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The Consequences of U.S. Fuel Performance Standards

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The United States consumes more petroleum-based liquid fuel per capita than any other developed country — 30 percent more than the second-highest consumer (Canada) and 40 percent more than the third-highest consumer (Luxembourg). The majority of U.S. oil consumption — 70 percent — goes into the transportation sector.

A variety of policies has been adopted to reduce petroleum consumption, with the justification for such policies usually being the negative effects of this consumption. For example, the transportation sector contributes to local pollution, accounting for 67 percent of carbon monoxide emissions, 45 percent of nitrogen oxide (NOx) emissions, and significant emissions of particulate matter and volatile organic compounds. These emissions contribute to air pollution and lead to health problems ranging from respiratory ailments to cardiac arrest. Both NOx and volatile organic compounds are precursors to ground-level ozone (smog). The transportation sector accounts for roughly 30 percent of U.S. greenhouse gas emissions, contributing to climate change. In addition, oil consumption leads to externalities associated with energy security and to potential macroeconomic costs associated with oil dependency.

Within the United States, a number of policies aimed at reducing oil consumption rely on "performance standards."[1] In the transportation context, performance standards require manufacturers, for example automobile manufacturers, to meet some performance benchmark. In the case of Corporate Average Fuel Economy (CAFE) standards, the geometric average fuel economy of a given manufacturer must exceed the benchmark. For local pollutants, standards are typically set on average per-mile emissions of a given pollutant, such as nitrogen oxides or carbon monoxide.

Policymakers more recently have adopted performance standards for fuels. For example, California's "Low Carbon Fuel Economy Standard" (LCFS) sets a maximum average carbon intensity for fuels — effectively a CAFE standard for fuels. The LCFS in essence requires a fuel producer to sell a prescribed amount of comparatively low-carbon fuels, such as some types of ethanol, for every gallon of gasoline sold. At the federal level, the Renewable Fuel Standard (RFS), while not setting a direct performance standard, sets a minimum total amount of different types of ethanol that must be sold in a given year. The way the RFS is implemented makes it similar to a performance standard.

While the United States traditionally has relied on performance standards, taxing various externalities directly — so-called "Pigouvian taxes," after the British economist A.C. Pigou who advocated them — would provide an alternative approach to reducing the externalities associated with fuel consumption. In a series of research studies, Stephen Holland, Jonathan Hughes, and I compare the economic consequences of fuel-based performance standards and Pigouvian taxes, notably carbon taxes. This research summary briefly describes the work and points to future directions for research.

The Economic Efficiency of Low Carbon Fuel Standards

Our first project in this line of research analyzes how an LCFS affects market equilibria and uses simulations to understand the outcomes of national LCFSs that reduce the average carbon intensity of fuels by 1, 5, and 10 percent.[2] Our theoretical modeling illustrates that a performance standard can be thought of as a tax-and-subsidy program. In particular, any product whose carbon intensity is better than the standard is subsidized, while any product whose carbon intensity is worse than the standard is taxed. The relative size of the tax/subsidy moves linearly with the fuels' carbon intensities.

We can readily compare these pricing effects to those of Pigouvian taxes. Under Pigouvian taxes, the tax moves linearly with the fuels' carbon intensities, but no fuels are subsidized. We show that if demand is perfectly inelastic, then an LCFS can achieve economic efficiency; however, if demand is not perfectly inelastic the average cost of the LCFS per unit of carbon reduced will exceed the average cost of carbon reductions under a Pigouvian carbon tax.

Having established the theoretical properties of a LCFS, we next simulate market outcomes. This entails parameterizing the demand for liquid fuels, the supply curves for gasoline and ethanol, and the relative carbon intensity of the two fuels. We investigate a number of alternative sets of assumptions. Our results suggest that the social cost of greenhouse gas reductions under an LCFS tends to be at least five times greater than the social cost of greenhouse gas reductions under carbon pricing. While changing the underlying parameter assumptions has significant implications for the level of costs, changes in the relative costs across the two policies are much smaller.

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Unintended Consequences of Performance Standards

Our next paper in this line of work, with additional co-author Nathan Parker, expands the scope of policies and refines our supply curves for low-carbon fuels.[3] In particular, we analyze not just carbon pricing and LCFSs, but also the existing U.S. Renewable Fuel Standard and the biofuel subsidies that expired in 2012. We also expand the scope of economic outcomes that we analyze, and consider changes in land-use patterns, the potential for uncontrolled emissions, and incentives for innovation.

The Renewable Fuel Standard defines minimum sales for five different "types" of biofuels, differentiated by their carbon intensities. For each gallon of gasoline a refinery sells, it must sell some fraction of a gallon of ethanol. We use detailed, spatially-differentiated, simulation-based information on the distillation method, the feedstock, and collection and transportation costs required to produce ethanol to construct supply curves for the different types of ethanol, representing supply conditions in 2020. Our supply curves not only provide us with information on the cost of a given type of ethanol, but also its carbon content, the county where the distillery would be located, and the source and county location of the feedstock for the ethanol. These supply curves allow us not only to simulate market outcomes under different policies, but to also understand how county-level land use patterns and other outcomes change as a result of the policy.

