



## ECON 548 Applied Econometric Modelling (CRN: 21113)

Spring Term, Jan-Apr 2023

**Instructor Name:** Dr. Tao Wang

**Office:** BEC 392

**Class Times:** BEC 363, Mondays and Thursdays 08:30-09:50 AM

**E-Mail:** taow@uvic.ca

**Office Hours:** Thursdays 12:30-14:30 PM and via email appointment

### Course Content

Modern econometric methods have revolutionized the way we utilize data, statistics, and research design to move beyond correlation to causation and thoroughly understand the impact of some potential cause on certain outcomes. The objective of this course is to develop your empirical skills (modern econometric/causal inference methods) by exploring the properties, applications, and limitations of a variety of reduced form-econometric tools, practicing their implementation, and encouraging you to apply the appropriate tools to analyze your own research question. This course is oriented toward applied practitioners rather than aspiring econometricians, which sets it apart from many other econometrics courses. If you ever want to collect data, analyze data, critically read an article that presents a data analysis, or think about the relationship between theory and the real world, then this course will be beneficial for you. The core materials cover *experiments, matching estimators, instrumental variable estimation, fixed effects models, regression discontinuity designs, difference-in-difference, synthetic control, and machine learning methods.*

### Learning Outcomes

The purpose of this course is to provide you with a solid foundation in applied econometric techniques. Upon successful completion of this course, you will be able to:

- (i) Understand the problem of causality in economics in both an intuitive and theoretical manner;
- (ii) Recognize how applied econometric techniques are utilized to test and advance economic theory;
- (iii) Effectively apply the covered econometrics techniques to evaluate the effectiveness of policy programs;
- (iv) Conduct econometric analysis and apply empirical evidence to critically assess economic arguments.

### Prerequisites

*Willingness to work hard on unfamiliar materials.* Understanding of basic econometric methods, linear algebra, calculus, and probability. You typically benefit more from the class if you have taken ECON 545. This course presupposes that you are familiar with the fundamentals of R (you may also use other software packages that you are very familiar with, i.e., STATA and MATLAB).

### Textbook

Recommended paper readings for each section of the course are listed at the end of this syllabus. No textbook is required, but the following four books are highly suggested.

- Angrist, J. D. and J-S. Pischke. *Mostly Harmless Econometrics: An Empiricist's Companion* (Princeton University Press)
- Imbens, G. W. and Donald B. Rubin. *Causal Inference for Statistics, Social, and Biomedical Sciences: An Introduction*. Cambridge University Press, 2015.
- Morgan, S. and Winship, C. *Counterfactuals and Causal Inference: Methods and Principles for Social Research*. Cambridge University Press, 2015. 2nd ed.
- Cunningham, S. *Causal Inference: The Mixtape*. <https://mixtape.scunning.com/>.

**Note:** The materials posted on Brightspace are meant solely for students attending ECON 548 this semester. You do not have the instructor's permission to supply the ECON 548 course materials to any sites.

**Grading**

The course involves lectures and presentations. The course grade will base on participation, referee reports, in-class presentation, and final project (proposal+paper). Two copies of the referee reports, proposal, and paper must be submitted: (1) a *printed hard copy* submitted in class; and (2) an *electronic pdf copy* submitted through email. All results described in your project must be supported by copies of the data and codes (sent via email) that are used to produce them. Details will be discussed in class.

