



第七届 Stata 中国用户大会

DID 安慰剂检验及 Stata 应用

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- DID 所依赖的关键假设：平行趋势假定(Parallel Trends Assumption)
- 可能存在混杂事件(confounding events) 导致内生性与估计偏差

DID 实践中，通过安慰剂检验 (placebo tests) 考察是否存在混杂事件：

- 通过生成伪处理变量进行安慰剂检验
- 安慰剂检验的类型：
 - 时间安慰剂检验
 - 空间安慰剂检验
 - 混合安慰剂检验
 - 外部安慰剂检验

标准 DID 模型:

- 政策冲击同步发生, 且不存在政策退出
- 包含两组 (处理组与控制组) 与两时段 (处理前 $1 \dots T_0$ 与处理后 $T_0 + 1 \dots T$) 的数据

对于标准 DID, 双向固定效应 (TWFE) 的 OLS 估计量为一致估计:

$$y_{it} = \mathbf{x}_{it}'\boldsymbol{\beta} + \delta D_{it} + u_i + \lambda_t + \varepsilon_{it} \quad (i = 1, \dots, N, t = 1, \dots, T) \quad (1)$$

- δ 为处理效应 (treatment effect), D_{it} 为处理变量

$$D_{it} = \begin{cases} 1 & \text{若 } i \in \text{处理组, 且 } t \in \text{处理后} \\ 0 & \text{其他} \end{cases} \quad (2)$$

- 处理变量可写作交互项, 即 $D_{it} = treat_i \times post_t$

时间安慰剂检验：选择处理前某期（第 s 期）作为伪处理时间
定义**伪处理变量**(fake treatment variable):

$$D_{it}^* = \begin{cases} 1 & \text{若 } i \in \text{处理组, 且 } t \geq s \\ 0 & \text{其他} \end{cases} \quad (3)$$

- $2 \leq s \leq T_0$, 伪处理变量 D_{it}^* 称为**安慰剂变量**(placebo variable)

将安慰剂变量代入方程(1):

$$y_{it} = \mathbf{x}_{it}'\boldsymbol{\beta} + \delta^* D_{it}^* + u_i + \lambda_t + \varepsilon_{it}^* \quad (i = 1, \dots, N, t = 1, \dots, T_0) \quad (4)$$

- D_{it}^* 的系数 δ^* 为安慰剂效应
- 限制仅使用处理前样本：**完全剔除处理效应的影响**

2 标准 DID 的时间安慰剂检验

假定 $N = 4, T = 8, T_0 = 5$, 伪处理时间为真实处理时间的前置 2 期:

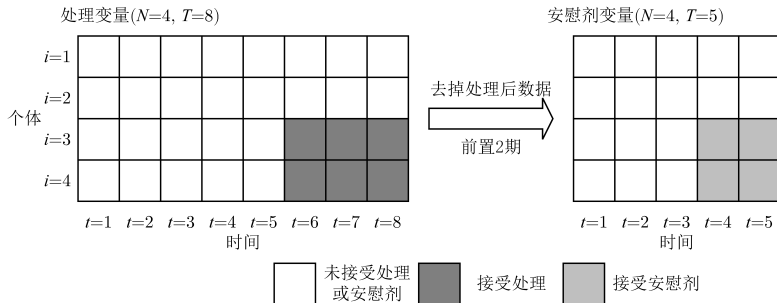


图 1 标准 DID 的时间安慰剂检验

$$H_0 : \delta^* = 0 \quad (\text{安慰剂效应为 } 0)$$

若拒绝原假设，即存在显著的安慰剂效应：

- 怀疑处理效应可能由混杂事件驱动
- 违背平行趋势假定
- 原因：个体预期政策到来而提前改变行为，即预期效应(anticipation effects)

实施时间安慰剂检验时应注意：

- 原假设为“安慰剂效应为 0”
- 去掉处理后的样本数据
- 尽量使用除第 1 期外的所有处理前各期，分别进行时间安慰剂检验

空间安慰剂检验：选择部分单元作为**伪处理个体**(fake treatment units)

- 根据指定伪处理个体的不同方法，分为“非随机”与“随机”方式
记处理组个体数目 N_1 ，控制组个体数目 $N_0 = N - N_1$ ，安慰剂变量 D_{it}^*
- 随机空间安慰剂检验：

- 从全样本中无放回地随机抽取 N_1 个个体作为伪处理个体 (当 $t \geq T_0 + 1$ 时 $D_{it}^* = 1$)
- 未抽中的 N_0 个个体作为伪控制个体 ($D_{it}^* = 0$)

该随机抽样过程也称为**随机置换**(random permutation)

随机空间安慰剂检验可视为**置换检验**(permutation test)

3 标准 DID 的空间安慰剂检验

假定 $N = 4, T = 8, T_0 = 5$, 由处理变量随机置换生成安慰剂变量:

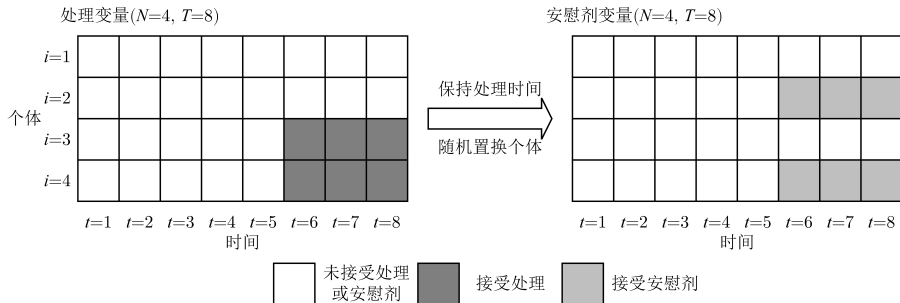


图 2 标准 DID 的空间安慰剂检验

重复随机抽样 M 次获得安慰剂效应的分布 $\{\hat{\delta}_{(1)}^*, \dots, \hat{\delta}_{(M)}^*\}$

$$H_0 : \delta = 0 \quad (\text{处理效应为 } 0)$$

替代假设与 p 值计算:

- $H_1 : \delta \neq 0$, 双边 p 值 $= \frac{1}{M} \sum_{m=1}^M \mathbf{1} \left(\left| \hat{\delta}_{(m)}^* \right| \geq |\hat{\delta}| \right)$
- $H_1 : \delta > 0$, 右边 p 值 $= \frac{1}{M} \sum_{m=1}^M \mathbf{1} \left(\hat{\delta}_{(m)}^* \geq \hat{\delta} \right)$
- $H_1 : \delta < 0$, 左边 p 值 $= \frac{1}{M} \sum_{m=1}^M \mathbf{1} \left(\hat{\delta}_{(m)}^* \leq \hat{\delta} \right)$

检验的有效性依赖于**对称性假定**(Canay et al., 2017) 是否成立

若对称性假定成立, 置换检验有**正确的尺度**(correct size)

实施空间安慰剂检验时应注意：

- 原假设为“处理效应为 0”
- 相对于安慰剂效应的分布，可计算处理效应的双边、左边或右边 p 值，得到相应的检验结论

混合安慰剂检验：同时使用伪处理时间与伪处理个体

- 从全样本中无放回地随机抽取 N_1 位个体作为伪处理组，其余 N_0 位个体构成伪控制组
- 对伪处理组中的个体随机选取统一的伪处理时间

重复随机抽样 M 次获得安慰剂效应的分布 $\{\hat{\delta}_{(1)}^*, \dots, \hat{\delta}_{(M)}^*\}$

$$H_0 : \delta = 0 \quad (\text{处理效应为 } 0)$$

替代假设与 p 值计算方法与空间安慰剂检验相同

4 标准 DID 的混合安慰剂检验

假定 $N = 4, T = 8, T_0 = 5$, 从区间 $[2, 8]$ 上的均匀分布随机抽取第 4 期
作为统一的伪处理时间:

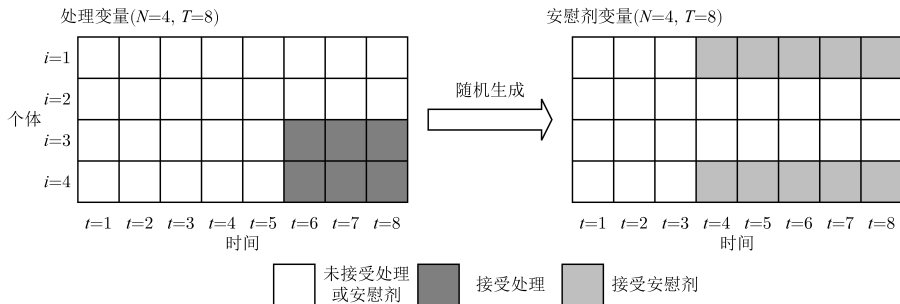


图 3 标准 DID 的混合安慰剂检验

实施混合安慰剂检验时应注意：

- 明确混合安慰剂检验的原假设为“处理效应为 0”
- 为保持标准 DID 设计，针对每个安慰剂样本，应使用统一的伪处理时间（否则，安慰剂样本可能变为交叠 DID 设计）
- 相对于安慰剂效应的分布，可计算双边、左边或右边 p 值，得到相应的检验结论

交叠 DID 模型：

- 允许个体的处理时间不尽相同

对于交叠 DID，双向固定效应 (TWFE) 的 OLS 估计量为一致估计：

$$y_{it} = \mathbf{x}_{it}'\boldsymbol{\beta} + \delta D_{it} + u_i + \lambda_t + \varepsilon_{it} \quad (i = 1, \dots, N, t = 1, \dots, T) \quad (5)$$

- δ 为处理效应 (treatment effect), D_{it} 为处理变量 (treatment variable)
- 处理变量不可写作交互项

5.1 交叠 DID 的时间安慰剂检验

- 去掉处理后的观测值
- 将处理时间前置若干期，设为伪处理时间
- 进行 DID 估计，考察安慰剂效应的显著性

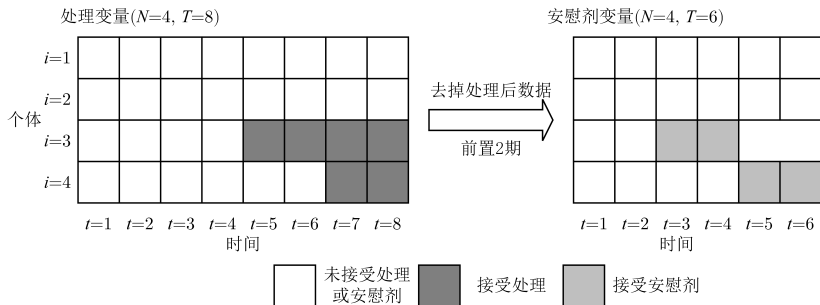


图 4 交叠 DID 的时间安慰剂检验

假设样本中共有 G 个组群, 记组群 $g(g = 1, \dots, G)$ 开始接受处理的时间为 t_g , 始终未受处理 (never treated) 记为 $t_g = \infty$

