Area-of-Effect placebo tests

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Econometricians Without Borders: The case of spatially delineated policies (with uncertain borders)

We are used to evaluate policies' effectiveness on the administrative level

▶ Effectiveness of a state-level health care intervention?

▶ Run a state-level DiD!

▶ Treated areas are clearly delineated and (perfectly) observable

How about the effectiveness of patrolling activities, e.g. naval operations in the Mediterranean?

▶ Due to secrecy, operational areas are not perfectly observable

▶ Leaked (graphical) information may introduce a substantial degree of area misspecification

▶ This uncertainty regarding the Area-of-Effect (AoE) impacts on estimates

AoE uncertainty

Source: www.wordpress.com, 21/03/2016

Even if an AoE is spatially clearly delineated, the available information
might introduce considerable AoE uncertainty
► due to (purposefully) imprecisely depicted AoE,
► distortions in graphical source material,
► unclear map projections, ...

Background

Starting point: Investigation of the effectiveness of a spatially delineated policy in regards to the occurrence of geo-referenced incidents

Pitfalls: Policy implementation might coincide with seasonal and geographical incident variation

**Econometric setup**: To control for time-variant confounding factors
▶ superimpose an artificial grid and derive cell-time aggregates
▶ identify treated cells (in AoE)
▶ run a cell-time FE model

AoE uncertainty:
▶ Assuming (optimistically) we compiled all available information we cannot do much about AoE uncertainty itself
▶ However, we can investigate how sensitive AoE estimates are w.r.t. AoE uncertainty in three dimensions (position, orientation, scale)

Setting the (geographic) scene

Month with active AoE policy
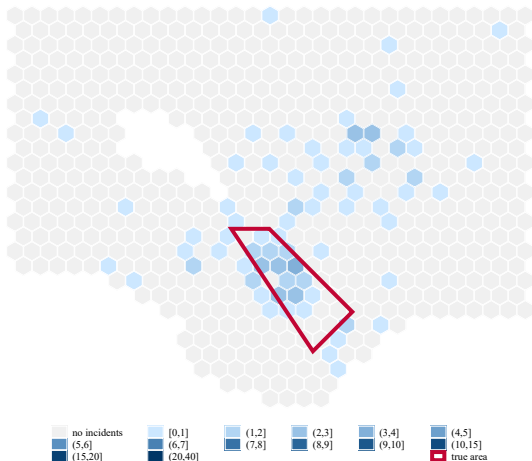
The AOEPLACEBO programme

```
aoeplacebo design ,
        areadata(filename) celldata(filename) estimation(string) method(string)
        grid(varname) tid(varname) etime(varname) evariable(newvarname)
        [ position(# [#] [,*]) rotation(# [#] [,*]) scale([#] # [#] [,*]) replications(#) seed(#)
        complex(string) templacebo(# # [,*]) egridmatch(string) multiarea(varlist [,*])
        addstat(string) evreport(string) ovreport(string) tempreport(# # [,*]) permreport(string)
        cellpoly(filename) mapdb(filename) mapco(filename)
        progress(string) output(foldername [,*]) outname(string) ]
```

The **AOEPLACEBO** programme provides two designs
▶ **diagnostic**: incrementally varies an area's reference points in one dimension and creates AoE placebo estimate plots
▶ **permutation**: derives the distribution of AoE estimates for random levels of AoE uncertainty across all dimension

Further features:
▶ degree-based or geodetic derivation of placebo areas
▶ complex AoE effects (lags, leads, duration & interaction effects)
▶ spatio-temporal placebo tests
▶ accommodates multi-sector AoE with different intervention dates

