THE UNIVERSITY OF CHICAGO

THE HARRIS SCHOOL OF PUBLIC POLICY

PPHA 44340:
ENERGY AND ENVIRONMENTAL ECONOMICS III

Spring 2022: Tuesday 2 PM

Instructor: Professor Koichiro Ito
Harris School, Office 2071
ito@uchicago.edu
Office hours: By appointment

1. Course Description: Optimal environmental regulation requires an analysis of the trade-offs between market and regulatory imperfections. Market allocations are inefficient in the presence of imperfections such as externalities, market power, and informational asymmetries. On the other hand, government intervention to mitigate these imperfections is not costless, and can even make market performance worse.

This course is the third course in the Ph.D. environmental and energy economics sequence at the University of Chicago. We focus on recent empirical analysis of the costs and benefits of environmental and energy policies, including an introduction to the relevant econometric methodologies such as randomized controlled trials, regression discontinuity design, bunching analysis, and structural estimation. Topics will include: energy demand and the energy efficiency gap, fuel economy and appliance efficiency standards, non-linear and real-time electricity pricing, wholesale electricity markets, renewable electricity policies, natural gas markets, retail gasoline markets, and technology innovations.

2. Prerequisites: 1) PhD-level coursework on microeconomics, 2) PhD-level coursework on econometrics and 3) Environmental and Energy Economics I & II (PPHA443201 & PPHA44330). If you have not taken these courses, please obtain consent of the instructor to enroll.

3. Readings: Course readings are listed below. There is no textbook.

4. Audits: I welcome students who choose to audit the course. However, my class is a no-free-rider zone, so auditing students will be required to participate in class presentations and discussions as if they were taking the course for credit. Specifically, auditing students are

required to read assigned papers (* and ** in the reading list) and participate in class discussions. Auditors may also be asked to present a paper in class. Auditors are exempt from turning in referee reports, problem sets, research summaries, and from taking the exam.

5. Seminars: All students interested in environmental and energy economics should attend the EPIC lunch seminar. In addition, two web sites that will be of interest to students in environmental and energy economics are the EEE NBER Working Paper series (http://www.nber.org/papersbyprog/EEE.html) and the Energy Economics Exchange blog from UC Berkeley (http://energyathaas.wordpress.com/). For both of these sites, you can sign up for notifications of new papers and posts.

6. Course design for 2022

I will adopt an instruction design called "flipped classroom design." In a traditional classroom setting, teachers give one-way lectures in class, often leaving limited time for answering questions, engaging in discussions, and opportunities for working on advanced materials in class. Then, students are usually asked to review class materials and work on advanced materials at home on their own.

The flipped classroom design aims to "flip" this conventional structure. I will upload 1) lecture slides and 2) pre-recorded lectures (40-50 minutes per lecture) in advance and require students to submit their answers to quiz questions that I ask in pre-recorded lectures as well their questions about lecture materials via Google form:
https://forms.gle/vLh2WuC6LgrpE9v27

Then, we get together in person in our regularly scheduled class times (once a week), aiming to do three things: 1) I will answer your questions on the pre-recorded lecture, 2) I will provide more instructions on concepts that turn out to be harder for many students, and 3) a student presents an assigned paper, which all students read before coming to class. To respect your time, I plan to finish each in-person session in roughly 1.5-2 hours.

Here is the current plan:

Date	Time	Item
Thursday	Noon	Professor Ito uploads pre-recorded lectures
Monday	Noon	Students submit quiz answers via Google form
Tuesday	2 PM -3:30 PM*	In person class meeting: 1) discussion and additional instruction of pre-recorded lectures, and 2) student presentation & discussion for an assigned paper

*Note: We plan to finish at 4 PM when we have two student presentations.

7. Required readings and student presentation: Every week, a student presents a paper with ** in the reading list. This will give you an opportunity to practice your presentation skill, which is important for your academic career (for both research and teaching).

