Visualization, Identification, and Estimation in the Linear Panel Event-Study Design

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Heterogeneous Policy Effects

Heterogeneous effects of the policy

$$y_{it} = \alpha_i + \gamma_t + q'_{it}\psi + \sum_{m=-G}^{M} \beta_m z_{i,t-m} + C_{it} + \varepsilon_{it} \qquad \text{(homogeneous DGP)}$$

- So far maintained homogeneity:
  1. DGPs where the effect of the policy is homogeneous across units.
  2. Estimators that estimate a single path of policy effects for all units.
- Growing literature explores the implications of relaxing this homogeneity.
- Focus on staggered adoption.
- Define a unit's cohort $t^*(i)$ as the period in which unit i adopts the policy.

Policy effects vary by cohort t^*

Equation of interest becomes:

$$y_{it} = \alpha_i + \gamma_t + q_{it}'\psi + \sum_{m=-G}^{M} \beta_{m,t^*(i)} z_{i,t-m} + C_{it} + \varepsilon_{it}, \quad \text{(cohort-specific effects DGP)}$$

where $\{\beta_{m,t^*}\}_{m=-G}^{M}$ denotes the causal effects for cohort t^*.

- Previously discussed approaches to identification can be applied to recover $\{\beta_{m,t^*}\}_{m=-G}^{M}$.

Policy effects vary by unit *i*

- Estimates of β_{m,t^*} in cohort-specific effects DGP need not be valid estimates of a proper weighted average of the unit-specific policy effects $\beta_{m,i}$ for units in the corresponding cohort.
- In general, not possible to recover such an average at all.
- However, possible in special cases...

Policy effects vary by unit *i*

Assumption:
Random assignment, i.e., $t^*(i)$ assigned independently of all variables in the model including $\{\beta_{m,i}\}_{m=-G}^{M}$.

$$y_{it} = \alpha_i + \gamma_t + q_{it}'\psi + \sum_{m=-G}^{M} \beta_m z_{i,t-m} + \varepsilon_{it}, \quad \text{(homogeneous estimating equation)}$$

- The two-way fixed effects estimator $\{\hat{\beta}_m\}_{m=-G}^{M}$ applied to the homogeneous estimating equation is a valid estimate of a proper weighted average of the unit-specific policy effects $\{\beta_{m,i}\}_{m=-G}^{M}$.

Policy effects vary by unit *i*

Assumption:
Static policy effects ($\beta_{m,i} = 0$ for all $m \neq 0$), no confound ($C_{it} = 0$), and no control variables ($\psi = 0$).

$$y_{it} = \alpha_i + \gamma_t + \sum_{m=-G}^{M} \beta_m z_{i,t-m} + \varepsilon_{it}, \qquad \text{(homogeneous estimating equation)}$$

- Static two-way fixed effects estimator applied to the homogeneous estimating equation is a valid estimate of a proper weighted average of unit-specific policy effects (de Chaisemartin and D'Haultfoeuille 2021, Online Appendix Section 3.1).

Policy effects vary by unit *i*

Assumption:
No confound ($C_{it} = 0$), no control variables ($\psi = 0$), and some never-treated units.

$$y_{it} = \alpha_i + \gamma_t + \sum_{m=-G}^{M} \beta_{m,t^*(i)} z_{i,t-m} + \varepsilon_{it} \qquad \text{(cohort-specific estimating equation)}$$

- Two-way fixed effects estimator applied to the cohort-specific estimating equation is a valid estimate of a proper weighted average of the unit-specific policy effects β_i for units in the corresponding cohort (Sun and Abraham forthcoming).

Policy effects vary by unit *i*

- Common theme in previous assumptions: rule out most forms of confounding.
- Many economic settings will exhibit both confounding and heterogeneous policy effects.
- Developing approaches robust to both confounding and heterogeneous policy effects seems a useful direction for future work.

Simulations

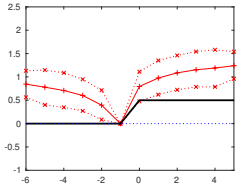
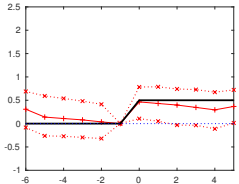
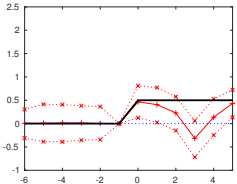
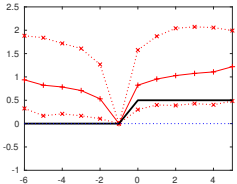
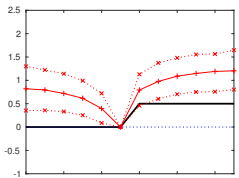
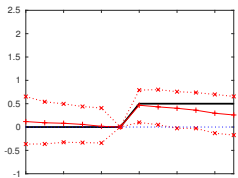
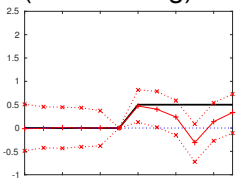
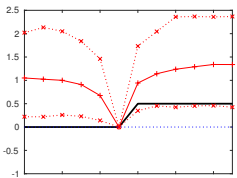
Explore treatment heterogeneity in three ways:

1. Explore the performance of estimators that are designed to be robust to treatment heterogeneity under homogeneous DGPs.