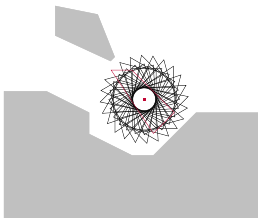# Diagnostic AoE test: Syntax and placebo areas

```
aoeplacebo diagnostic, area("observed_area.dta")                     ///
    cell("grid_time_incidents.dta")                                  ///
    estimation(reghdfe I_incident Inc_parea, a(hex_ID mdate))        ///
    evar(Inc_parea) grid(hex_ID) tid(mdate) egrid(centroid) etime(op_act)  ///
    position(1.5 0.5) rotation(180 15) scale(2 0.2) method(degree)   ///
    progress(detail) mapdb("map_db.dta") mapco("map_co.dta")
```
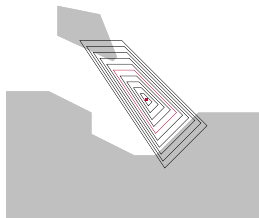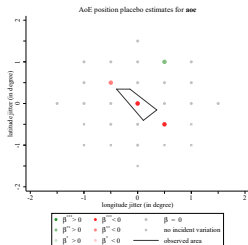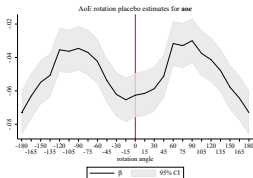
Position
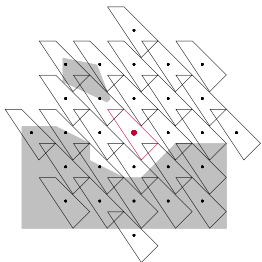
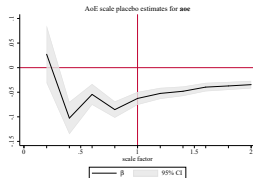Rotation

Scale

Diagnostic AoE test: Diagnostic plots

Position

Rotation

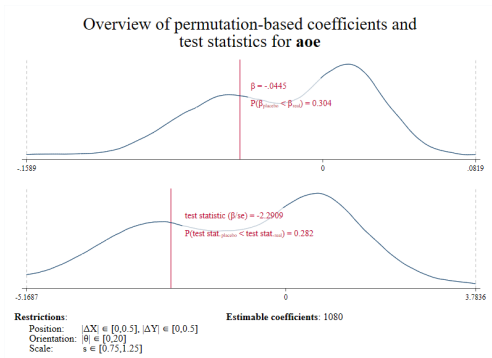### Scale

Permutation AoE test: Syntax and distribution plots

```
aoeplacebo permutation, area("observed_area.dta")              ///
    cell("grid_time_incidents.dta")                           ///
    estimation(reghdfe I_incident aoe wave, a(hex_ID mdate))   ///
    evar(aoe) grid(hex_ID) tid(mdate) egrid(centroid) etime(op_act)  ///
    complex(L(0/1).aoe c.TS_aoe##c.TS_aoe)                     ///
    evreport(aoe) method(degree) progress(detail)             ///
    position(1.5) rotation(45, centered) scale(0.5 1.5, centered)  ///
    replications(10000) seed(123456789)                       ///
    tempreport(p=(0 0.5) r=(0 20) s=(0.75 1.25))
```


Overview of permutation-based coefficients and test statistics for **aoe**

$\beta = -.0445$
$P(\beta_{placebo} < \beta_{real}) = 0.304$

-.1389   0   .0819

test statistic (β/se) = -2.2909
$P(\text{test stat}_{placebo} < \text{test stat}_{real}) = 0.282$

-3.1687   0   3.7836

Restrictions: **Estimable coefficients**: 1080
Position: $|\Delta X| \in [0,0.5]$, $|\Delta Y| \in [0,0.5]$
Orientation: $|\theta| \in [0,20]$
Scale: $s \in [0.75,1.25]$

Conclusion

▶ AOEPLACEBO provides a convenient way to investigate the impact of area uncertainty on AoE estimates

▶ The programme is relatively easy to handle, yet allows complex AoE placebo models to be estimated

▶ In contrast to other permutation-based inference in a spatial context (cf. Anderson, 2008; Orozco-Aleman, 2017), AoE placebo tests preserve more of the available spatial information