The student presents the paper for 30 minutes and leads the class discussion for 30 minutes. The presentation slides in PDF must be uploaded in Canvas **by noon on the day before** the presentation day. The presentation should include the following items:

A) What is the research question?
B) Why is it interesting/important?
C) Brief data description
D) Estimation method (and a brief description of your model, if any, but not required)
E) Results
F) Contributions of the paper relative to previous studies (compare the paper to a few of the most key/relevant studies in the literature and explain why the paper provides novel contributions).
G) Your questions and critiques for the paper to lead the class discussion

8. Research Paper: The second goal of this course is to help students to start conducting original research in this field. Remember that your goal in the PhD program is to produce original research. Understanding someone else's research is useful but not a goal for your grad school. With this motivation, I ask you to work on the following items:

(Note for non-PhD students: I will not ask you to do this research paper requirement. Instead, I will give you extra reading assignments that replace this paper requirement.)

1) **Two Research Ideas:** Email a summary of two research ideas in PDF to me. The summary should include texts (max 3 pages) along with a reference list, tables, and figures. It should contain the following six sections:
   A) What is the research question?
   B) Why is it interesting/important?
   C) Data description
   D) Estimation method (and a brief description of your model, if any, but not required)
   E) Preliminary results
   F) Contributions of your paper relative to previous studies (compare your paper to a few of the most key/relevant studies in the literature and explain why your study provides novel contributions).

2) **Summary of Preliminary Findings:** Email a summary of the preliminary findings of your project in PDF to me. The summary should include texts (max 3 pages) along with a reference list, tables, and figures. It should contain all of the items A to F listed above.

3) **Final Presentation Slides (deadline: Noon on the day before the presentation day)**: Email me your slides in PDF. Your presentation will be 10-20 minutes (depending on class size for this year) with no interruptions followed by 5-minute Q&A. Your presentation needs to cover all of the items A to F listed above.

4) **Final Paper**: Email me your final paper in PDF. This should include texts (max 4 pages) along with a reference list, tables, and figures. Your paper needs to cover all of the items A to F listed above.

9. Grading: The course grades will break out as follows:

Presentation of assigned papers and active class discussion: 30%
Weekly assignment submissions: 30%
Research papers (two ideas, preliminary results, final proposal & presentation): 40%

(Note for non-PhD students: Your 40% grade will come from extra reading assignments that replace the research paper requirement.)

10. Policy for Late Assignments: Please meet the deadline. Each assignment that missed its deadline will create a 5-point deduction per day from your final course grade, with no exception.

11. Course Schedule (subject to change):

Date	Topic	Lecture	Assigned Papers	Research paper assignment due
3/29	Course Introduction & Introduction to Energy Markets	1	None. Please watch pre-recorded lecture before coming to class	
4/5	Electricity Markets: Supply	2	Ryan (2021) "Holding Up Green Energy"	
4/12	Electricity Markets: Demand	3	Meeks, Omuraliev, Isaev and Wang (2022)	Two research ideas + meeting with Professor
4/19	Natural Gas and Oil Markets	4	Davis and Hausmann (2022)	
4/26	Selection and Targeting in Energy Markets	5	Knittel and Stolper (2019)	
5/3	Renewable Energy	6	Covert and Sweeney (2022)	Preliminary results + meeting with Professor
5/10	Transboundary Air Pollution	7	Hernandez-Cortes and Meng (2022)	
5/17	Energy and Environmental Economics in Developing Countries	8	Buntaine, Greenstone, He, Liu, Wang and Zhang (2022)	
5/24	Student Presentation of Research Papers	9		Presentation (PDF)
6/4	Final Paper Deadline			Final version of research paper

12. Reading list:

All papers with asterisk (*) and double-asterisk (**) are **required readings** for the course. The double-asterisk (**) means the paper is assigned for student presentation & discussion.