2. Explore the performance of estimators that are designed to be robust to confounding under heterogeneous DGPs.

3. Suggest an extension of the estimators that are designed to be robust to confounding that is also robust to treatment heterogeneity.

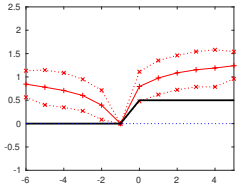
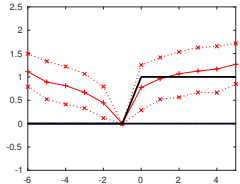
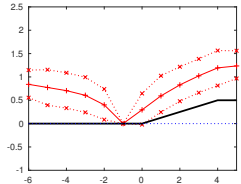
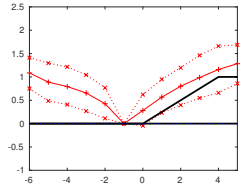
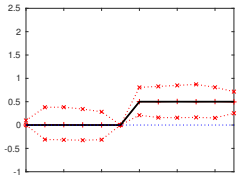
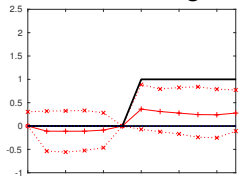
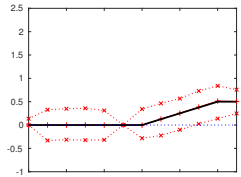
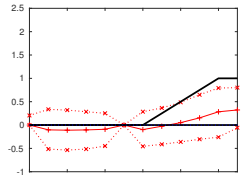
Heterogeneous estimators - homogeneous DGP

Mean-rev. trend	Monotone trend	No pre-trend	Multidimensional
Two-way fixed effects			
			
Sun and Abraham (forthcoming)			
			

Adding heterogeneity

- Policy effect differs by unit
- Each unit is assigned to one of two treatment profiles
- Earlier-adopting cohorts more likely to be assigned to the larger policy effect

Homogeneous estimators - heterogeneous DGP

Static, homog.	Static, heterog.	Dynam., homog.	Dynam., heterog.
Two-way fixed effects			
			
Instrumenting for x_{it} with leads of z_{it}			
			

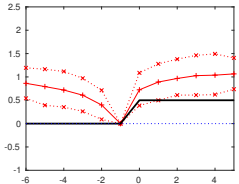
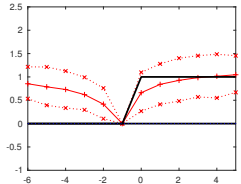
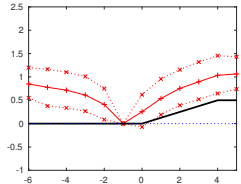
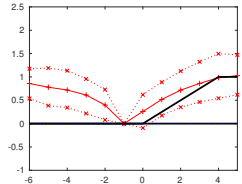
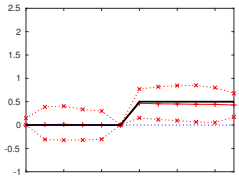
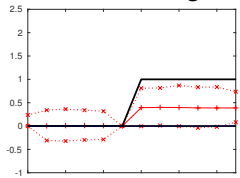
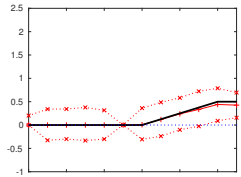
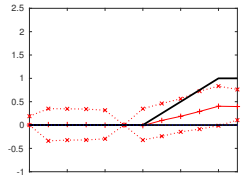
Suggested extensions

$$y_{it} = \alpha_i + \gamma_t + q'_{it}\psi + \sum_{m=-G}^{M} \beta_{m,t^*(i)} z_{i,t-m} + C_{it} + \varepsilon_{it}$$

(cohort-specific estimating equation)

- Estimate cohort-specific estimating equation by interacting the policy variables with indicators for cohort
- Can then proceed with estimators discussed in videos on Identification

Interacted estimator - heterogeneous DGP

Static, homog.	Static, heterog.	Dynam., homog.	Dynam., heterog.
Two-way fixed effects			
			
Instrumenting for x_{it} with leads of z_{it}			
			

Conclusion

- Addressing the possibility of confounding and addressing the possibility of heterogeneous policy effects are not substitutes for one another
- In settings with severe confounding, estimators robust to heterogeneous effects under no-confounding assumptions can perform poorly, and vice versa

Paper and Stata package

- The material in this video series was based on our paper:

  Visualization, Identification and Estimation in the Linear Panel Event-Study Design

- A companion Stata package `xtevent` implements most of the estimators that we discussed
- To install, type `ssc install xtevent` in Stata's command window