



FROM THE RESEARCH BENCH

What are parallel trends? The assumption behind difference-in-differences

Parallel trends is a counterfactual assumption, not a pre-trend badge. Declare the estimand, timing, overlap, and sensitivity before interpreting DiD.

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MANAGEMENT SUMMARY

Parallel trends is the assumption that, absent treatment, the treated and comparison groups would have followed the same outcome path under the declared design. It is the counterfactual bridge behind difference-in-differences, not a universal visual pattern or a pass awarded by a non-significant pre-trend test. Callaway and Sant'Anna provide group-time estimands and covariate-conditional identification for multiple periods, while Roth and co-authors review heterogeneity, pre-trend power, and inference problems. A synthetic trend chart shows how to document the assumption without turning a descriptive pre-period resemblance into causal proof.

Keywords: Parallel Trends · Difference-in-Differences · Causal Inference · Counterfactual · Treatment Timing · Common Support

A difference-in-differences result can be written as a clean subtraction while its key comparison remains unobserved. The treated group rose by 10 points. The comparison group rose by 4. The reported difference is 6. That arithmetic becomes a treatment effect only if the comparison path is credible for what would have happened to the treated group without treatment.

Parallel trends is the assumption that treated and comparison units would have followed the same outcome trend in the absence of treatment, conditional on the declared design and covariates. It is a counterfactual bridge, not a generic quality score.

The staggered difference-in-differences article owns the choice of cohort-time estimand when treatment arrives at different times. This page owns the assumption underneath that choice and the review discipline needed before a trend comparison is read causally.

What does parallel trends mean?

Let $Y_t(0)$ be the untreated potential outcome at time t . A simple version of the assumption requires the expected change in $Y_t(0)$ to be the same for treated and comparison units over the declared pre-treatment and post-treatment design. In symbols, the untreated change for the treated group must be recoverable from the comparison group's change, possibly after conditioning on observed pre-treatment covariates.

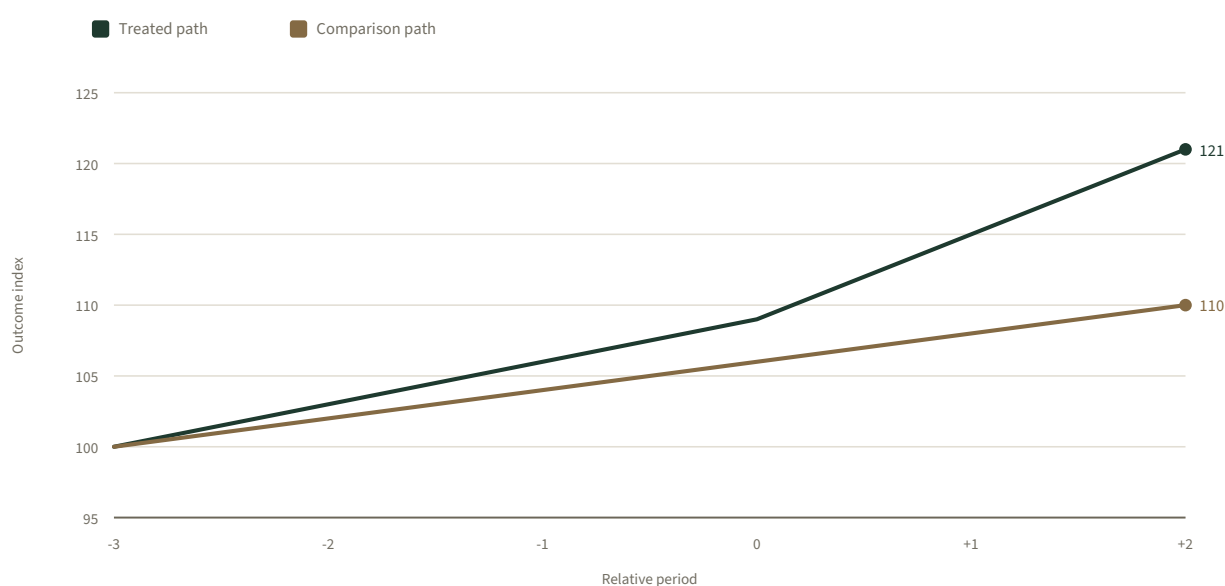
The assumption is about a missing path. We observe the treated group after treatment, but not its untreated outcome in that same period. A graph can show pre-period resemblance. It cannot show the post-period counterfactual directly.

Callaway and Sant'Anna identify group-time average treatment effects in settings with multiple periods and variation in treatment timing. Their framework allows parallel trends conditional on observed covariates and supports outcome-regression, inverse-probability, and doubly robust approaches (Callaway & Sant'Anna, 2021).

What does a trend chart show?

The chart below is synthetic. The index is set to 100 three periods before treatment. The lines illustrate a pre-period that looks similar and a post-period that separates. They do not show a real intervention or identify an effect.

Figure 1 The synthetic parallel-trends screen



Author's synthetic trend illustration grounded in Callaway and Sant'Anna (2021) and Roth, Sant'Anna, Bilinski and Poe (2023). The indexed paths illustrate a review question, not an observed treatment effect or benchmark.

The pre-period is not a pass-fail decoration. Ask whether the groups have comparable outcome definitions, stable composition, common measurement, and enough support in the effect-modifier space. A similar slope can coexist with different levels, anticipation, or a later shock that affects the groups differently.

Why is a pre-trend test not enough?

Roth and co-authors review recent difference-in-differences work and emphasize that two-way fixed-effects estimates can mislead under treatment-effect heterogeneity. They also note that pre-trend tests can be underpowered and can create pretest bias when the analyst chooses the estimator or sample after seeing the test (Roth et al., 2023).

A non-significant pre-trend test therefore does not prove parallel trends. A significant test does not tell you the direction or size of the post-treatment bias without a model. The test is one piece of evidence, alongside plots, institutional timing, covariate balance, placebo designs, alternative windows, composition changes, and sensitivity analysis.

Which fields make a DiD comparison reproducible?

Preserve these fields before estimating:

- 1 Unit and treatment time: who is treated, by which rule, and when.
- 2 Outcome: exact measure, unit, construction, and observation window.
- 3 Comparison: why the comparison group can represent the missing untreated path.
- 4 Pre-period: number of periods, trend definition, anticipation boundary, and exclusions.
- 5 Covariates: effect modifiers, conditioning rule, and common-support screen.
- 6 Estimand: group-time effect, event-time effect, average effect, or another declared target.

- 7 Estimator: outcome model, weighting, doubly robust procedure, or other method.
- 8 Sensitivity: alternative windows, placebo dates, composition changes, and plausible trend departures.

Positivity or common support matters here as well. If the target treated units occupy feature combinations absent from the comparison or source data, a trend resemblance in the remaining units does not identify the target counterfactual.

What is parallel trends not?

It is not equal levels, identical raw series, a universal business benchmark, or proof that a pre-trend test passed. It is not an assumption that can be transferred unchanged when the treatment timing, outcome, unit, comparison, or institutional context changes.

A difference-in-differences estimate is only as credible as the declared counterfactual bridge, the estimand, the support, and the sensitivity argument that accompany it.

The external-validity article extends the same discipline to the population and context in which a comparison is meant to travel.

REFERENCES

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END OF ESSAY

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