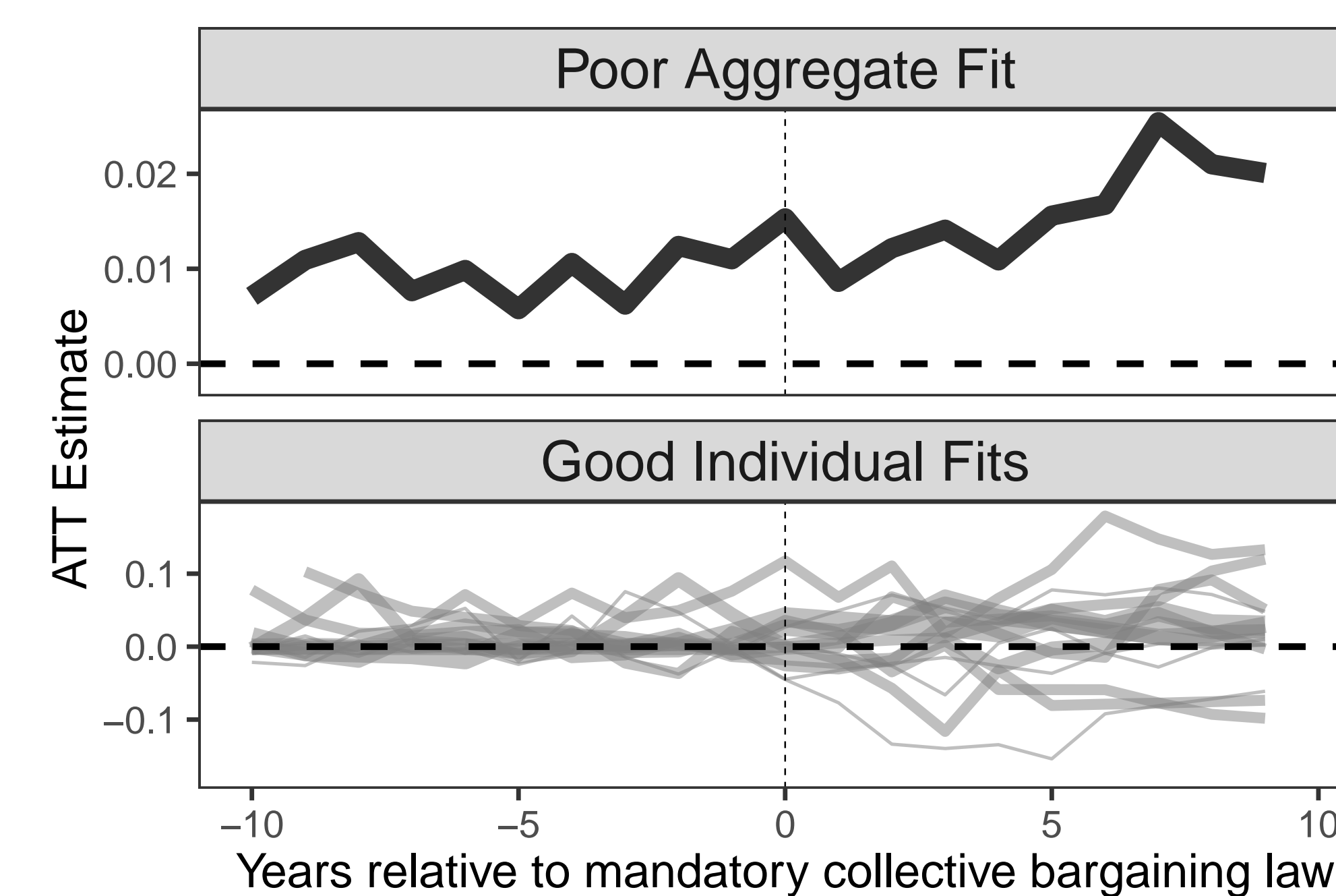


- Standard DiD analysis \Rightarrow non-parallel trends!

No parallel trends? No problem!