- **Referee Reports (30%):** This is a methodological course, developing skills in understanding and applying econometric methods. You can only learn applied metrics by doing critical judgments and therefore referee report for this course is important. By doing so, you can learn how to provide and respond to constructive criticism. The referee report should summarize and critique the paper you choose. It can be a published paper or a working paper. You will need to submit three referee reports, each with a *minimum length of 3 pages* (12-point font, double space, excluding references). Sample referee reports will be discussed in class.
- **Project Presentation (20%):** You need to develop an empirical project using one of the methods we will learn to answer a causal question of interest. It can be a replication or extension of an existing research paper. Those who choose to replicate a paper must do so without requesting the cleaned version of the data. You need to present your work—a *20-minute presentation*. You are required to share your slides with the whole class 1 week prior to the presentation. Everyone who is not presenting is expected to have read the slides and to come prepared to ask questions.
- **Final Research Project (Proposal 10%+Paper 30%):** The project should be a short empirical paper that applies methods learned in this class to a research question of your choice. You can work in a *group of maximum 2 students*. You should carefully prepare the proposal since it is the beginning of a proper research project. You are encouraged to discuss with me first. Note that the final project will not be accepted without the approval of the proposal. The proposal should be *no longer than 2 pages* (12-point font, double space, excluding references), and it should include information on the nature of the problem, how it might be framed as an economic topic, and how econometric technique works. The final paper should be with a *minimum length of 10 pages* (12-point font, double space, excluding references and appendix, where the tables and figures should be included). Paper focusing primarily on the techniques that are not covered in this course (i.e., multivariate regression, GARCH models, or VAR models) will not be accepted.
- **Class participation (10%):** This is a graduate course and I assume that you are interested in learning the materials. You are expected to attend every class and actively participate in class activities.

**Note:** I strongly encourage you to attend the department seminars. These seminars are usually Wednesdays 12:30-13:20 PM and Fridays 15:00-16:30 PM. Though seminar attendance is not counted in your grade for this class, attending seminars is an excellent way to expose yourself to current research and practically utilize the techniques learned in this course.

Grading Scale:

A+	A	A-	B+	B	B-	C+	C	D	F or N
90-100	85-89	80-84	77-79	73-76	70-72	65-69	60-64	50-59	0-49

Students should review the University's more detailed [summary of grading](#).

**Course Policies**

Arriving late for class, sleeping, talking out of turn, using a cell phone or other device, or acting otherwise distraught and disturbing are not permitted in the classroom. Please let me know immediately if you have a health problem or

disability that necessitates leaving the room during class time, or if you have a conflict that regularly prevents you from getting to class on time.

Consideration for missed projects or late referee reports will be given only on the basis of documented illness (in-line with the University's policies at the time), accident, or family affliction, and for no other reasons. Students are advised not to make work or travel plans during lecture hours to be able to attend all classes and presentations. There will be no special accommodation if travel plans conflict with presentations held during class hours.

I want you to perform well in this class. If you become concerned about your progress, please see me immediately. Please stop by during office hours if you have any questions about the materials covered in this course.

### **Academic Integrity:**

Academic integrity requires commitment to the values of honesty, trust, fairness, respect, and responsibility. Students are expected to observe the same standards of scholarly integrity as their academic and professional counterparts. A student who is found to have engaged in unethical academic behaviour, including the practices described in the [Policy on Academic Integrity](#) in the University Calendar, is subject to penalty by the University.

### **Student Code of Conduct:**

We are all responsible for creating a learning environment that is welcoming, inclusive, equitable, and respectful. The Humanities, Science, and Social Sciences Faculties have adopted this [Student code of conduct](#).

### **University Policy on Human Rights, Equity and Fairness:**

The University is committed to promoting, providing and protecting a positive, supportive and safe learning and working environment for all its members. See [General University Policies](#)

### **Accessibility & Health Resources:**

Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability/health consideration that may require accommodations, you are free to approach me; however, you must register with the [Centre for Accessible Learning](#) (CAL) for formal arrangements to be made. The CAL staff are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations. The sooner you let us know your needs the quicker we can assist you in achieving your learning goals in this course.

### **Brightspace:**

*Brightspace* is used extensively for the course. All students are expected to be fully functional with the system. The lecture notes will be posted in *Brightspace*. Please note that the lecture notes online are only outlines of the actual lectures. All announcements will be posted in *Brightspace*. Students are advised to check it frequently.