组群 g 中的个体数为 N_g , 满足 $N_1 + N_2 + \dots + N_G = N$

- 从全样本 N 位个体中随机抽取 N_1 个个体, 伪处理时间设为 t_1
- 从剩余的 $(N - N_1)$ 位个体中随机抽取 N_2 个个体, 伪处理时间设为 t_2
-

进行 DID 估计, 重复 M 次, 得到安慰剂效应的分布, 计算相应的 p 值得到检验结果 (与标准 DID 的空间安慰剂检验相同)

5.2 交叠 DID 的空间安慰剂检验

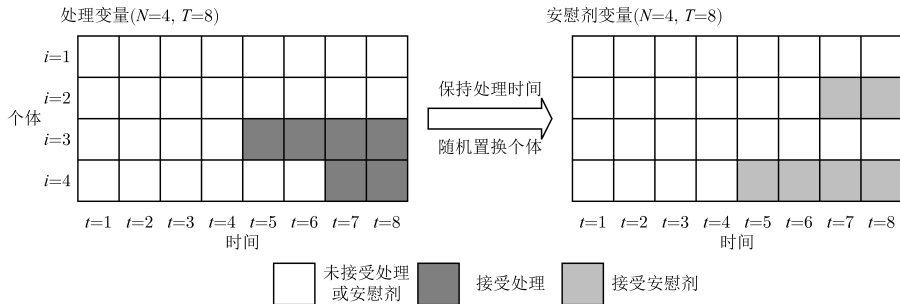


图 5 交叠 DID 的空间安慰剂检验

交叠 DID 的混合安慰剂检验有两种不同的做法：

无约束(unrestricted) 的交叠 DID 混合安慰剂检验：

- 对于样本中的每位个体，在指定范围内随机抽取一个伪处理时间
- 不保持组群结构

有约束(restricted) 的交叠 DID 混合安慰剂检验：

- 随机生成伪处理时间 $\tilde{t}_1, \dots, W\tilde{t}_G$
- 对于 $g = 1, \dots, G$ ，不断从剩余样本中随机抽取 N_g 个个体，伪处理时间设为 \tilde{t}_g
- 保持组群结构

5.3 交叠 DID 的混合安慰剂检验

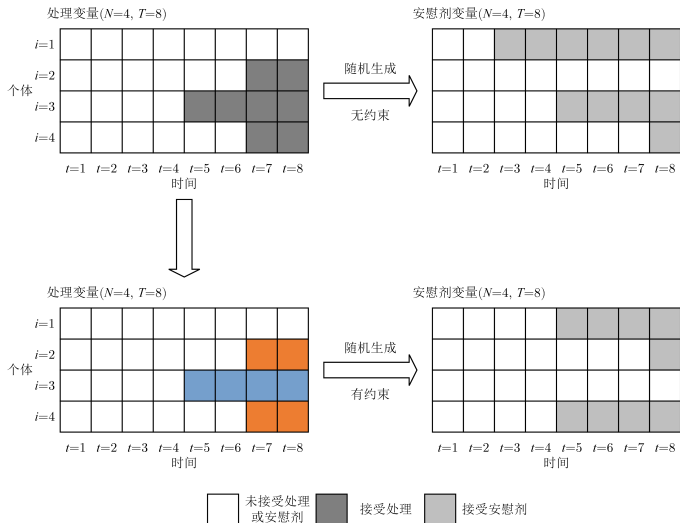


图 6 交叠 DID 的混合安慰剂检验

从 SSC 安装 didplacebo 命令 (Stata 16 及以上):

```
. ssc install didplacebo, all replace
```

运行后, 将同时安装以下命令:

- didplacebo: 运行 DID 模型的安慰剂检验
- tofirstttreat: 将处理变量由虚拟变量 (0,1) 转换为首次处理时期的变量
- xtrantreat: 随机化面板数据集中的处理变量
- xtshuffle: 沿个体维度按块对面板数据集中的变量随机排序

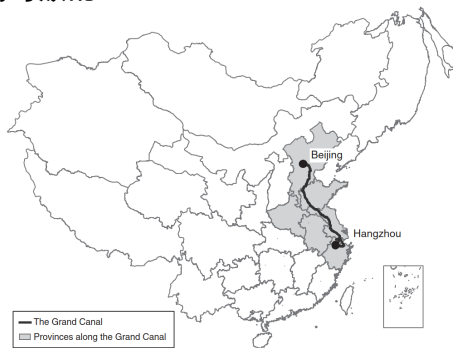
```
didplacebo estimatename , treatvar(treatvarname) [ pbotime(#)  
pbounit pbomix([1|2|3]) repeat(int) seed(int) ranunitnum(int)  
rantimescope(tmin tmax) frame(framename) nofigure  
savegraph(prefix, [asis replace]) ]
```