1) Introduction to Energy Markets: Market Power, Regulation and Deregulation

Borenstein Severin, James Bushnell, and Steven Stoft. "The Competitive Effects of Transmission Capacity in a Deregulated Electricity Industry." *Rand Journal of Economics,* Vol 31, No. 2, Summer 2000.

* Borenstein, Severin. 2002. "The Trouble with Electricity Markets: Understanding California's Restructuring Disaster," *Journal of Economic Perspectives,* 16(Winter).

Borenstein, Severin, and James Bushnell. "The US electricity industry after 20 years of restructuring." Annu. Rev. Econ. 7, no. 1 (2015): 437-463. Available at http://www.annualreviews.org/doi/pdf/10.1146/annurev-economics-080614-115630

* Borenstein, Severin, James Bushnell, and Frank Wolak. 2002. "Measuring Market Inefficiencies in California's Restructured Wholesale Electricity Market," *American Economic Review,* 92(5): 1376-1405.

Joskow, Paul L. 1973. "Pricing Decisions of Regulated Firms: A Behavioral Approach." *Bell Journal of Economics* 4(1): 118-140.

* Joskow, Paul L. 1997. "Restructuring, Competition and Regulatory Reform in the U.S. Electricity Sector." *Journal of Economic Perspectives* 11: 119-138.

Joskow, Paul L. and Nancy L. Rose. 1989. "The Effects of Economic Regulation." In Handbook of Industrial Organization, North Holland.

Rose, Nancy L. 1987. "Labor Rent-Sharing & Regulation: Evidence from the Trucking Industry, *Journal of Political Economy,* 95 (December): 1146-1178.

Sweeny, J. L. (2002). *The California electricity crisis*. Hoover Institution Press.

Wolfram, Catherine. 1999. "Measuring Duopoly Power in the British Electricity Spot Market." *American Economic Review,* 89(4): 805-826.

2) Electricity Markets: Supply

Bohn, R.E., Caramanis, M.C., and Schweppe, F.C., (1984) "Optimal Price Electrical Networks Over Space and Time," *Rand Journal of Economics,* volume 15, pp. 360-376.

* Bushnell, James, Erin Mansur and Celeste Saravia. 2008. "Vertical Arrangements, Market Structure, and Competition: An Analysis of Restructured U.S. Electricity Markets," *American Economic Review,* 98(1): 237-266.

Cicala, Steve. "When Does Regulation Distort Costs? Lessons From Fuel Procurement in U.S. Electricity Generation." *American Economic Review*, 105(1): 411-44.

Cicala, Steve. "Imperfect Markets versus Imperfect Regulation in U.S. Electricity Generation." http://home.uchicago.edu/~scicala/papers/elec_gov_v_mkt/elec_gov_v_mkt_draft_2.pdf

Davis, Lucas W. and Catherine D. Wolfram. 2012. "Deregulation, Consolidation and Efficiency: Evidence from U.S. Nuclear Power," *American Economic Journal: Applied Economics, 2012, 4(4), 194-225*

Fabrizio, Kira R., Nancy L. Rose, and Catherine D. Wolfram. 2007. "Do Markets Reduce Costs? Assessing the Impact of Regulatory Restructuring on U.S. Electric Generation Efficiency." *American Economic Review,* 97(4), 1250-1277.

Hortacsu, A. and Puller, S. L. (2008). "Understanding Strategic Bidding in Multi-Unit Auctions: A Case Study of the Texas Electricity Spot Market." The RAND Journal of Economics, 39(1):86-114.

Hortaçsu, Ali and Fernando Luco and Steven L. Puller and Dongni Zhu (2017). Does Strategic Ability Affect Efficiency? Evidence from Electricity Markets. Available at https://sites.google.com/site/stevepuller/research.

* Ito, Koichiro and Mar Reguant. Sequential Markets, Market Power, and Arbitrage. *American Economic Review*, 106(7):1921–1957, July 2016.