### **Course Experience Survey (CES):**

I value your feedback on this course. Towards the end of term you will have the opportunity to complete a confidential course experience survey (CES) regarding your learning experience. The survey is vital to providing feedback to me regarding the course and my teaching, as well as to help the department improve the overall program for students in the future. I will remind you nearer the time.

### **Course Schedule**

A tentative session-by-session schedule is below (subject to change).

Topic	Important Dates
Topic 1: The Potential Outcomes Framework	Jan 30th Referee Report 1 deadline

Topic 2: Selection on Observables	Feb 20th Referee Report 2 deadline
Topic 3: Decomposition in Economics	Feb 27th Final Paper Proposal deadline
Topic 4: Instrumental Variables	March 13rd Referee Report 3 deadline
Topic 5: Regression Discontinuity Designs	March 23rd Slides Share deadline
Topic 6: Fixed Effects Panel Model	March 30th Class Presentation
Topic 7: Differences-in-Differences	April 3rd Class Presentation
Topic 8: Synthetic Control	April 10th Final Paper deadline
Topic 9: Machine Learning Methods	

**Note:** All deadlines are before the start of class (8:30 AM).

### **E-mail Correspondence**

Emails should be limited to critical matters, such as inability to attend class, an exam, or prolonged illness, and should include the course name and number in the subject line. Questions on course materials should be asked during office hours or in class. Should you send an email for whatever reason, please put “ECON 548” in the subject line. I will strive to respond to your course emails within 24 hours.

### **Electronic Devices**

You are encouraged to install econometric software on your personal computers. [R](#) and [RStudio](#) are freely available online.

### **Sexualized Violence Prevention & Response**

UVic takes sexualized violence seriously, and has raised the bar for what is considered acceptable behaviour. Students are encouraged to learn more about how the university defines sexualized violence and its overall approach by visiting [www.uvic.ca/svp](http://www.uvic.ca/svp). If you or someone you know has been impacted by sexualized violence and needs information, advice, and/or support please contact the sexualized violence resource office in Equity and Human Rights (EQHR). Contact [svpcoordinator@uvic.ca](mailto:svpcoordinator@uvic.ca).

### **UVic Land Acknowledgement**

*We acknowledge with respect the Lekwungen peoples on whose traditional territory the university stands, and the Songhees, Esquimalt and WSÁNEĆ peoples whose historical relationships with the land continue to this day.*

### **Introduction and Statistical Inference**

Blundell, R. and M. Costa Dias. 2009. “Alternative Approaches to Evaluation in Empirical Microeconomics,” *Journal of Human Resources*, 44, 565-640.

Deaton, A. 2010. “Instruments, Randomization, and Learning about Development,” *Journal of Economic Literature*, 48, 424–455.

Heckman, J. J. 2010. “Building Bridges between Structural and Program Evaluation Approaches to Evaluating Policy,” *Journal of Economic Literature*, 48, 356-398.

Imbens, G. and J. Wooldridge. 2009. “Recent Developments in the Econometrics of Program Evaluation,” *Journal of Economic Literature*, 47, 5-86.

## **Causality and Random Experiments**

Baranov, V., S. Bhalotra, P. Biroli, and J. Maselko. 2020. "Maternal Depression, Women's Empowerment, and Parental Investment: Evidence from a Randomized Controlled Trial," *American Economic Review*, 110, 3, 824-59.

Carrell, S. E., M. Hoekstra, and J. E. West. 2011. "Is Poor Fitness Contagious? Evidence from Randomly Assigned Friends," *Journal of Public Economics*, 95, 657-663.

Fairlie, R. W., and J. Robinson. 2013. "Experimental Evidence on the Effects of Home Computer on Academic Achievement among Schoolchildren," *American Economic Journal: Applied Economics*, 5, 211-240.

Heckman, J., and J. Smith. 1995. "Assessing the Case for Social Experiments," *Journal of Economic Perspectives*, 9, 85-110.