- 使用 `didplacebo` 前，必须运行 `xtset panelvar timevar` 命令声明面板数据；详见 [XT] **xtset**
- *estimatename* 应是由 `estimates store` 命令存储的估计对象；详见 [R] **estimates store**

7 标准 DID 案例：中国大运河废弃对社会稳定的影响

1825 年大运河在与黄河交界处决堤，迫使清政府于 1826 年首次进行“漕粮海运”的尝试

因海运的成本优势，大运河逐渐废弃，运河周边城市失去原有贸易通道，导致社会动荡与叛乱



注：图片来源于 Cao and Chen (2022)

7 标准 DID 案例：中国大运河废弃对社会稳定的影响

Cao and Chen(2022) 以清朝 1650-1911 年 575 个县的面板数据，使用标准 DID 研究漕粮海运政策对地方叛乱的影响

运河流经的县构成处理组 (73 县)，未流经的县构成控制组 (502 县)
基准回归方程：

$$y_{it} = \delta(\text{canal}_i \times \text{post}_t) + u_i + \lambda_t + \varepsilon_{it} \quad (6)$$

- y_{it} 为县城 i 在第 t 年的每百万人叛乱数量
- canal_i 表示县城 i 是否为运河县
- post_t 表示第 t 年是否在政策冲击 (1826 年及以后取值为 1)
- $\text{canal}_i \times \text{post}_t$ 为处理变量

估计结果：漕粮海运导致运河县的叛乱显著增加，双向固定效应估计值为 $\hat{\delta} = 0.038$ ，且在 5% 水平上显著

```
. use cao_chen.dta, clear
```

```
. xtset county year
```

Panel variable: county (strongly balanced)

Time variable: year, 1650 to 1911

Delta: 1 unit

```
. reghdfe rebel canal_post, absorb(i.county i.year) cluster(county)
```

(MWFE estimator converged in 2 iterations)

(output omitted)

rebel	Robust		t	P> t	[95% conf. interval]	
	Coefficient	std. err.				
canal_post	.0380143	.016621	2.29	0.023	.0053639	.0706647
_cons	.0313251	.0007227	43.35	0.000	.0299054	.0327447

(output omitted)

```
. estimates store did_cao_chen
```

时间安慰剂检验：

```
. didplacebo did_cao_chen, treatvar(canal_post) pbotime(1(1)10)
```

- `did_cao_chen` 为存储的 TWFE 回归结果
- `treatvar(canal_post)` 指定处理变量为 `canal_post`
- `pbotime(1(1)10)` 表示将处理时间分别前置 1 至 10 期进行时间安慰剂检验

```
. didplacebo did_cao_chen, treatvar(canal_post) phtime(1(1)10)
```

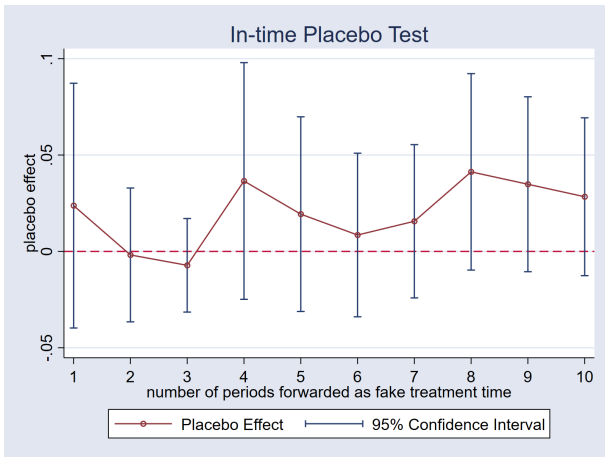
Implementing in-time placebo test using fake treatment time forwarded by 1, 2, 3
> , 4, 5, 6, 7, 8, 9, 10 periods respectively.

Results of in-time placebo test using fake treatment times:

	Coefficient	Std. err.	z	P> z	[95% conf. interval]	
canal_post						
F1.	.0237488	.0323933	0.73	0.463	-.039741	.0872386
F2.	-.0018263	.0177129	-0.10	0.918	-.0365429	.0328903
F3.	-.0072098	.0123804	-0.58	0.560	-.0314749	.0170552
F4.	.0365355	.0313244	1.17	0.243	-.0248592	.0979302
F5.	.0193318	.0257651	0.75	0.453	-.0311668	.0698304
F6.	.0085124	.0216505	0.39	0.694	-.0339218	.0509467
F7.	.0156334	.0202899	0.77	0.441	-.0241341	.055401
F8.	.0412773	.0259976	1.59	0.112	-.0096771	.0922318
F9.	.0348408	.0231507	1.50	0.132	-.0105337	.0802153
F10.	.0283695	.020891	1.36	0.174	-.0125762	.0693151

Note: The standard errors are computed using the same method as specified by the Stata command previously used for DID estimation. For example, if "xtreg, r" or "reghdfe, cluster(clustvar)" is used, then cluster-robust standard errors are reported.

Finished.



