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The identification of causal effects in environmental and energy economics

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Environmental and energy economics has grown broad and diverse. The challenges of managing environmental quality, especially in light of climate change and growing energy demands, are well-recognized and becoming increasingly important. At the same time, the research methods of environmental and energy economics continue to advance and provide a basis for more informed decision making. Mirroring trends in empirical economics generally, environmental and energy economists are placing ever more emphasis on careful identification strategies that underlie conclusions about causal effects.

Environmental and energy economists are making greater use of randomized laboratory and field experiments, have trained their eyes to spot natural experiments, and are refining quasi-experimental methods for use in observational studies. The emphasis on identification and causality has brought with it more careful thinking about the sources of variation in data, the presence of self-selection, the assumptions needed for consistent and/or unbiased estimation, and the importance of establishing the robustness of estimates across possible specifications. With increased data collection capabilities and efforts on the part of government agencies, nonprofit organizations and businesses to increase data availability, these identification tools, in turn, provide important synergistic opportunities.

This special issue of the *Journal of Economic Behavior & Organization* (JEBO) on "The Identification of Causal Effects in Environmental and Energy Economics" showcases some of the leading research in the field. The included articles were part of a workshop in July 2013 generously hosted by the Howard H. Baker Jr. Center for Public Policy at the University of Tennessee. The Baker Center was established to honor the legacy of Senator Baker, whose contributions to public policy were numerous and include facilitating passage of the Clean Water Act of 1972 and the Clean Air Act of 1970. As the Baker Center has developed its portfolio of research and policy engagement, it has maintained a steady course in focusing on environmental and energy policy issues. Consistent with this agenda, the workshop attracted papers that span a wide range of methodologies and policy-relevant topics within the field of environmental and energy economics. We thank Matthew Murray, the Director of the Baker Center, along with the Baker Center staff, for their help in making the workshop such a success.

Many of the papers focus on topics related to demand for electricity, and three of them exploit high resolution residential billing data. Benjamin Gilbert and Joshua Graff Zivin investigate how exposure to expenditure information via the receipt of an electricity bill affects the pattern of electricity consumption. Their identification strategy relies on exogenous variation in billing cycles and the availability of hourly consumption data from smart meters. They find reduced consumption following receipt of an electricity bill, with the implication that spending "reminders" can reduce peak demand, particularly during summer months. Katrina Jessoe, David Rapson, and Jeremy Smith consider how shifting to time-of-use billing affects electricity demand using a regression discontinuity approach. They find a surprising response where the program effectively lowered the price of electricity: they observe a decrease rather than an increase in consumption, for which they conjecture explanations based on dynamic considerations and behavioral factors. The paper by Matthew Harding and Alice Hsiaw focuses entirely on psychological and behavioral motives related to voluntary energy conservation. Based on

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comparisons among groups of consumers, some of whom opt into a voluntary program, they find that consumers exhibit present-biased and reference-dependent preferences, and that those who voluntarily choose more realistic conservation goals save substantially more electricity.

Other electricity studies are based on analyses of the distribution grid. Ujjayant Chakravorty, Martinio Pelli, and Beyza Ural Marchand find that improved access to electricity in rural India—including grid connection and reliability—has significant benefits for nonagricultural household incomes. To obtain the estimates and overcome endogeneity concerns, they use an instrumental variable approach based on the density of transmission cables at the district level. Focusing on the United States, Joshua Graff Zivin, Matthew Kotchen, and Erin Mansur develop a new method for estimating the marginal emissions of electricity demand at different hours of the day in different regions of the country. The approach relies on features of electricity transmission within the grid, and they show how the estimates are useful for evaluating a range of electricity shifting policies and behaviors, with a focus in particular on how electric cars affect carbon dioxide emissions.

Two studies provide evidence against conventional wisdom on policies designed to save energy. Arik Levinson considers whether California's energy efficiency standards are responsible for the state's relatively constant residential electricity consumption per capita over a period of time when per capita consumption significantly increased in other states. He finds that the vast majority of the divergence between California and other states is explained by trends in migration within the United States, California's mild climate, and shifting demographics, rather than the frequently cited energy efficiency standards. Alison Sexton and Timothy Beatty contribute to the literature showing that Daylight Saving Time increases electricity consumption rather than decreasing it as intended. While other studies are based on ex post estimates of changes in electricity consumption, Sexton and Beatty use the American Time Use Survey to consider how people adjust their activities when shifting in and out of the time changes. They find evidence that, during Daylight Saving Time, individuals shift energy intensive activities to earlier in the day, which helps explain the increase in electricity consumption.