Katz, K. F., J. R. Kling, and J. B. Liebman. 2001. "Moving to Opportunity in Boston: Early Results of a Randomized Mobility Experiment," *Quarterly Journal of Economics*, 116, 607-654.

Kling, J., J. Liebman and L. Katz. 2007. "Experimental Analysis of Neighborhood Effects," *Econometrica*, 75, 83-119.

Muralidharan, K. and V. Sundararaman. 2011. "Teacher Performance Pay: Experimental Evidence from India," *Journal of Political Economy*, 119, 1, 39-77.

Oster, E., and R. Thornton. 2011. "Menstruation, Sanitary Products, and School Attendance: Evidence from a Randomized Evaluation," *American Economic Journal: Applied Economics*, 3, 91-100.

Planas, N. R. 2012. "Longer-Term Impacts of Mentoring, Educational Services, and Learning Incentives: Evidence from a Randomized Trial in the United States," *American Economic Journal: Applied Economics*, 4, 121-139.

Sacerdote, B. 2007. "How Large Are the Effects from Changes in Family Environment? A Study of Korean American Adoptees," *Quarterly Journal of Economics*, 122, 119-157.

## **Selection on Observables**

Behncke, S., M. Frölich, and M. Lechner. 2010. "A Caseworker Like Me-Does the Similarity Between the Unemployed and Their Caseworkers Increase Job Placements?" *Economic Journal*, 120, 1430-1459.

Black D., and J. Smith. 2004. "How Robust is the Evidence on the Effects of College Quality? Evidence from Matching," *Journal of Econometrics*, 121, 99-124.

Caliendo, M. and S. Kopeinig. 2008. "Some Practical Guidance for the Implementation of Propensity Score Matching," *Journal of Economic Surveys*, 22, 31-72.

Dehejia, R., and S. Wahba. 2002. "Propensity Score Matching Methods for Nonexperimental Causal Studies," *Review of Economics and Statistics*, 84, 151-161.

Hahn, J. 1998. "On the Role of the Propensity Score in Efficient Semiparametric Estimation of Average Treatment Effects." *Econometrica*, 66(2): 315-331.

Heckman, J., H. Ichimura, and P. Todd. 1997. "Matching as an Econometric Evaluation Estimator: Evidence from Evaluating a Job Training Program," *Review of Economic Studies*, 64, 605-654.

Huber, M., M. Lechner and A. Strittmatter. 2018. "Direct and Indirect Effects of Training Vouchers for the Unemployed," *Journal of the Royal Statistical Society Series A*, 181, 441-463.

Imbens, G. W. 2004. "Nonparametric Estimation of Average Treatment Effects under Exogeneity: A Review," *Review of Economics and Statistics*, 86, 4-29.

Khalil, U. and Yildiz, N. 2022. "A Test of the Selection on Observables Assumption Using A Discontinuously Distributed Covariate." *Journal of Econometrics*, 226 (2), 423-450.

Simonsen, M., and L. Skipper. 2006. "The Costs of Motherhood: An Analysis Using Matching Estimators," *Journal of Applied Econometrics*, 21, 919-934.

### **Decomposition in Economics**

Baum-Snow, N. and Pavan, R. 2013. "Inequality and City Size," *The Review of Economics and Statistics*, 95 (5), 1535-1548.

Blinder, A. S. 1973. "Wage Discrimination: Reduced Form and Structural Estimates," *Journal of Human Resources*, 8, 436-455.

Card, D., Cardoso, A. R., and Kline, P. 2016. "Bargaining, Sorting, and the Gender Wage Gap: Quantifying the Impact of Firms of the Relative Pay of Women," *The Quarterly Journal of Economics*, 131 (2), 633-686.

Cotton, J. 1988. "On the Decomposition of Wage Differentials," *The Review of Economics and Statistics*, 70, 236-243.

