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Program Report

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Environmental and Energy Economics

Don Fullerton*

The NBER's Program on Environmental and Energy Economics (EEE) was initiated in 2007, but has grown to 80 members and 240 NBER Working Papers in less than three years. The Program's research is broad and diverse. Program members study topics as varied as pollution abatement technology, the role of "pollution havens," regulated electricity markets, pollution-tax incidence, and the effects of environmental policy on employment, morbidity, and mortality. Because this body of research is too broad and too diverse to summarize in one Program Report, I will touch on only a few topics here.

Gasoline Use and Vehicle Emissions

Numerous federal policies are directed at the reduction of gasoline consumption, with the aim being to improve environmental quality and to reduce oil imports. Recent research covers a range of such policies, including gasoline taxes, fuel-efficiency regulation, and alternative fuel subsidies. The current federal tax is 18.4 cents/gallon, with state taxes adding about 30 cents more. Changes to the tax at the state level are frequent, as are proposals to alter the federal tax. The sharp gasoline price increases experienced through 2008 offer a valuable source of variation for examining the influence of gasoline price on the vehicle fleet.

Meghan Busse, Christopher Knittel, and Florian Zettelmeyer use this price variation to examine changes in the price and composition of cars purchased.¹ They find that each \$1 increase in the gas price causes more than a 20 percent change in new car sales at the high and low end of fuel efficiency, and changes the resale price for used cars by as much as \$3000. Shanjun Li, Roger von Haefen, and Christopher Timmins investigate the effect on the

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fleet as a whole, showing that each 10 percent increase from the \$2.34 per gallon price in 2005 generated improvements in fuel economy that were only 0.22 percent in the short run and 2 percent in the long run.²

Politically, direct mandates have proven more successful in achieving their goals than gasoline taxes. Still, recent increases in required fuel efficiency of about 30 percent by 2016 raise questions about technological feasibility. However, Knittel draws from a long time-series of vehicle characteristics, estimating shifts in the technological frontier of fuel economy, weight, and power,³ and finds that if technological progress since 1980 had been put toward fuel economy rather than weight and power, it could have reduced fuel use by 50 percent. Meeting the strict new rules may require little more than halting the observed increases in weight and horsepower, he concludes.

Lawrence Goulder, Mark Jacobsen, and Arthur van Benthem examine ambitious new state-level mandates on fuel economy.⁴ Fourteen states have agreed to improve fuel economy by about 45 percent for the 2020 model year, expecting large savings in gasoline use within their borders. Yet 65 to 75 percent of these savings may be offset in the rest of the country. Federal rules are applied nationwide, so more fuel economy in some states means that less is required elsewhere. This issue of overlapping jurisdictions also applies to low carbon fuel standards and to proposals for greenhouse gas reductions.

Some policies and proposals would encourage alternative fuels such as ethanol through subsidies, mandates, and standards. Stephen Holland, Knittel, and Jonathan Hughes examine the low carbon-fuel standard, a mandate on the average ethanol content of fuels in California.⁵ That standard implicitly taxes conventional fossil fuel and subsidizes ethanol; yet the impact of the subsidy component can outweigh the tax and result in more overall emissions of carbon dioxide. Other policies to encourage ethanol production avoid this effect.

Mandated increases in ethanol production from corn also create pressure on world food supplies. Michael Roberts and Wolfram Schlenker calculate that mandated ethanol production in the United States will consume 5 percent of world caloric production from corn, wheat, rice, and soybeans.⁶ They show that U.S. mandates alone could increase world food prices by 20 to 30 percent.

Each of these policies would alter miles driven and change the vehicle fleet, in turn influencing traffic congestion and trade patterns. Lucas Davis and Matthew Kahn study the trade in used vehicles to Mexico, showing that 2.5 million used vehicles were exported in the four years following the North American Free Trade Agreement.⁷ Policies that influence the future of the U.S. vehicle fleet therefore can be expected to affect the Mexican fleet, altering gasoline use in both countries.

Energy Markets

Heightened concerns about climate change have fuelled interest in making energy production and consumption more efficient and less carbon intensive. Leading climate policy proposals would price the externality, so that the cost of energy includes all social costs, but this approach presumes that current energy prices paid by consumers already reflect private supply costs. However, Lucas Davis and Eric Muehlegger document significant departures from marginal cost pricing in domestic natural gas markets.⁸ They estimate that residential and commercial gas customers face an average markup of more than 40 percent over the period 1991–2007.

A paper by Steven Davis, Cheryl Grim, John Haltiwanger, and Mary Streitwieser studies the electricity prices paid by U.S. manufacturing plants from 1963 to 2000.⁹ They document tremendous dispersion in electricity prices paid by manufacturers and they find that marginal supply costs exceed marginal prices for smaller manufacturing customers by 10 percent or more.

