Difference-in-Differences Designs

Escuela en Métodos

July 27-31, 2026

Universidad Católica del Uruguay, Montevideo

1 Course Information

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2 Course Description

This course covers the statistical foundations and practical aspects of difference-in-differences (DiD) designs. DiD designs are one of the most popular tools for causal inference and policy evaluation in non-experimental settings. The main idea behind them is to compare the evolution over time of the outcome of a group of units (such as individuals, households, counties, firms, etc.) that are exposed to some intervention to the evolution of the outcomes of a group of units that are unaffected by the intervention. Under certain assumptions, DiD models allow the researcher to learn about the causal effect of the intervention by flexibly controlling for unobserved heterogeneity and common time trends. The use of DiD models is widespread in economics, political science, education, sociology, health sciences, environmental sciences and many other areas.

We will introduce the potential outcomes framework to rigorously define causal effects and to study classical results and recent advances in identification, estimation and statistical inference for DiD models. The topics discussed in the course will be illustrated with hands-on empirical applications using statistical software.

3 Course Prerequisites

While the course will be as self-contained as possible and will provide review material, participants are expected to have a working knowledge of econometrics and linear regression, and some familiarity with either `R` or `Stata`.

4 Software

Empirical applications will be analyzed using a combination of standard and recently developed software packages. Most of the packages used in this course are available in both `R` and `Stata`. The data sets and code will be provided with the course materials.

Before the course begins, please make sure to install `R` from the following link:

https://cran.r-project.org/

In addition, `RStudio` offers a friendlier user interface and several other advantages, and can be downloaded free of charge from the following link:

https://rstudio.com/products/rstudio/

The empirical applications will use a series of user-written packages to implement the methods discussed in the slides. You may install the required packages using the following commands:

```
install.packages(c("ggplot2","lmtest","sandwich",
                   "fixest","did","remotes",
                   "panelView","bacondecomp","Synth"))
remotes::install_github("asheshrambachan/HonestDiD")
```

Alternatively, if you have access to a `Stata` license, you may install the corresponding packages using the following commands:

```
ssc install reghdfe, replace
ssc install coefplot, replace
ssc install drdid, replace
ssc install csdid, replace
net install honestdid, from(https://raw.githubusercontent.com/mcaceresb/stata-honestdid/main) replace
net install grc1leg, from(http://www.stata.com/users/vwiggins) replace
net install gr0075, from(http://www.stata-journal.com/software/sj18-4) replace
ssc install labutil, replace
ssc install sencode, replace
ssc install panelview, replace
ssc install bacondecomp, replace
net install github, from("https://haghish.github.io/github/")
github install lsun20/eventstudyinteract
ssc install did_imputation, replace
ssc install event_plot, replace
ssc install did_multiplegt, replace
ssc install did_multiplegt_dyn, replace
```

5 Background Reading Material

The course will be self-contained and will not follow any particular textbook. Relevant references for each specific topic are provided below for participants interested in further details. For background reading, see Angrist and Pischke (2009), Imbens and Rubin (2015), Hansen (2022) and Wooldridge (2010). In addition, slide set 0 ("Panel_data_review"), provided with the class material, contains a short review of panel data for participants interested in a quick refresher or background reading on the textbook treatment of panel data models.

6 Course Contents

6.1 Course Intro

Course overview, goals and outline.

6.2 Potential Outcomes, Causal Effects and Introduction to DiD Models

The potential outcomes framework and heterogeneous treatment effects. Problems with naive approaches: before-after and cross-sectional comparisons. Canonical two-period / two-group setting. Identification of the average treatment effect on the treated under the parallel trends assumption. Estimation "by hand" and using regression models. Inference procedures.

Empirical application: "Minimum Wages and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania" (Card and Krueger, 1994).

References: Angrist and Pischke (2009), Abadie and Cattaneo (2018), Imbens and Rubin (2015), Steigerwald, Vazquez-Bare and Maier (2021).