* Mansur, Erin and Matthew White (2012). "Organization and Efficiency in Electricity Markets." Working Paper available at https://mansur.host.dartmouth.edu/papers/mansur_white_pjmaep.htm

* McRae, Shaun and Frank A. Wolak, "How Do Firms Exercise Unilateral Market Power? Evidence from a Bid-Based Wholesale Electricity Market," EUI Working Papers 2009/36, (2009).

* McRae, Shaun and Frank A. Wolak, "Market Power and Incentive-Based Capacity Payment Mechanisms." 2019. Available at https://www.sdmcrae.com/publication/market-power-and-incentive-based-capacity/

Reguant, Mar. "Complementary bidding mechanisms and startup costs in electricity markets," *Review of Economic Studies*, vol. 81, pp. 1708–1742, June 2014.

** Ryan, Nicholas. *Holding Up Green Energy*. NBER Working Paper 29154. 2021. Available at https://www.nber.org/papers/w29154

Wolak, F. A. (2000). An Empirical Analysis of the Impact of Hedge Contracts on Bidding Behavior in a Competitive Electricity Market. International Economic Journal, 14(2):1-39.

Wolak, F. A. (2003). Identification and Estimation of Cost Functions Using Observed Bid Data: An Application to Competitive Electricity Markets, chapter 4, pages 133-169. Cambridge University Press.

Wolak, F. A. (2007). Quantifying the Supply-Side Benefits from Forward Contracting in Wholesale Electricity Markets. Journal of Applied Econometrics, 22:1179-1209.

3) Electricity Markets: Demand

Allcott, Hunt and Dmitry Taubinsky. 2015. "Evaluating Behaviorally Motivated Policy: Experimental Evidence from the Lightbulb Market." *American Economic Review*, 105(8): 2501-38.

Borenstein, S. and Holland, S. (2005). On the Efficiency of Competitive Electricity Markets with Time-Invariant Retail Prices. The RAND Journal of Economics, 36(3):469-493.

Borenstein, S (2012) "The Redistributional Impact of Non-Linear Electricity Pricing", forthcoming in *American Economic Journal: Economic Policy*.

Severin Borenstein, and James B. Bushnell, *Are Residential Electricity Prices Too High or Too Low? Or Both?* Available at http://papers.nber.org/sched/EEes18. Student presentation by: TBD

Fowlie, Meredith, Catherine Wolfram, C. Anna Spurlock, Annika Todd, Patrick Baylis, and Peter Cappers. 2017. "Default Effects and Follow-on Behavior: Evidence from an Electricity Pricing Program". https://www.meredithfowlie.com/s/main.pdf

Holland, S. P. and Mansur, E. T. (2008). Is Real-Time Pricing Green? The Environmental Impacts of Electricity Demand Variance. The Review of Economics and Statistics, 90(3):550-561.

Holland, Stephen P, Erin T. Mansur, Nicholas Z. Muller and Andrew J. Yates. 2016. "Are There Environmental Benefits from Driving Electric Vehicles? The Importance of Local Factors." *American Economic Review*, 106(12): 3700-3729.

Hortaçsu, Ali, Seyed Ali Madanizadeh, and Steven L. Puller. 2017. "Power to Choose? An Analysis of Consumer Inertia in the Residential Electricity Market." *American Economic Journal: Economic Policy*, 9 (4): 192-226.

* Ito, Koichiro. 2014. "Do Consumers Respond to Marginal or Average Price? Evidence from Nonlinear Electricity Pricing." *American Economic Review*, 104(2): 537–63.

* Ito, Koichiro. 2015. "Asymmetric Incentives in Subsidies: Evidence from a Large-Scale Electricity Rebate Program." *American Economic Journal: Economic Policy*, 7(3): 209–237.

* Ito, Koichiro, Takanori Ida, and Makoto Tanaka. 2018. "Moral Suasion and Economic Incentives: Field Experimental Evidence from Energy Demand." *American Economic Journal: Economic Policy*, 10(1): 240-67.