- 安慰剂效应的 p 值均大于 0.1，95% 区间均包括 0，故不拒绝“安慰剂效应为 0”的原假设

空间安慰剂检验：

```
. didplacebo did_cao_chen, treatvar(canal_post) pbounit rep(500) seed(1)
```

- pbounit 表示进行空间安慰剂检验
- rep(500) 表示重复 500 次 (默认选项，可省略)
- seed(1) 指定随机种子为 1(默认选项，可省略；使用相同随机种子可保证结果可复现)

```
. didplacebo did_cao_chen, treatvar(canal_post) pbounit rep(500) seed(1)
```

Implementing in-space placebo test using fake treatment units:

```
Simulations (500):.....10.....20.....30.....40.....50.....
```

(output omitted)

```
> 0.....460.....470.....480.....490.....500
```

Results of in-space placebo test results using fake treatment units:

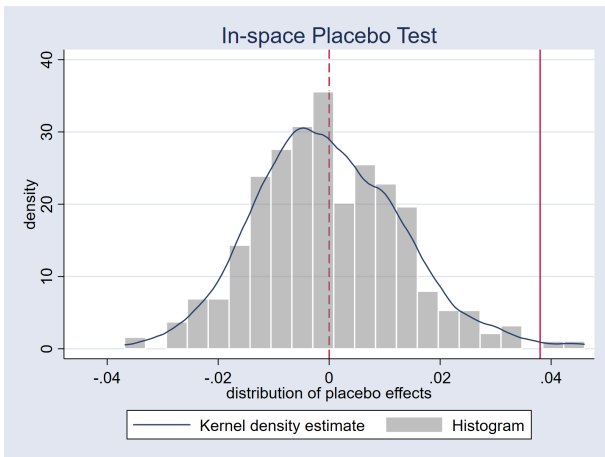
	Coefficient	P-value		
		Two-sided	Left-sided	right-sided
canal_post	0.038014	0.0080	0.9920	0.0080

Note: (1) The two-sided p-value is the frequency that the absolute values of the placebo effects are greater than or equal to the absolute value of estimated treatment effect.

(2) The left-sided (right-sided) p-value is the frequency that the placebo effects are smaller (greater) than or equal to the estimated treatment effect.

Finished.

- 双边及右边 p 值均为 0.008，故在 1% 水平上强烈拒绝“处理效应为 0”的原假设



- 处理效应估计值 (0.038) 位于安慰剂效应分布的右侧尾部

混合安慰剂检验：

```
. didplacebo did_cao_chen, treatvar(canal_post) pbomix(1)
```

- `pbomix(1)` 表示进行适合于标准 DID 的混合安慰剂检验

```
. didplacebo did_cao_chen, treatvar(canal_post) pbomix(1)
```

Implementing mixed placebo test for standard DID (version 1) using both fake treatment units and times:

The number of units randomly selected as fake treatment units	The range within which fake treatment times are randomly selected
73	[1650, 1911]

```
Simulations (500):.....10.....20.....30.....40.....50.....  
(output omitted)
```

```
> 0.....460.....470.....480.....490.....500
```

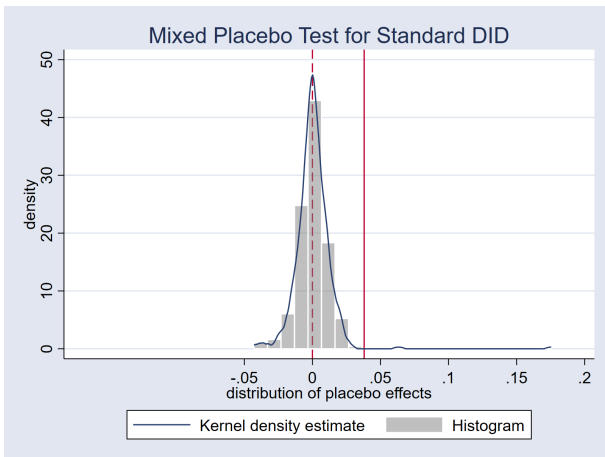
Results of mixed placebo test for standard DID (version 1) using both fake treatment units and times:

	Coefficient	P-value		
		Two-sided	Left-sided	right-sided
canal_post	0.038014	0.0100	0.9960	0.0040

(output omitted)

Finished.

- 双边 p 值为 0.01，右边 p 值为 0.004，均在 1% 水平上显著，故可强烈拒绝“处理效应为 0”的原假设



- 处理效应估计值 (图中垂直实线) 位于安慰剂效应分布的右侧尾部

8 交叠 DID 案例：美国银行放松管制对收入分配的影响

20 世纪 70 年代至 90 年代，美国大多数州逐渐取消了在州内开设银行分支机构的限制，银行竞争加剧，提升了银行业绩

Beck et al. (2010) 使用 1976-2006 年美国 48 个州和哥伦比亚特区的面板数据，进行交叠 DID 估计

$$y_{it} = \mathbf{x}'_{it}\beta + \delta_intra_{it} + u_i + \lambda_t + \varepsilon_{it} \quad (7)$$

- y_{it} 为基尼系数的对数; $_intra_{it}$ 为处理变量, 表示第 i 州在第 t 年是否放松银行管制
- \mathbf{x}_{it} 包含 5 个控制变量, 即人均州内实际生产总值、黑人比例、高中辍学率、女性户主家庭比例、失业率

结果显示: 双向固定效应估计值为 $\hat{\delta} = -0.018$, 且在 1% 水平上显著, 放松银行管制显著改善了收入不平等

```
. use bbb.dta, clear
(Data for 'Big Bad Banks?' paper.)
```

```
. xtset statefip wrkyr
```

Panel variable: statefip (strongly balanced)