The energy sector also is affected by market failures associated with technology innovation and diffusion. Policies that aim to accelerate the development and adoption of clean energy technologies have become an important component of environmental policy more broadly. Gilbert Metcalf analyzes the impacts of incentives for energy investment offered under the Federal tax code.¹⁰ He concludes that the Federal production tax credit has played an important role in increasing investment in wind energy development over the past decade.

Asking a slightly different question, David Popp and Richard Newell posit that new investment in the development of climate change mitigation technologies comes at the expense of other investment.¹¹ Linking patent data and financial data by firm, they ask whether increases in alternative energy R and D are likely to represent new R and D spending, or how much of the additional climate change R and D comes at the expense of other types of patenting activity. Although they find evidence of crowding out for alternative energy firms, they also find that alternative energy patents are cited more frequently, and by a wider range of other technologies, than other patents by these firms, suggesting that their social value is higher.

In addition to environmental externalities and the imperfect appropriability of the returns to R and D, sub-optimal investment in energy efficiency and conservation may be the result of a series of market barriers, market failures, and cognitive failures. These distortions help to rationalize more prescriptive policy interventions, including appliance standards and building energy efficiency codes. EEE Program Members evaluate the impacts of these programs and test some of their underlying assumptions. Using detailed micro data from California, for example, Dora Costa and Matthew Kahn show that the phase-in of building codes in 1983 has effectively reduced residential electricity consumption.¹² Jacobsen and Kotchen analyze the impacts of a more recent building code change in Florida.¹³ Using household-level billing data from Gainesville, they conclude that the increased stringency of the energy code is associated with a statistically and economically significant reduction in both electricity and natural gas consumption.

Economic Effects of Environmental Policy

Environmental and energy policy can affect employment, productivity, and growth, as well as emissions and overall economic welfare. Alternative policies differ in terms of these effects, and therefore deserve study. These policies certainly

affect the price and availability of natural resources, including fisheries,¹⁴ land,¹⁵ water,¹⁶ and petroleum.¹⁷

Policies for environmental protection may affect the benefit or value of ecosystem services. Jared Carbone and Kerry Smith investigate how willingness to pay for such services depends on changes in demand for complementary market goods, where these demands can change with pollution regulations.¹⁸ As a result, partial equilibrium estimates differ from general equilibrium calculations. Arik Levinson matches survey happiness data with EPA air quality data to infer the dollar value of air quality.¹⁹ A major economic impact of environmental policies is their overall cost. Because air quality varies through the course of the year, Maureen Cropper and her co-authors demonstrate that costs can be reduced by limiting driving more on high-ozone days, for example by selling fewer permits to drive on those days.²⁰ Meredith Fowlie, Knittel, and Catherine Wolfram find higher marginal abatement costs for stationary sources than for mobile sources, indicating further cost reductions from reallocation of abatement between those sources.²¹

Environmental protection also has important effects on technology,²² trade,²³ and human health. Using random variations in annual temperature, Olivier Deschênes and Michael Greenstone find that climate change could raise the annual mortality rate from 0.5 percent to 1.7 percent by the end of the twenty-first century, a modest amount that is not statistically significant, except for infants.²⁴ Janet Currie and Reed Walker estimate health damages from congestion-related air pollution.²⁵ They exploit changes in congestion from the introduction of electronic toll collection. As a result of the improved traffic flow, they find that mothers living within two kilometers of toll stations experience more than a 10 percent reduction in the incidence of low birth weight.

The EEE group also studies the distribution of the costs of environmental policy. Some researchers use partial equilibrium or input-output models to calculate the effects of increased energy

costs on output prices, finding regressive effects.²⁶ Others use computable general equilibrium (CGE) models to find effects on factor prices as well as output prices.²⁷ Still others use analytical general equilibrium models with few sectors to solve for expressions that show how parameters affect output prices and factor prices²⁸ and other researchers investigate redistributions between generations,²⁹ between locations,³⁰ or between ethnic groups.³¹

Absent coordinated and harmonized global climate change policy, emissions regulation imposed in one jurisdiction may lead to increases in emissions in other jurisdictions that are less stringently regulated. Meredith Fowlie analyzes the potential for this emissions “leakage” from California’s electricity sector under a source-based cap-and-trade program. Regulation that exempts out-of-state producers achieves approximately one third of the emissions reductions achieved under complete regulation, at more than twice the cost per ton of emissions abated.

James Bushnell and Yihsu Chen develop a regional model of the power sector in the western United States.³² They examine the impacts of alternative cap-and-trade designs on operations, emissions, and electricity prices. Even when the scope of the cap-and-trade program is expanded to include seven western states, they find, emissions leakage in the electricity sector could still be significant. They provide evidence to suggest that emissions leakage could be mitigated significantly by making permit allocations contingent upon past electricity production choices.

