Econometrics **August 18, 2026**

Difference in Differences

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1 Difference in Differences

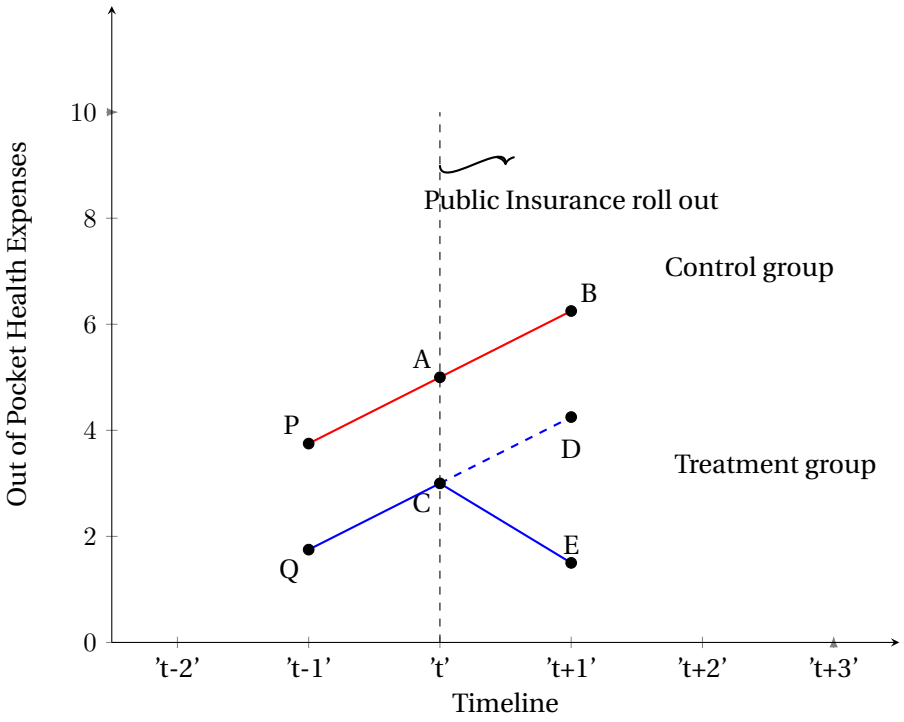
Difference in Differences

The *difference-in-differences* method is a quasi-experimental approach that compares the changes in outcomes over time between a population enrolled in a program (the treatment group) and a population that is not (the comparison group).

Diff-in-Diff approach combines two counterfeit estimates of counterfactuals (*before-after estimates* and comparisons between *enrolled-unenrolled* groups.) to produce a better estimate of the counterfactual.

The approach removes biases in post-intervention period comparisons between the treatment and control group that could be the result from permanent differences between those groups, as well as biases from comparisons over time in the treatment group that could be the result of trends due to other causes of the outcome.

1.1 Visualizing Diff-in-Diff



1. Calculate the before-after difference in the outcome (Y) for the control group ($B - P$).

2. Calculate the before-after difference in the outcome (Y) for the treatment group ($E - Q$).

3. Calculate the difference between the difference in outcomes for the treatment group $(B - P)$ and the difference for the comparison group $(E - Q)$. This is the difference-in-differences: DD $= (E - Q) - (B - P)$.

1.2 Difference-in-Differences (DiD) Model

The basic Difference-in-Differences (DiD) model can be expressed as:

$$Y_{it} = \beta_0 + \beta_1 \text{Treated}_i + \beta_2 \text{Post}_t + \beta_3 (\text{Treated}_i \times \text{Post}_t) + \epsilon_{it} \tag{1}$$

- Y_{it} is the outcome variable for individual i at time t.
- Treated_i is a binary indicator equal to 1 if the individual belongs to the treatment group, and 0 otherwise.
- Post_t is a binary indicator equal to 1 if the time period is after the intervention, and 0 otherwise.
- $\text{Treated}_i \times \text{Post}_t$ is the interaction term between treatment status and the post-intervention period.
- β_0 is the intercept.
- β_1 captures the difference between the treatment and control groups before the intervention.
- β_2 captures the difference over time for the control group.
- β_3 is the coefficient of interest, representing the Difference-in-Differences (DiD) estimate of the treatment effect.
- ϵ_{it} is the error term.

1.3 DiD Assumptions

In order to estimate any causal effect, three assumptions must hold: exchangeability, positivity, and Stable Unit Treatment Value Assumption (SUTVA).

SUTVA

Stable Unit Treatment Value Assumption **SUTVA**, essentially contains two parts:

1. No Interference: The treatment status of one unit should not affect the outcome of another unit.
2. Consistency: Each unit has a unique potential outcome corresponding to its treatment status.

For extended discussion, students must read Lechner (2010).

DID estimation also requires that:

1. Intervention (treatment assignment) is unrelated to outcome at baseline (allocation of intervention was not determined by outcome).
2. Treatment/intervention and control groups have Parallel Trends in outcome (see Section 1.4 below for details).
3. Composition of intervention and comparison groups is stable for repeated cross-sectional design (part of SUTVA)
4. No spillover effects (part of SUTVA)

1.4 Validity of DiD (Assumption)

Equal Trends Assumption The validity of the difference-in-differences approach relies on the equal trends assumption, or rather the assumption that no time-varying differences exist between the treatment and control groups.

$$E\left[Y_1(1) - Y_1(0)|T=1\right] = \left(E\left[Y_1|T=1\right] - E\left[Y_0|T=1\right]\right) - \left(E\left[Y_1|T=0\right] - E\left[Y_0|T=0\right]\right)$$

1.5 DiD technique - Strengths and Weaknesses

Strengths

- Intuitive interpretation
- Can obtain causal effect using observational data if assumptions are met
- Can use either individual and group level data
- Comparison groups can start at different levels of the outcome. (DID focuses on changerather than absolute levels)
- Accounts for change/change due to factors other than intervention

Weakness

- Requires baseline data and a non-intervention group
- Cannot use if intervention allocation determined by baseline outcome
- Cannot use if comparison groups have different outcome trend (Abadie 2005 has proposed solution)

- Cannot use if the composition of groups pre/post change is not stable

Students must read the article by Bertrand et al. (2004) to understand the limitations of Difference in Difference techniques.

References

Bertrand, M., Duflo, E., and Mullainathan, S. (2004). How much should we trust differences-in-differences estimates? *The Quarterly Journal of Economics*, 119:249–275.

Lechner, M. (2010). The estimation of causal effects by difference-in-difference methods. *Foundations and Trends R in Econometrics*, 4:165–224.

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