6.3 DiD Models and Event-Study Designs Under Simultaneous Adoption

DiD models with multiple time periods under simultaneous treatment adoption. Estimation and inference. Assessing the parallel trends assumption and pre-treatment trends tests. Two-way fixed effects estimation and event-study designs.

Empirical application: "Provider Supply, Utilization, and Infant Health: Evidence from a Physician Distribution Policy" (Carrillo and Feres, 2019).

References: Angrist and Pischke (2009), Abadie and Cattaneo (2018), Steigerwald, Vazquez-Bare and Maier (2021).

6.4 Pre-treatment Trends and Violations of the Parallel Trends Assumption

Pre-treatment trends adjustments: linear adjustments and group-time fixed effects. Conditional-on-covariates parallel trends. Sensitivity analysis for violations of the parallel trends assumption.

Empirical application: "Provider Supply, Utilization, and Infant Health: Evidence from a Physician Distribution Policy" (Carrillo and Feres, 2019).

References: Ashenfelter (1978), Abadie (2005), Angrist and Pischke (2009), Callaway and Sant'Anna (2021), Heckman et al. (1999), Manski and Pepper (2018), Rambachan and Roth (2023), Tazhitdinova and Vazquez-Bare (2023).

6.5 DiD Models and Event-study Designs Under Staggered Adoption

Estimation in staggered treatment adoption designs: pitfalls and possible solutions.

Empirical application: "The War on Poverty's Experiment in Public Medicine: Community Health Centers and the Mortality of Older Americans"(Bailey and Goodman-Bacon, 2015).

References: Athey and Imbens (2022), Sun and Abraham (2021), Borusyak, Jaravel and Spiess (2024), Callaway and Sant'Anna (2021), de Chaisemartin and D'Haultfœuille (2020), Goodman-Bacon (2021), Imai and Kim (2021), Steigerwald, Vazquez-Bare and Maier (2021).

6.6 Synthetic Control Methods

Synthetic control methods for case studies. Graphical representation, estimation and inference.

Empirical application: "The Economic Costs of Conflict: A Case Study of the Basque Country" (Abadie and Gardeazabal, 2003).

References: Abadie, Diamond and Hainmueller (2010), Abadie et al. (2015), Abadie and Cattaneo (2018), Abadie (2021).

6.7 Further Issues (time permitting)

Unequal-baseline DiD. DiD with continuous treatments. Fuzzy DiD.

References: de Chaisemartin, D'Haultfœuille, Pasquier and Vazquez-Bare (2022), Callaway, Goodman-Bacon and Sant'Anna (2021), de Chaisemartin and D'Haultfœuille (2017), Tazhitdinova and Vazquez-Bare (2023).

References

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Ashenfelter, O. (1978), "Estimating the Effect of Training Programs on Earnings," *The Review of Economics and Statistics*, 60, 47–57.

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Callaway, B., Goodman-Bacon, A., and Sant'Anna, P. H. (2021), "Difference-in-Differences with a Continuous Treatment," *working paper*.

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Card, D., and Krueger, A. B. (1994), "Minimum Wages and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania," *The American Economic Review*, 84, 772–793.

Carrillo, B., and Feres, J. (2019), "Provider Supply, Utilization, and Infant Health: Evidence from a Physician Distribution Policy," *American Economic Journal: Economic Policy*, 11, 156–96.

de Chaisemartin, C., and D'Haultfœuille, X. (2017), "Fuzzy Differences-in-Differences," *The Review of Economic Studies*, 85, 999–1028.

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Goodman-Bacon, A. (2021), "Difference-in-differences with variation in treatment timing," *Journal of Econometrics*, 225, 254–277.

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Heckman, J. J., Lalonde, R. J., and Smith, J. A. (1999), "Chapter 31 - The Economics and Econometrics of Active Labor Market Programs," Vol. 3 of *Handbook of Labor Economics*, Elsevier, pp. 1865–2097.

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