Finally, environmental and energy policy may be able to reduce uncertainty. Martin Weitzman first noted the importance of a “fat-tail” probability distribution for damages, such that a climate catastrophe might have low probability but also very high damages that outweigh the effects of discounting.³³ The importance of the possible catastrophe then depends on risk aversion in utility. Constant relative risk aversion means that marginal utility is unbounded, and society would pay huge amounts to avoid a major catastrophe. Robert Pindyck finds that once marginal utility is bounded, extreme results

disappear, and a thin-tailed distribution can yield higher willingness to pay for abatement.³⁴

The Design and Implementation of U.S. Climate Policy

Although academic environmental economists like to discuss major conceptual issues in the choice between pollution taxes, permit systems, or command and control mandates,³⁵ the U.S. House of Representatives in June of 2009 passed actual climate policy legislation. The choices are no longer just conceptual, but involve many small aspects of policy design that collectively determine the effectiveness of the policy. For this reason, Catherine Wolfram and I organized an NBER conference in Washington D.C. in May 2010, which focused on the actual problem of policymakers trying to design climate legislation.

In their paper for the conference, Lawrence Goulder and Robert Stavins show how federal policy interacts with state and local policy to control greenhouse gas (GHG) emissions.³⁶ For cap-and-trade legislation, a regional policy reduces pressure on federal constraints and allows polluters in other regions to increase emissions.

With a carbon tax, however, a particular region can have a stricter policy without that leakage. Kahn points out that cities have policies affecting carbon emissions, too.³⁷ Zoning rules may encourage urban density, for example, which can reduce commuting, residential unit sizes, and thus energy use.

Lucas Davis points out that the House Bill also tightens energy efficiency standards for consumer appliances.³⁸ Such standards are not necessary if higher energy prices encourage energy-efficient appliances, but they may help if landlords buy cheap inefficient appliances because renters pay electric bills. Controlling for household income and characteristics using household-level data, Davis finds that renters are significantly less likely to have efficient appliances.

Kotchen studies the effects of voluntary programs on “green electricity” adop-

tion.³⁹ Knittel and Ryan Sandler analyze the effects of carbon pricing on GHG emissions from the transportation sector; they find large effects of gasoline prices on consumer choices both about vehicle miles travelled and about when to scrap older vehicles.⁴⁰ Other papers prepared for the conference analyze distributional effects,⁴¹ interactions of climate policy with other regulations,⁴² and issues of monitoring and enforcement.⁴³

Continuing with the details of cap-and-trade policy, Meredith Fowlie looks at whether eligibility for output-based allocation of permits might be based on energy intensity and import penetration in a way that would mitigate adverse impacts on international competitiveness.⁴⁴ Robertson Williams analyzes the time-profile of climate policies, finding efficiency reasons for phase-in of a permit policy but not for a carbon tax.⁴⁵ Erin Mansur looks at reasons to implement climate policy downstream (on emissions) rather than upstream (on the carbon content of coal, natural gas, and petroleum).⁴⁶

Climate policy is likely to have other effects as well. Stephen Holland shows how carbon emission restrictions might have output effects that reduce other pollutants, or substitution effects that increase other pollutants.⁴⁷ Olivier Deschênes notes that higher industrial energy costs may affect labor demand; he uses 30 years of data to estimate a cross-price elasticity of -0.15 to -0.08, implying that the proposed bill’s 3 percent increase in electricity prices might result in 0.3 percent less employment in the short run.⁴⁸ Charles Kolstad looks at incentives for R and D, showing that a permit system can allow the innovator to capture the gains from innovation, while a tax system might not.⁴⁹

The design of climate policy also must account for international considerations. Kala Krishna uses a general equilibrium model to draw analogies between emission permit restrictions and quotas or other trade restrictions, with effects on output prices, factor prices, and traded quantities.⁵⁰ Besides the effects on traded goods, climate policy might create trade in “offsets,” with problems that are ana-

lyzed by James Bushnell.⁵¹ More broadly looking at all natural-carbon cycles, Severin Borenstein notes that many types of human activities could have indirect as well as direct effects on climate, in ways that might be very difficult to regulate.⁵²

V. Kerry Smith suggests that besides introducing carbon pricing, climate policy might provide incentives for adaptation.⁵³ Changes in climate will affect the demand for substitutes, for example when variations between normal and dry periods change the residential demand for water.

Finally, Michael Roberts and Wolfram Schlenker look at the effects of climate change on agricultural output.⁵⁴ While average yields have risen over past decades, crop tolerance to extreme heat has not. Unfortunately, climate change may significantly reduce yields under current technologies.

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