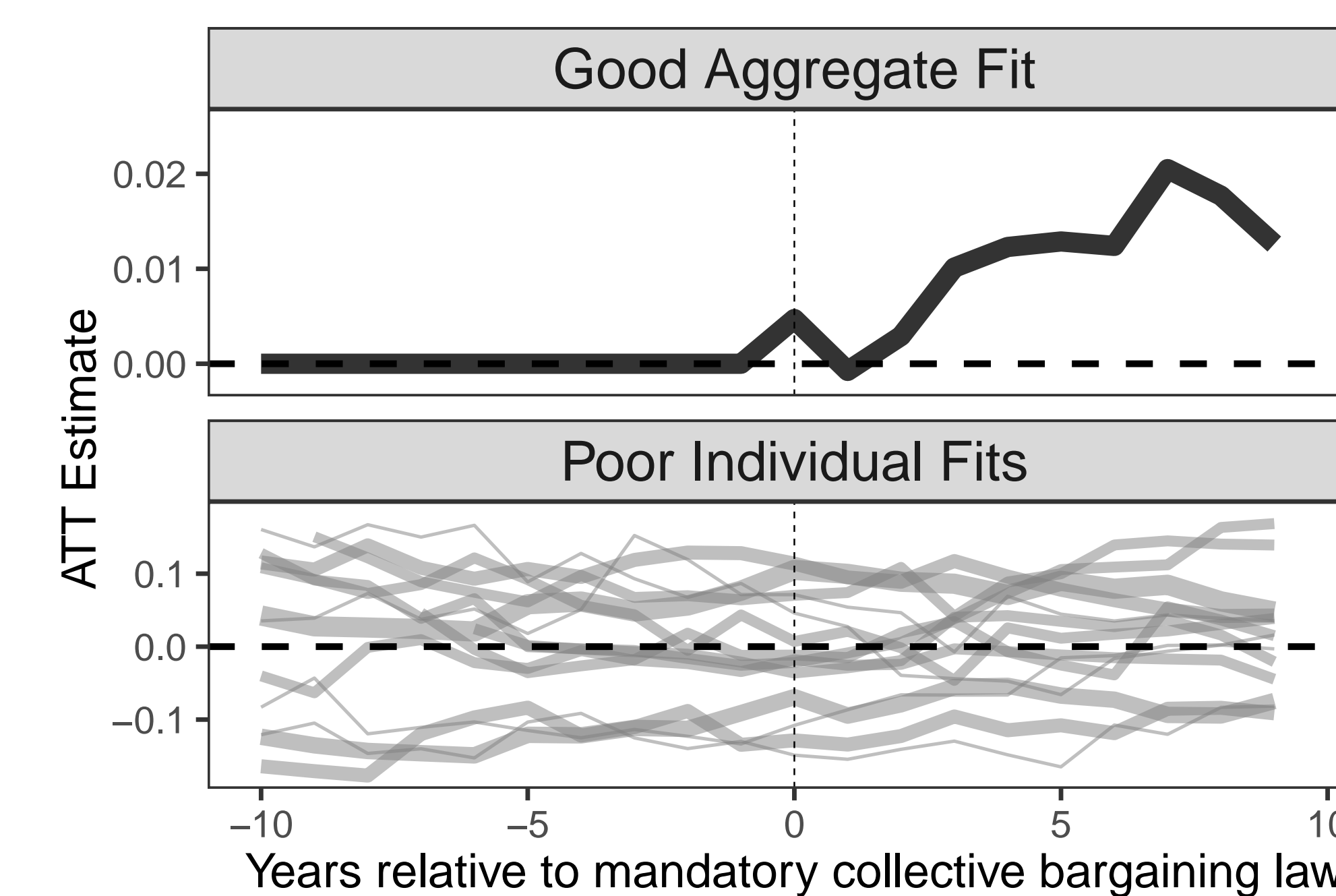
Separate SCM

Fit many separate synthetic controls



Aggregated SCM

Fit a single aggregated synthetic control

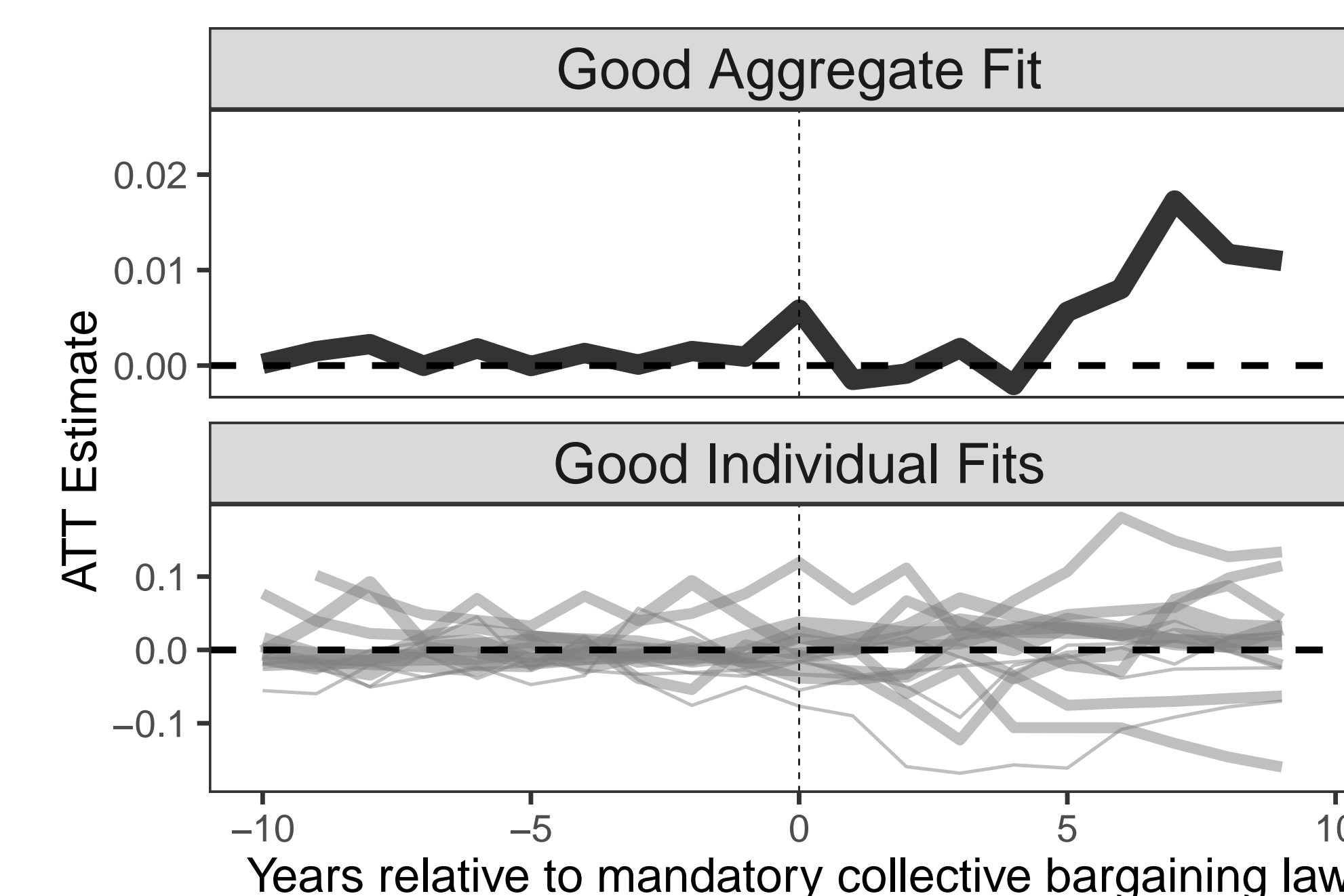


Partially Pooled SCM

Solution: Combine objectives

$$\text{Aggregate Imbalance} + \sum_j \text{Individual Imbalance}_j$$

- Move continuously between both solutions
- Trades off individual fit and aggregate fit
- Dual view as partial pooling across adoption times



Hierarchical Generalized Propensity Score

- Lagrangian dual \Rightarrow implicit p-score estimate
- Selection on lagged outcomes
- Separate parameters β_j for treatment time T_j