Kahn, Matthew and Erin Mansur. "Do Local Energy Prices and Regulation Affect the Geographic Concentration of Employment? A Border Pairs Approach". Working Paper. 2011. http://www.dartmouth.edu/~mansur/papers/kahn_mansur_manufacturing.pdf

** Meeks, Omuraliev, Isaev and Wang (2022). Impacts of Electricity Quality Improvements: Experimental Evidence from Infrastructure Investments. Available at https://conference.nber.org/conf_papers/f161563/f161563.pdf

Myers, Erica and Steven L. Puller, Jeremy D. West. 2019. "Effects of Mandatory Energy Efficiency Disclosure in Housing Markets." NBER Working Paper No. 26436.

Reiss, P. and White, M. (2005). Household Electricity Demand, Revisited. Review of Economic Studies, 72(3):853-883.

Reiss, Peter and Matthew W. White, 2008. "What changes energy consumption? Prices and public pressures," RAND Journal of Economics, RAND Corporation, vol. 39(3), pages 636-663.

Wolak, F. A. (2006). Residential Customer Response to Real-Time Pricing: The Anaheim Critical-Peak Pricing Experiment.

Wolak, F. A. (2010). An Experimental Comparison of Critical Peak and Hourly Pricing: The PowerCentsDC Program. Working paper available at Professor Wolak's website.

4) Selection and Targeting in Energy and Environmental Markets

Allcott, Hunt, and Michael Greenstone. Measuring the welfare effects of residential energy efficiency programs. No. w23386. National Bureau of Economic Research, 2017.

Allcott, Hunt, Christopher Knittel, and Dmitry Taubinsky. "Tagging and targeting of energy efficiency subsidies." American Economic Review 105, no. 5 (2015): 187-91.

* Ito, Koichiro, Takanori Ida, and Makoto Tanaka. *Selection on welfare gains: Experimental evidence from electricity plan choice*. No. w28413. National Bureau of Economic Research, 2021.

** Knittel, Christopher R., and Samuel Stolper. Using machine learning to target treatment: The case of household energy use. No. w26531. National Bureau of Economic Research, 2019.

5) Renewable Energy Markets

Aldy, Gerarden, and Sweeney, Investment versus Output Subsidies: Implications of Alternative Incentives for Wind Energy, 2018. Available at http://www.richard-sweeney.com/research/ Student presentation by: TBD

Bollinger, Bryan and Kenneth Gillingham. "Peer Effects in the Diffusion of Solar Photovoltaic Panels." *Marketing Science* (2012), 31(6): 900-912

Borenstein, Severin. 2008. "The market value and cost of solar photovoltaic electricity production." Center for the Study of Energy Markets Working Paper

Borenstein, Severin. 2012. "The Private and Public Economics of Renewable Energy." *Journal of Economic Perspectives*.

Callaway, Duncan and Meredith Fowlie. 2009. "Greenhouse Gas Emissions Reductions from Wind Energy: Location, Location, Location?" http://nature.berkeley.edu/~fowlie/papers.html.

Callaway, Duncan S. 2009. "Tapping the energy storage potential in electric loads to deliver load following and regulation, with application to wind energy." *Energy Conversion and Management,* 50(5):1389---1400.

Cory, Karlynn and Paul Schwabe. 2009. "Wind Levelized Cost of Energy: A Comparison of Technical and Financing Input Variables." National Renewable Energy Laboratory Technical Report NREL/TP---6A2--- 46671. http://www.nrel.gov/docs/fy10osti/46671.pdf.

** Covet and Sweeney 2022. Winds of Change: Estimating Learning by Doing without Cost or Input Data. Available at https://conference.nber.org/conf_papers/f161578/f161578.pdf

Cullen, Joseph. 2013. "Measuring the Environmental Benefits of Wind-Generated Electricity." *American Economic Journal: Economic Policy*, 5(4): 107-33.