Time variable: wrkyr, 1976 to 2006

Delta: 1 unit

```
. global cov gsp_pc_growth prop_blacks prop_dropouts prop_female_headed unemploy
> mentrate
```

```
. xtreg log_gini _intra $cov i.wrkyr, fe r
(output omitted)
```

log_gini	Robust			t	P> t	[95% conf. interval]
	Coefficient	std. err.				
_intra	-.0177239	.0064033	-2.77	0.008	-.0305986	-.0048493
gsp_pc_growth	-.0288419	.0412498	-0.70	0.488	-.1117802	.0540965
prop_blacks	-.2128497	.1584963	-1.34	0.186	-.5315277	.1058284
prop_dropouts	.1641627	.0713148	2.30	0.026	.0207748	.3075507
prop_female_d	.0190403	.056497	0.34	0.738	-.0945545	.1326352
unemploymen_e	.0063327	.0012649	5.01	0.000	.0037895	.0088759
(output omitted)						

```
. estimates store did_bbb
```

时间安慰剂检验：

```
. didplacebo did_bbb, treatvar(_intra) pbotime(1(1)10)
```

- did_bbb 为存储的 TWFE 回归结果
- treatvar(_intra) 指定处理变量为 _intra
- pbotime(1(1)10) 表示将处理时间分别前置 1 至 10 期进行时间安慰剂检验

```
. didplacebo did_bbb, treatvar(_intra) pbotime(1(1)10)
```

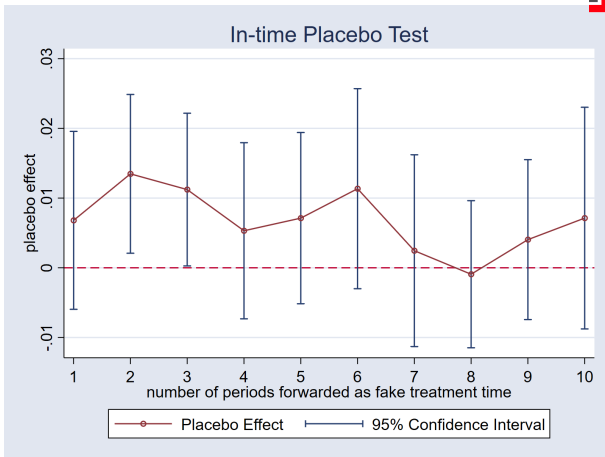
Implementing in-time placebo test using fake treatment time forwarded by 1, 2, 3
> , 4, 5, 6, 7, 8, 9, 10 periods respectively.

Results of in-time placebo test using fake treatment times:

	Coefficient	Std. err.	z	P> z	[95% conf. interval]	
_intra						
F1.	.0068046	.0065114	1.05	0.296	-.0059575	.0195667
F2.	.0134762	.0058096	2.32	0.020	.0020895	.0248629
F3.	.0112213	.0055885	2.01	0.045	.0002681	.0221744
F4.	.0053115	.0064456	0.82	0.410	-.0073216	.0179446
F5.	.0071231	.006268	1.14	0.256	-.0051619	.0194082
F6.	.0113446	.0073201	1.55	0.121	-.0030025	.0256917
F7.	.002451	.00702	0.35	0.727	-.0113078	.0162099
F8.	-.0009252	.0053834	-0.17	0.864	-.0114765	.0096262
F9.	.0040415	.0058517	0.69	0.490	-.0074277	.0155106
F10.	.0071297	.0081124	0.88	0.379	-.0087703	.0230296

Note: The standard errors are computed using the same method as specified by the Stata command previously used for DID estimation. For example, if "xtreg, r" or "reghdfe, cluster(clustvar)" is used, then cluster-robust standard errors are reported.

Finished.



- 将银行放松管制时间前置 2 或 3 年，安慰剂效应均在 5% 水平上显著为正，说明银行放松管制可能存在前置 2 至 3 年的预期效应

空间安慰剂检验：

```
. didplacebo did_bbb, treatvar(_intra) pbounit rep(500) seed(1)
```

- `pbounit` 表示进行空间安慰剂检验
- `rep(500)` 表示重复 500 次 (默认选项, 可省略)
- `seed(1)` 指定随机种子为 1 (默认选项, 可省略; 使用相同随机种子可保证结果可复现)

```
. didplacebo did_bbb, treatvar(_intra) pbounit rep(500) seed(1)
```

Implementing in-space placebo test using fake treatment units:

```
Simulations (500):.....10.....20.....30.....40.....50.....
```

(output omitted)

```
> 0.....460.....470.....480.....490.....500
```

Results of in-space placebo test results using fake treatment units:

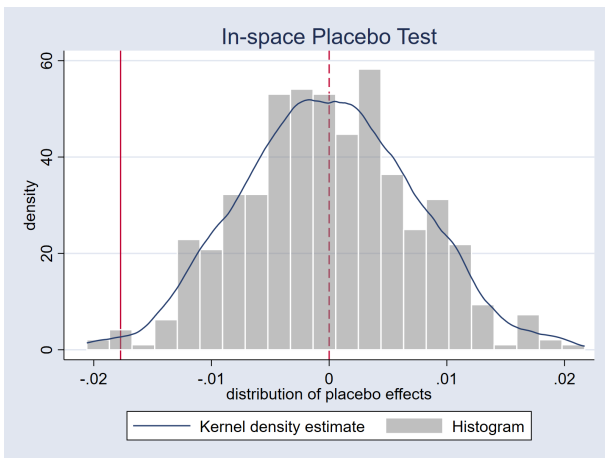
	Coefficient	P-value		
		Two-sided	Left-sided	right-sided
_intra	-0.017724	0.0120	0.0060	0.9940

Note: (1) The two-sided p-value is the frequency that the absolute values of the placebo effects are greater than or equal to the absolute value of estimated treatment effect.