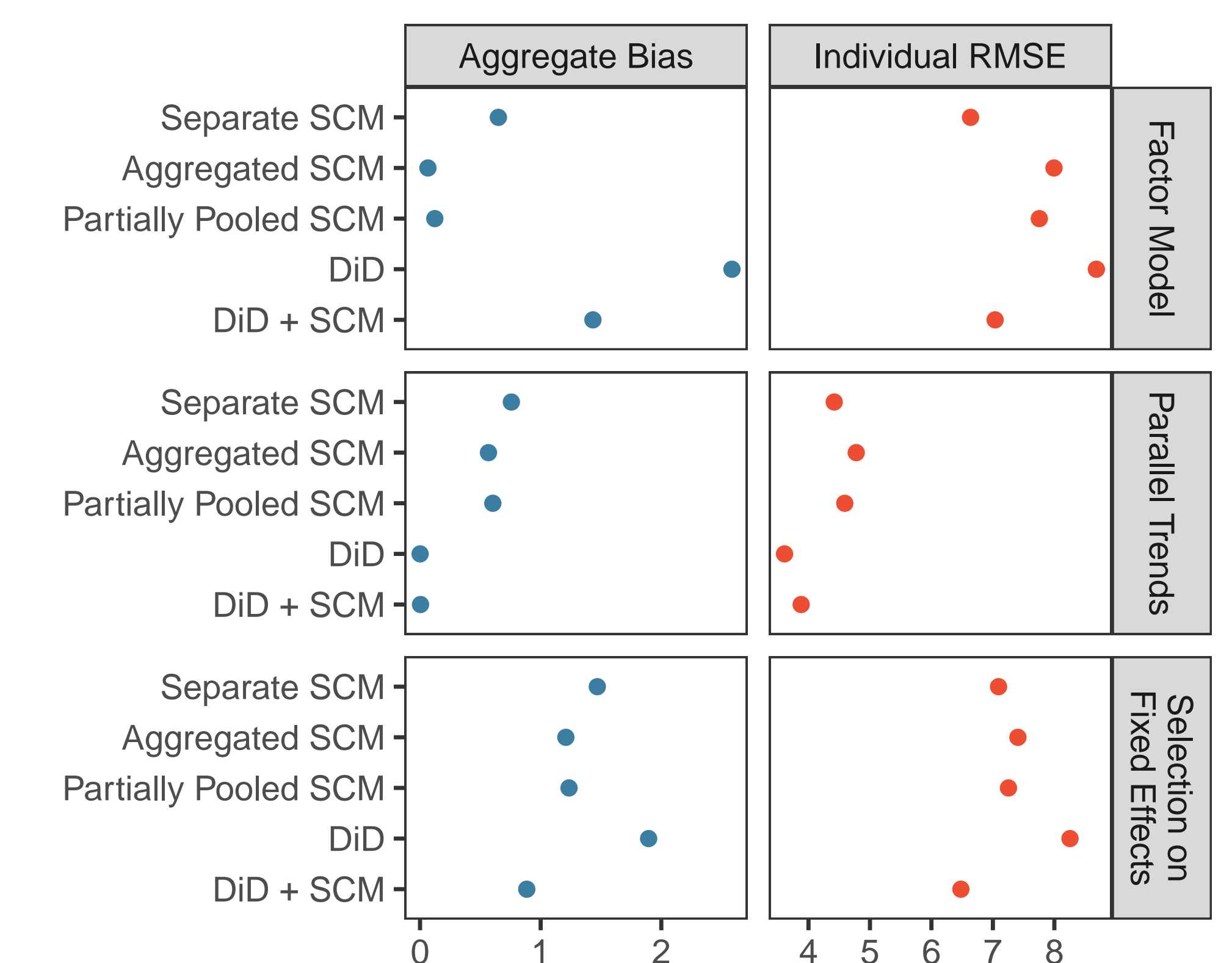
$$\log \frac{P(W_i = j \mid Y_{i(T_j-K)}, \dots, Y_{iT_j})}{P(W_i = 0 \mid Y_{i(T_j-K)}, \dots, Y_{iT_j})} = \alpha_j + \sum_{\ell=1}^K \beta_{\ell j} Y_{i(T_j-\ell)}$$

- Hierarchical propensity score model
- Shrinkage to a global model w/params μ_β

$$\beta_{j\ell} \sim N(\mu_{\beta\ell}, \sigma_\beta^2)$$

$$\mu_{\beta\ell} \sim N(0, \sigma_\mu^2)$$

Data Calibrated Simulation Study



References

- [1] A. S. Paglayan, "Public-sector unions and the size of government," *American Journal of Political Science*, vol. 63, no. 1, pp. 21–36, 2019.
- [2] E. Ben-Michael, A. Feller, and J. Rothstein, "The Augmented Synthetic Control Method," 2018.
- [3] A. Abadie, "Semiparametric difference-in-differences estimators," *The Review of Economic Studies*, vol. 72, no. 1, pp. 1–19, 2005.
- [4] C. Hazlett and Y. Xu, "Trajectory balancing: A general reweighting approach to causal inference with time-series cross-sectional data," 2018.
- [5] A. Abadie, A. Diamond, and J. Hainmueller, "Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program," *Journal of the American Statistical Association*, vol. 105, no. 490, pp. 493–505, 2010.



Combining Weighting and DiD

Augment w/pre-period average: weighted DiD [2]

$$\frac{1}{T_j} \sum_{t=1}^{T_j} \left[\frac{1}{N_{1j}} \sum_{W_i=j} (Y_{it} - Y_{it'}) - \sum_{W_i=0} \hat{\gamma}_{ij} (Y_{it} - Y_{it'}) \right]$$

- Adjust for non-parallel trends
- Balance *residuals* after unit/time fixed effects
- Add fixed effects and weighted residuals
- Key assumption: conditional parallel trends [3, 4]