Energy Information Administration. 2011. “Levelized Costs in the Annual Energy Outlook 2011.” http://205.254.135.24/oiaf/aeo/electricity_generation.html

Fell, Harrison, Daniel T. Kaffine, and Kevin Novan. “Emissions, transmission, and the environmental value of renewable energy”. Forthcoming at *AEJ: Economic Policy*.

* Gonzales, Ito, and Reguant (2022). The Value of Infrastructure and Market Integration: Evidence from Renewable Expansion in Chile. Available at https://conference.nber.org/conf_papers/f161540/f161540.pdf

Gowrisankaran, Gautam, Stanley S. Reynolds, and Mario Samano, "Intermittency and the Value of Renewable Energy," *Journal of Political Economy* 124, no. 4 (August 2016): 1187-1234.

Hughes, Jonathan and Molly Podolefsky. "Getting Green with Solar Subsidies: Evidence from the California Solar Initiative." *Journal of the Association of Environmental and Resource Economists*, 2(2), June 2015.

Intergovernmental Panel on Climate Change Working Group III. 2011. *Special Report on Renewable Energy Sources and Climate Change Mitigation.* http://srren.ipcc-wg3.de/

Joskow, Paul. 2011. “Comparing the Costs of Intermittent and Dispatchable Electricity Generation Technologies.” *American Economic Review*

National Renewable Energy Laboratory. 2010. “Windpowering America: Estimates of Windy Land Area and Wind Energy Potential, by State, for areas >= 30% Capacity Factor at 80m.” http://www.windpoweringamerica.gov/docs/wind_potential_80m_30percent.xlsx.

Novan, Kevin. 2015. "Valuing the Wind: Renewable Energy Policies and Air Pollution Avoided." *American Economic Journal: Economic Policy*, 7(3): 291-326.

Pless, Jacquelyn and Arthur A. van Benthem. 2017. “The Surprising Pass-Through of Solar Subsidies.” NBER Working Paper #23260.

Schmalensee, Richard. Forthcoming. “Evaluating Policies to Increase the Generation of Electricity from Renewable Energy.” *Review of Environmental Economics and Policy.*

Wiser, Ryan, Galen Barbose, Carla Peterman, and Naim Darghouth. 2009. “Tracking the Sun II: The Installed Cost of Photovoltaics in the U.S. from 1998 - 2008.” Lawrence Berkeley National Laboratory Paper LBNL---2674E. http://eetd.lbl.gov/ea/emp/reports/lbnl---2674e.pdf

6) Natural Gas Markets

Davis, Lucas. Erich Muehlegger. Do Americans Consume Too Little Natural Gas? RAND Journal of Economics, 2010, 41(4), 791-810.

Davis, Lucas. 2021. What Matters for Electrification? Evidence from 70 Years of U.S. Home Heating Choices. Available at https://haas.berkeley.edu/wp-content/uploads/WP309.pdf

** Davis and Hausmann 2022. "Who Will Pay for Legacy Utility Costs?" https://haas.berkeley.edu/wp-content/uploads/WP317.pdf

Marks, Levi, Charles F. Mason, Kristina Mohlin, and Matthew Zaragoza-Watkins (2017). Vertical Market Power in Interconnected Natural Gas and Electricity Markets. RFF Working Paper 17-27.
Available at http://www.rff.org/files/document/file/RFF%20WP%2017-27.pdf

Oil and Gasoline Markets

Anderson, Soren T., Ryan Kellogg, and James M. Sallee, "What Do Consumers Believe About Future Gasoline Prices?" working paper (2010).

Auffhammer, M., & Kellogg, R. (2011). "Clearing the air? The effects of gasoline content regulation on air quality." *American Economic Review*, *101*(6), 2687-2722.