(2) The left-sided (right-sided) p-value is the frequency that the placebo effects are smaller (greater) than or equal to the estimated treatment effect.

Finished.

- 双边 p 值为 0.012 (在 5% 水平上显著), 左边 p 值为 0.006 (在 1% 水平上显著), 故可拒绝 “处理效应为 0” 的原假设



- 处理效应估计值 (图中垂直实线) 位于安慰剂效应分布的左侧尾部

8.2 交叠 DID 案例的空间安慰剂检验 (xtshuffle)

```
. xtshuffle _intra
```



```
. quietly xtreg log_gini _intra $cov i.wrkyr, fe r

. local tr_eff = _b[_intra]

. capture program drop InSpacePlaceboTest

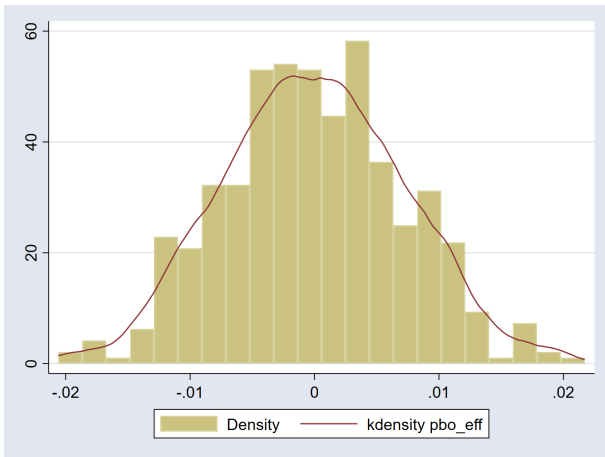
. prog def InSpacePlaceboTest, rclass
    1.      preserve
    2.      xtshuffle _intra
    3.      xtreg log_gini _intra $cov i.wrkyr, fe r
    4.      return scalar pbo_eff = _b[_intra]
    5. end

. simulate pbo_eff = r(pbo_eff), seed(1) reps(500): InSpacePlaceboTest

    Command: InSpacePlaceboTest
    pbo_eff: r(pbo_eff)

Simulations (500): .....10.....20.....30.....40.....50.....
> ...60.....70.....80.....90.....100.....110.....120....
> ....130.....140.....150.....160.....170.....180.....1
> 90.....200.....210.....220.....230.....240.....250....
> ....260.....270.....280.....290.....300.....310.....3
> 20.....330.....340.....350.....360.....370.....380....
> ....390.....400.....410.....420.....430.....440.....4
> 50.....460.....470.....480.....490.....500 done

. graph twoway (histogram pbo_eff) (kdensity pbo_eff)
```



无约束 (unrestricted) 的混合安慰剂检验：

```
. didplacebo did_bbb, treatvar(_intra) pbomix(2)
```

有约束 (restricted) 的混合安慰剂检验：

```
. didplacebo did_bbb, treatvar(_intra) pbomix(3)
```

- pbomix(2) 表示以无约束的方式 (version 2) 进行混合安慰剂检验
- pbomix(3) 表示以有约束的方式 (version 3) 进行混合安慰剂检验

```
. didplacebo did_bbb, treatvar(_intra) pbomix(2)
```

Implementing unrestricted mixed placebo test for staggered DID (version 2) using

```
> both fake treatment units and times:
```

The number of units randomly selected as fake treatment units	The range within which fake treatment times are randomly selected
49	[1976, 2006]

```
Simulations (500):.....10.....20.....30.....40.....50.....  
(output omitted)
```

```
> 0.....460.....470.....480.....490.....500
```

Results of unrestricted mixed placebo test for staggered DID (version 2) using b

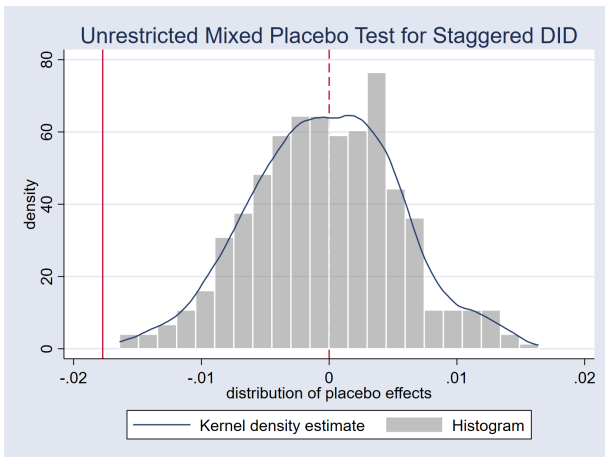
```
> oth fake treatment units and times:
```

	Coefficient	P-value		
		Two-sided	Left-sided	right-sided
_intra	-0.017724	0.0000	0.0000	1.0000

(output omitted)

Finished.