Fortin, N. M., Oreopoulos, P., and Phipps, S. 2017. "Leaving Boys Behind Gender Disparities in High Academic Achievement," *Journal of Human Resources*, 50 (3), 549-579.

Gardeazabal, J. and Ugidos, A. 2004. "More on Identification in Detailed Wage Decompositions," *The Review of Economics and Statistics*, 86 (4), 1034-1036.

Gustafsson, B. and Li, S. 2000. "Economic Transformation and the Gender Earnings Gap in Urban China," *Journal of Population Economics*, 13, 305-329.

Liu, X., Mazumdar, T., and Li, B. 2014. "Counterfactual Decomposition of Movie Star Effects with Star Selection," *Management Science*, 61 (7), 1473-1740.

Oaxaca, R. L. 1973. "Male-Female Wage Differentials in Urban Labor Markets," *International Economic Review*, 14 (3), 693-709.

Oaxaca, R. and Ransom, M. 1998. "Calculation of Approximate Variances for Wage Decomposition Differentials," *Journal of Economic and Social Measurement*, 24, 55-61.

### **Instrumental Variables**

Aizer, A., and J. Doyle. 2015. "Juvenile Incarceration, Human Capital, and Future Crime: Evidence from Randomly Assigned Judges," *Quarterly Journal of Economics*, 130, 759-803.

Alesina, A., P. Giuliano and N. Nunn. 2013. "On the Origins of Gender Roles: Women and the Plough," *Quarterly Journal of Economics*, 128, 469-530.

Card, David. 2001. "Estimating the Return to Schooling: Progress on Some Persistent Econometric Problems," *Econometrica*, 69, 1127-1160.

Fruehwirth, J. C., S. Iyer, and A. Zhang. 2019. "Religion and Depression in Adolescence." *Journal of Political Economy*, 127, 1178-1209.

Gordon, B. D., and L. Lochner. 2012. "The Impact of Family Income on Child Achievement: Evidence from the Earned Tax Credit," *American Economic Review*, 102, 1927-1956.

Heckman, J., S. Urzua, and E. Vytlacil. 2006. "Understanding Instrumental Variables in Models with Essential Heterogeneity," *Review of Economics and Statistics*, 88(3):389-432.

Imbens G., and J. Angrist. 1994. "Identification and Estimation of Local Average Treatment Effects," *Econometrica*, 62, 467-475.

Imbens, G., J. Angrist, and D. Rubin. 1996. "Identification of Causal Effects Using Instrumental Variables," *Journal of Econometrics*, 71, 145-160.

Nunn, N. 2008. "The Long-Term Effects of Africa's Slave Trades," *Quarterly Journal of Economics*, 123, 139-176.

Oreopoulos, P. 2006. "Estimating Average and Local Average Treatment Effects of Education when Compulsory Schooling Laws Really Matter," *American Economic Review*, 96, 152-175.

### **Regression Discontinuity Designs**

Card, D. and C. Dobkin and N. Maestas. 2009. "Does Medicare Save Lives?" *Quarterly Journal of Economics*, 124, 2, 597-636.

Carpenter, C., and C. Dobkin. 2009. "The Effect of Alcohol Consumption on Mortality: Regression Discontinuity Evidence from the Minimum Drinking Age," *American Economic Journal: Applied Economics*, 1, 164-182.

Carrell, S. E., M. Hoekstra, and J. West. 2011. "Does Drinking Impair College Performance? Evidence from a Regression Discontinuity Approach," *Journal of Public Economics*, 95, 54-62.

Dahl, Gordon B., K. V. Loken, and M. Mogstad. 2014. "Peer Effects in Program Participation," *American Economic Review*, 104, 7, 2049-2074.

Hahn, J., P. Todd, and W. van der Klaauw. 2001. "Identification and Estimation of Treatment Effects with a Regression-Discontinuity Design," *Econometrica*, 69, 201-209.