Several studies focus on water to investigate more general economic phenomena. Casey Wichman uses a shift to increasing block-rate pricing for water to consider whether consumers respond to marginal or average price. A nice feature of the study is that the shift caused marginal and average prices to move in opposite directions, and Wichman uses a regression discontinuity approach to find that most residential water users respond to average price. The non-price based instrument of outdoor watering restrictions is the focus of the paper by Anita Castledine, Klaus Moeltner, Michael Price, and Shawn Stoddard. They find evidence of an unintended consequence whereby consumers that adhere to a more prescribed schedule use more rather than less water. Their identification strategy is based on an exogenous change in the watering restriction and comparisons among households that do and do not follow the regulation. Paul Ferraro and Juan Jose Miranda use the results of a randomized field experiment on the effect of norm-based messages on water conservation to make a more general methodological contribution. Specifically, they engage in a design-replication exercise where they construct a non-experimental control group that is characteristic of observational studies, and then determine whether various quasi-experimental identification techniques are able to replicate the results of the randomized experiment. They find the greatest support for a procedure based on matching to pre-process the data before estimating the treatment effects using ordinary least squares.

The first of two studies related to land use employs the procedure outlined by Ferraro and Miranda. Sarah Jacobson considers a form of policy-induced "leakage" through time, whereby agricultural land unenrolled in the Conservation Reserve Program is more likely than enrolled land to be farmed at a later date, implying that the environmental benefits of the program may be less than anticipated. Jacobson overcomes the identification challenge of finding a valid control group of land that did not enroll in the program by selecting a matched sample based on similar land quality characteristics. The other land use paper, by Martin Burda and Matthew Harding, investigates the extent to which cleanup durations at Superfund sites depend on the demographic characteristics of the surrounding area and may therefore raise questions about environmental justice. Unlike other studies that focus on Superfund listing decisions, their study considers cleanup duration, which helps address endogeneity concerns. While they find that sites located in black, urban, and lower educated neighborhoods are discriminated against initially, the bias has diminished over time consistent with changes in policy.

The final paper reports results of a laboratory experiment on the effects of market design on an emissions trading program. William Shobe, Charles Holt, and Thaddeus Huetteman consider features of California's greenhouse gas emissions trading market where there are limits on allowance ownership, a price containment reserve, and auctions based on the lowest accepted bid. Their main finding is that tight holding limits substantially reduce banking, which in turn reduces market liquidity. The advantage of their identification approach is, of course, is the ability to vary the institutional features exogenously in order to help inform actual market design.

This special issue exemplifies the current application of identification techniques to important issues in environmental and energy economics. As suggested by these articles, the techniques provide us with an opportunity to revisit stylized facts, to carefully identify the effects of policies and interventions, and to inform the creation of new policies. Also evident from this research is that we have much to learn, both in terms of knowledge in the field and methodologies underlying the identification of causal effects. The papers themselves suggest important avenues for future research, and here we highlight two of them. First, one common theme in the papers as well as the program evaluation literature more broadly is that effort is taken to clarify (usually untestable) assumptions needed for identification and to establish the robustness of results. However, as highlighted by the Ferraro and Miranda article, even seemingly sensible assumptions and established estimation techniques can lead to biases. Additional design-replication studies are warranted to help guide model selection. Further, efforts to expand the set of techniques commonly used to establish robustness (e.g., placebo tests) are worthwhile.

One potential avenue lies in within-sample estimations (i.e., estimating treatment effects for subsamples) especially if there is reason to suspect that assumptions are more likely to hold for certain units. Second, while observational data have the advantage of strong external validity, as several papers show, they do not often lend themselves to pinning down the mechanisms underlying treatment effects. Additionally, surprising or unintuitive results observed in the field yearn for additional verification. One possibility therefore is to use the experimental laboratory, which provides a means for isolating the potential underlying mechanisms and identifying treatment effects, as a complementary research approach.

We look forward to such future progressions, and the role that the articles in this special issue will have on shaping them. Collectively and individually, we believe the papers advance the literature in environmental and energy economics.

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