- 双边 p 值和左边 p 值均为 0.000，故可强烈拒绝“处理效应为 0”的原假设



- 处理效应估计值 (图中垂直实线) 位于安慰剂效应分布的左侧尾部

```
. didplacebo did_bbb, treatvar(_intra) pbomix(3)
```

```
Implementing restricted mixed placebo test for staggered DID (version 3) using b  
> oth fake treatment units and times:
```

The range within which fake
treatment times are randomly selected

[1976, 2006]

```
Simulations (500):.....10.....20.....30.....40.....50.....  
(output omitted)
```

```
> 0.....460.....470.....480.....490.....500
```

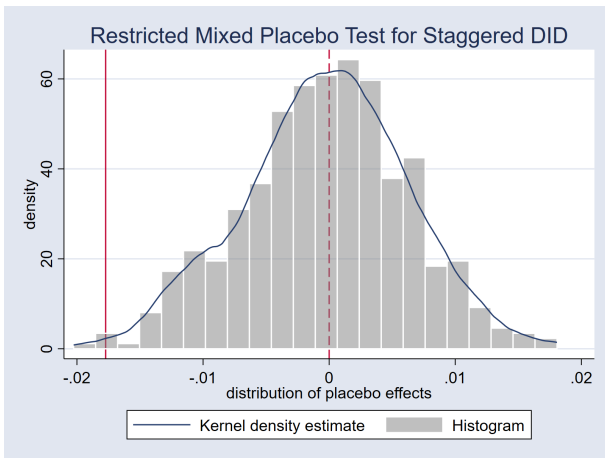
```
Results of restricted mixed placebo test for staggered DID (version 3) using bot  
> h fake treatment units and times:
```

	Coefficient	P-value		
		Two-sided	Left-sided	right-sided
_intra	-0.017724	0.0080	0.0040	0.9960

(output omitted)

Finished.

- 双边 p 值和左边 p 值分别为 0.008 和 0.004，均在 1% 水平上显著，故可强烈拒绝“处理效应为 0”的原假设

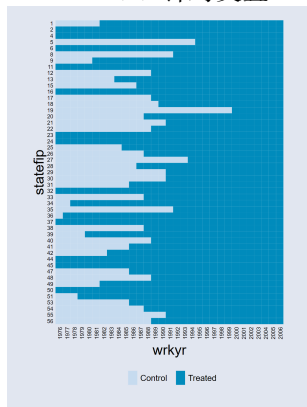


- 处理效应估计值 (图中垂直实线) 位于安慰剂效应分布的左侧尾部

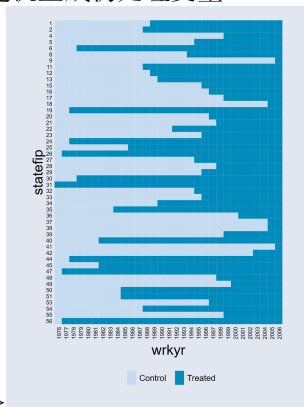
8.3 交叠 DID 案例的空间安慰剂检验 (xtrantreat)

```
. xtrantreat _intra, method(2)
```

- method(1) 针对标准 DID 随机生成伪处理变量
- method(2) 针对交叠 DID 以无约束的方式随机生成伪处理变量
- method(3) 针对交叠 DID 有无约束的方式随机生成伪处理变量



xtrantreat, method(2)



```
. quietly xtreg log_gini _intra $cov i.wrkyr, fe r

. local tr_eff = _b[_intra]

. capture program drop MixPlaceboTest

. program define MixPlaceboTest, rclass
    1.     preserve
    2.     xtrantreat _intra, method(2)
    3.     xtreg log_gini _intra $cov i.wrkyr, fe r
    4.     return scalar pbo_eff = _b[_intra]
    5. end

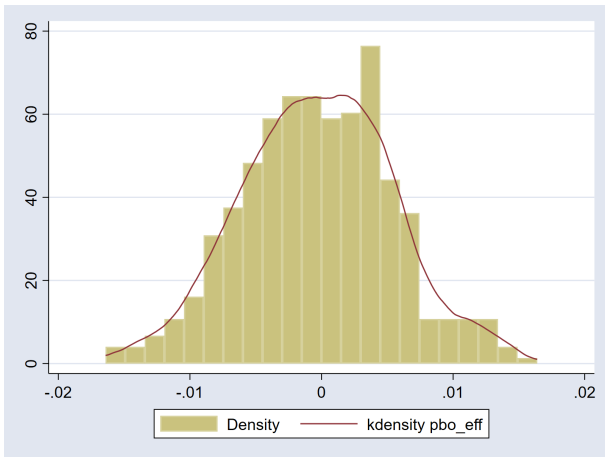
. simulate pbo_eff = r(pbo_eff), seed(1) reps(500): MixPlaceboTest
```

Command: MixPlaceboTest

pbo_eff: r(pbo_eff)

```
Simulations (500): .....10.....20.....30.....40.....50.....
> ...60.....70.....80.....90.....100.....110.....120.....
> ....130.....140.....150.....160.....170.....180.....1
> 90.....200.....210.....220.....230.....240.....250.....
> ....260.....270.....280.....290.....300.....310.....3
> 20.....330.....340.....350.....360.....370.....380.....
> ....390.....400.....410.....420.....430.....440.....4
> 50.....460.....470.....480.....490.....500 done
```

```
. graph twoway (histogram pbo_eff) (kdensity pbo_eff)
```



感谢聆听!