Lalive, R. 2007. "Unemployment Benefits, Unemployment Duration and Unemployment Jobs: A Regression Discontinuity Approach," *American Economic Review*, 97, 108-112.

Lee, D. S. 2008. "Randomized Experiments from Nonrandom Selection in US House Elections," *Journal of Econometrics*, 142(2):675-697.

Lee, D. S. and T. Lemieux. 2010. "Regression Discontinuity Design in Economics," *Journal of Economic Literature*, 48, 2, 281-355.

Ludwig, J., and D. L. Miller. 2007. "Does Head Start Improve Children's Life Chances? Evidence from a Regression Discontinuity Design," *Quarterly Journal of Economics*, 122, 159-208.

Pinotti, P. 2017. "Clicking on Heaven's Door: The Effect of Immigrant Legalization on Crime," *American Economic Review*, 107, 138-68.

### **Fixed Effects Panel Model**

- Athey, S., Bayati, M., Imbens, G., and Qu, Z. 2019. "Ensemble Methods for Causal Effects in Panel Data Settings," *AEA Papers and Proceedings*, 109, 65-70.
- Bojinov, I, Rambachan, A., and Shephard, N. 2021. "Panel Experiments and Dynamic Causal Effects: A Finite Population Perspective," *Quantitative Economics*, 12 (4), 1171-1196.
- Chaisemartin, C. and D'Haultfoeuille, X. 2020. "Two-Way Fixed Effects Estimators with Heterogeneous Treatment Effects," *American Economic Review*, 110 (9), 2964-2996.
- Frijters, P., Haisken-DeNew, J. P., and Shields, M. A. 2004. "Money Does Matter! Evidence from Increasing Real Income and Life Satisfaction in East Germany Following Reunification," *American Economic Review*, 94 (3), 730-740.
- Ferrer-i-Carbonell, A. and Frijters, P. 2004. "How Important is Methodology for the Estimates of the Determinants of Happiness?" *The Economic Journal*, 114 (497), 641-659.
- Gangl, M. 2010. "Causal Inference in Sociological Research," *Annual Review of Sociology*, 36 (1), 21-47.
- Holmlund, H., Lindahl, M., and Plug, E. 2011. "The Causal Effect of Parents' Schooling on Children's Schooling: A Comparison of Estimation Methods," *Journal of Economic Literature*, 49 (3), 615-651.
- Imai, K. and Kim, I. S. 2019. "When Should We Use Fixed Effects Regression Models for Causal Inference with Longitudinal Data?" *American Journal of Political Science*, 63 (2), 467-490.
- Imai, K. and Kim, I. S. 2021. "On the Use of Two-Way Fixed Effects Regression Models for Causal Inference with Panel Data?" *Political Analysis*, 29, 405-415.
- Mummolo, J. and Peterson, E. 2018. "Improving the Interpretation of Fixed Effects Regression Results," *Political Science Research and Methods*, 6 (4), 829-835.

### **Difference-in-Difference**

- Anderson, M. D. 2014. "In School and Out of Trouble? The Minimum Dropout Age and Juvenile Crime," *Review of Economics and Statistics*, 96, 2, 318-331.
- Bertrand, M., E. Duflo and S. Mullainathan. 2004. "How Much Should We Trust Difference-in-Difference Estimates?" *Quarterly Journal of Economics*, 119, 249-275.
- Besley, T., and R. Burgess. 2004. "Can Labor Market Regulation Hinder Economic Performance? Evidence from India," *Quarterly Journal of Economics*, 113, 91-134.
- Card, D., and A.B. Krueger. 1994. "Minimum Wages and Employment: A Case Study of the Fast Food Industry in New Jersey," *American Economic Review*, 84, 772-793.
- Currie, J. and R. Walker. 2011. "Traffic Congestion and Infant Health: Evidence from E-ZPass," *American Economic Journal: Applied Economics*, 3, 65-90.
- Duflo, E. 2001. "Schooling and Labor Market Consequences of School Construction in Indonesia: Evidence from an Unusual Policy Experiment," *American Economic Review*, 91, 795-813.
- Haber, N., Clarke-Deelder, E., Salomon, J. A., Feller, A., and Stuart, E. A. 2021. "COVID-19 Policy Impact Evaluation: A Guide to Common Design Issues," *American Journal of Epidemiology*, 190 (11), 2474-2486.
- Hong, S. H. 2013. "Measuring the Effect of Napster on Recorded Music Sales: Difference-in-Differences Estimates under Compositional Changes," *Journal of Applied Econometrics*, 28, 297-324.