Covert, Thomas R. and Ryan Kellogg (2018). Crude by Rail, Option Value, and Pipeline Investment. Available at http://kelloggryan.com/Papers/CBRpaper.pdf

Covert, Thomas, Richard Sweeney. Relinquishing Riches: Auctions vs Informal Negotiations in Texas Oil and Gas Leasing. http://www.richard-sweeney.com/pdfs/cs_texas.pdf

Borenstein, S., Cameron, C., and Gilbert, R. (1997) "Do Gasoline Prices Respond Asymmetrically to Crude Oil Price Changes?" *Quarterly Journal of Economics*, vol.112, 305-339.

Borenstein, S. and Shepard, A, (1996) "Dynamic Pricing in Retail Gasoline Markets," RAND Journal of Economics, vol. 27, No. 3, 429-451.

Borenstein, S. and Shepard, A, (1996) "Sticky prices, inventories, and market power in wholesale gasoline markets," RAND Journal of Economics, vol. 33, No. 1, 116-139.

Borenstein, S., Bushnell J. and Lewis, M. (2005), "Market Power in California's Gasoline Market, CSEM Working Paper No. 132 (available at http://www.ucei.berkeley.edu/PDF/csemwp132.pdf)

Cuddington, J.T. and Moss, D.L. (2001) "Technological Change, Depletion, and the U.S. Petroleum Industry, " American Economic Review, 1135-1148 (cuddington_and_moss.pdf)

Griffin, J.M. and Xiong, W. (1997) "The Incentive to Cheat: An Empirical Analysis of OPEC, Journal of Law and Economics, 40(2), 289-316.

Hamilton, J. (2008) "Understanding Crude Oil Prices," Department of Economics, UC-San Diego. (understand_oil.pdf).

Hastings, Justine, "Vertical Relationships and Competition in Retail Gasoline Markets: Empirical Evidence from Contract Changes in Southern California." *American Economic Review*, March 2004.

Hastings, Justine and Jesse Shapiro, "Wholesale Price Discrimination and regulation: Implications for Retail Gasoline Prices." Working Paper. April (2008).

Hastings, Justine and Jesse Shapiro, "Mental Accounting and Consumer Choice: Evidence from Commodity Price Shocks." Working Paper. April (2011).

Hastings, Justine, and Jesse Shapiro, "Fungibility and Consumer Choice: Evidence from Commodity Price Shocks," The Quarterly Journal of Economics, vol. 128, pp. 1449–1498, Nov. 2013.

Herrnstadt, Evan, Ryan Kellogg, and Eric Lewis, The Economics of Time-Limited Development Options: The Case of Oil and Gas Leases. Working paper (May, 2020). https://www.nber.org/papers/w27165

Hollingsworth, Alex and Ivan J. Rudik. 2020. *The Social Cost of Leaded Gasoline: Evidence from Regulatory Exemptions*. Available at https://conference.nber.org/conf_papers/f132540/f132540.pdf

Houde, J. F. (2012). "Spatial differentiation and vertical mergers in retail markets for gasoline". *American Economic Review*, 102(5), 2147-2182.

Hughes, Jonathan E., Christopher R. Knittel, and Daniel Sperling, "Evidence of a Shift in the Short-Run Price Elasticity of Gasoline Demand," *Energy Journal* 29 (2008).

Kellogg, Ryan, "Learning by Drilling: Inter-Firm Learning and Relationship Persistence in the Texas Oilpatch," *Quarterly Journal of Economics* 126 (Nov., 2011), 1961-2004.

Kellogg, Ryan. 2014. "The Effect of Uncertainty on Investment: Evidence from Texas Oil Drilling," *American Economic Review*, 104(6): 1698-1734.
Lewis, M., (2004) "Asymmetric Price Adjustment and Consumer Search: An Examination of the Retail Gasoline Market, May 2004 (available at http://economics.sbs.ohio-state.edu/mlewis/APACS_9_1_04.pdf)

Lewis, Matthew and Howard P. Marvel, "When Do Consumers Search?," *Journal of Industrial Economics*, 59 (3), September 2011: 457-483.