Groen, J. A., M. J. Kutzbach, and A. E. Polivka. 2020. "Storms and Jobs: The Effect of Hurricanes on Individuals' Employment and Earnings over the Long Term," *Journal of Labor Economics*, 38, 653-685.

Lovenheim, M. F., and A. Willen. 2019. "The Long Run Effects of Teacher Collective Bargaining," *American Economic Journal: Economic Policy*, 11, 292-324.

### **Synthetic Control**

Abadie, A. 2021. "Using Synthetic Controls: Feasibility, Data Requirements, and Methodological Aspects," *Journal of Economic Literature*, 59, 391-425.

Abadie, A., and J. Gardeazabal. 2003. "The Economic Costs of Conflict: A Case Study of the Basque Country," *American Economic Review*, 93, 113-132.

Abadie, A., A. Diamond, and J. Hainmueller. 2015. "Comparative Politics and the Synthetic Control Method," *American Journal of Political Science* 59(2): 495-510.

Abadie, A., A. Diamond, and J. Hainmueller. 2010. "Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program," *Journal of American Statistical Association*, 105, 493-505.

Amjad, M., Shah, D., and Shen, D. 2018. "Robust Synthetic Control," *Journal of Machine Learning Research*, 19, 1-51.

Athey, S., and G. W. Imbens. 2017. "The State of Applied Econometrics: Causality and Policy Evaluation," *Journal of Economic Perspectives*, 31, 3-32.

Billmeier, A., and T. Nannicini. 2013. "Assessing Economic Liberalization Episodes: A Synthetic Control Approach," *Review of Economics and Statistics* 95(3): 983-1001.

Chernozhukov, V., K. Wuthrich, and Y. Zhu. 2021. "An Exact and Robust Conformal Inference Method for Counterfactual and Synthetic Controls," *Journal of American Statistical Association*, 116, 1849-1864.

Doudchenko, N., and G. W. Imbens. 2016. "Balancing, Regression, Difference-In-Differences and Synthetic Control Methods: A Synthesis," *Working Paper 22791. National Bureau of Economic Research*.

Ferman, B., C. Pinto, and V. Possebom. 2020. "Cherry Picking with Synthetic Controls," *Journal of Policy Analysis and Management*, 39, 510-532.

### **Machine Learning Methods**

Varian, Hal R. 2014. "Big Data: New Tricks for Econometrics," *Journal of Economic Perspectives*, 28, 3-27.

Athey, S., and G. W. Imbens. 2019. "Machine Learning Methods That Economists Should Know About," *Annual Review of Economics*, 11, 685-725.

Mullainathan, S., and J. Spiess. 2017. "Machine Learning: An Applied Econometric Approach," *Journal of Economic Perspectives*, 87-106.

Belloni, A., V. Chernozhukov, and H. Christian. 2014. "High-Dimensional Methods and Inference on Structural and Treatment Effects," *Journal of Economic Perspectives*, 28, 29-50.

Bloniarz, A., H. Liu, C. H. Zhang, J. S. Sekhon, and B. Yu. 2016. "Lasso Adjustments of Treatment Effect Estimates in Randomized Experiments," *Proceedings of the National Academy of Sciences*, 113, 7383-7390.