Lewis, Matthew and Michael Noel, "The Speed of Gasoline Price Response in Markets with and without Edgeworth Cycles," *Review of Economics and Statistics*, 93 (2), May 2011: 672-682.

McRae, Shaun (2018). Crude Oil Price Differentials and Pipeline Infrastructure. Available at https://www.sdmcrae.com/publication/crude-oil-price-differentials-and-pipeline-infrastructure/crude-oil-price-differentials-and-pipeline-infrastructure.pdf

Muehlegger, Erich and Richard L. Sweeney. Pass-Through of Input Cost Shocks Under Imperfect Competition: Evidence from the U.S. Fracking Boom. 2018. Available at http://papers.nber.org/sched/EEes18

7) Transboundary Pollution

Shaoda Wang and Zenan Wang (2021). The Environmental and Economic Consequences of Internalizing Border Spillovers. Available at http://www.sdwang.org/uploads/4/4/8/5/44856715/draft_ws.pdf

* Heo, Ito, and Kotamarthi (2022). "Mortality Impact of Transboundary Air Pollution: Evidence from East Asia"

** Hernandez-Cortes, Danae, and Kyle C. Meng. *Do environmental markets cause environmental injustice? Evidence from California's carbon market*. No. w27205. National Bureau of Economic Research, 2020.
https://www.nber.org/papers/w27205

8) Environmental economics in Developing Countries

** Citizen Participation and Government Accountability: National-Scale Experimental Evidence from Pollution Appeals in China
Mark Buntaine, University of California, Santa Barbara
Michael Greenstone, University of Chicago and NBER
Guojun He, University of Hong Kong
Mengdi Liu, University of International Business and Economics
Shaoda Wang, University of Chicago
Bing Zhang, Nanjing University
Available at
https://www.nber.org/conferences/environment-and-energy-economics-program-meeting-spring-2022

Chen, Shuai, Paulina Oliva, Peng Zhang, "The Effect of Air Pollution on Migration: Evidence from China" NBER Working Paper No. 24036, 2017. https://www.nber.org/papers/w24036

Chen, Yuyu, Avraham Ebenstein, Michael Greenstone, and Hongbin Li. "Evidence on the Impact of Sustained Exposure to Air Pollution on Life Expectancy from China's Huai River Policy," *Proceedings of the National Academy of Sciences*, 2013, 110 (32): 12936–12941. also available at: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2291154

Ebenstein, Avraham, Maoyong Fan, Michael Greenstone, Guojun He, and Maigeng Zhou. 2017. "The Impact of Sustained Exposure to Particulate Matter on Life Expectancy: New Evidence from China's Huai River Policy," Mimeograph.

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Duflo, Esther, Michael Greenstone, Rohini Pande, and Nicholas Ryan. 2013. "The Value of Discretion in the Enforcement of Regulation: Experiment Evidence and Structural Estimates from Environmental Inspections in India," Mimeograph, 2016. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2513150

Greenstone, Michael and Rema Hanna. 2014. "Environmental Regulations, Air and Water Pollution, and Infant Mortality in India." *American Economic Review,* 104(10): 3038-3072.

Greenstone, Michael and B. Kelsey Jack. 2015. "Envirodevonomics: A Research Agenda for an Emerging Field," *Journal of Economic Literature*, 53(1): 5-42.

Hanna, Rema, and Paulina Oliva, 2015. "The effect of pollution on labor supply: Evidence from a natural experiment in Mexico City." *Journal of Public Economics*, 122: 68-79.

* Ito, Koichiro and Shuang. Zhang. "Willingness to Pay for Clean Air: Evidence from Air Purifier Markets in China." 2020. *Journal of Political Economy*.

Automobile Markets and Transportation (Not covered this year)

Allcott, Hunt and Nathan Wozny, "Gasoline Prices, Fuel Economy, and the Energy Paradox," working paper (2010).

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