We begin by simulating the reduction in greenhouse gas emissions resulting from the existing RFS. We then define an LCFS and carbon-pricing policy that leads to the same reduction in greenhouse gas emissions.[4] The performance standards rely more heavily on replacing gasoline consumption with ethanol consumption to achieve policy goals, while the Pigouvian taxes rely more heavily on reductions in consumption than on increases in biofuels. For example, our simulations suggest that the RFS leads to an additional 39 million acres of crop land devoted to production of ethanol feedstocks, compared to business as usual, to achieve a 10.2 percent reduction in greenhouse gas emissions, while carbon pricing results in only 1.2 million addition acres devoted to such crops.[5]

By construction, all of our policies lead to the same reduction in greenhouse gas emissions; however, if there exist other negative externalities associated with biofuels, then focusing only on greenhouse gas reductions understates the economic inefficiencies of performance standards. What are these other externalities? There has been considerable work measuring the externalities associated with land-use changes and farming practices, including the costs associated with habitat loss and fertilizer run-off. We consider a range of values for the cost of such externalities, varying from $10 to $25 per acre of additional cropland devoted to ethanol feedstock production. Under these assumptions, the cost of the externalities arising from land-use changes from the RFS is between 6 and 16 percent of the social cost of carbon. There are virtually no such externalities from a carbon pricing policy.

The heavy reliance on ethanol for greenhouse gas reductions under performance standards, instead of demand reductions, leads to the potential for a second unintended consequence: uncontrolled emissions arising from understating the carbon intensity of corn-based ethanol. The true carbon intensity of ethanol is controversial and difficult to estimate because tailpipe emissions must be adjusted for upstream carbon credits from biomass growth. Some claim corn-based ethanol has 80 percent of the carbon content of gasoline, while others claim it has more carbon than gasoline.[6] If the political process leads to policies that are based on an underestimate of the carbon content of biofuels, perhaps due to lobbying by renewable fuel proponents, then performance standards result in more "uncontrolled" emissions than carbon pricing. Our simulations suggest that if the true carbon intensity of corn-based ethanol is 90 percent of gasoline, instead of the assumed 80 percent, uncontrolled emissions are 7 percent and 4 percent of claimed emission reductions under the RFS and LCFS, respectively; they would be less than 1 percent for carbon pricing.

Finally, we compare the incentives to develop "second-generation" biofuels under an LCFS and carbon pricing. In principle, the RFS requires second-generation biofuels. Development of these fuels has lagged the RFS requirements, however, leading to annual waivers for their required sales. Therefore, understanding how different policies may affect innovation incentives is important for understanding their long-run implications.

We calculate the change in social surplus from having biofuels in the market by simulating outcomes with and without the supply curves for the second-generation biofuels. We find that the increase in social surplus is larger under carbon pricing under an LCFS. This is because the incentives to develop second-generation biofuels are inefficiently low under the LCFS regime, because the implicit price on carbon is lower than that corresponding to the optimal Pigouvian tax. The latter provides the socially efficient incentive for the development of new technologies.

We also decompose changes in social surplus into changes in consumer surplus, changes in the producer surplus of corn-based ethanol producers, and changes in the producer surplus of second-generation producers. Under the LCFS, there is a larger increase in consumer surplus from the development of second-generation biofuels, compared to carbon pricing, but there is a large reduction in producer surplus because corn-based ethanol producers are harmed by the development of second-generation ethanol under the LCFS.

Why Do We Have Performance Standards?

Given the higher social cost of greenhouse gas reductions and the other potentially negative unintended consequences of performance standards, we investigate one potential reason for their popularity: the distribution of winners and losers under alternative policies.[7] As noted, the

detailed supply curves for different types of ethanol described above allow us to trace the origin of the feedstock and distillery for each gallon of ethanol sold in the market. That is, for each gallon of ethanol sold, we can trace not only the type of feedstock used, but also the county in which the feedstock was grown or originated and the location of the distillery that manufactured the ethanol. Given data on the costs associated with distilleries and feedstocks, we are then able to calculate and simulate the county-level economic rents from different policies. We combine this with changes in consumer surplus to generate county-level net gains and losses from the different policies toward transportation fuel use.

Our simulations suggest another key difference between performance standards for transportation fuels and carbon taxes. While the average social cost per unit of greenhouse gas emissions abated is higher under performance standards than under carbon pricing, the distribution of gains and losses across counties is right-skewed, with a very long right tail. In short, while the social cost may be higher for the average county under performance standards, there are far greater numbers of bigger winners under performance standards than under carbon pricing. For example, while the social cost of greenhouse gas reductions under the RFS is roughly $60 per ton, one county gains over $6,500 per person per year. In contrast, the social cost of greenhouse gas reductions under carbon pricing is less than $20 per ton, but no county gains more than $1,100 per person per year. There are similar differences at different points of the distribution. For example, the 90th percentile of county gains and losses under the RFS is roughly $700 per person per year; the 90th percentile under carbon pricing is $35. The fact that the average person may lose slightly more under the RFS, but that there are also large winners, may imply that no individual has an incentive to lobby against an RFS, while some individuals have a large incentive to lobby for an RFS.

We also investigate whether differences in the distributions of winners and losers correlates with political activity. We aggregate our county-level measures of winners and losers to Congressional House districts and correlate these with campaign contributions and House voting behavior on H.R. 2454, also known as the Waxman-Markey Bill, which would have established a national cap-and-trade program for greenhouse gas emissions. The bill would have severely limited the economic rents associated with the RFS. Therefore interested parties likely viewed the Waxman-Markey Bill and the RFS as competitors.

We find that our simulated gains and losses from the RFS help to explain House voting behavior and campaign contributions even after we condition on the Congress Member's ideology, the district's per-capita greenhouse gas emissions, power plant emissions, corn production, and gains under cap and trade. A Congressman whose district stands to gain more from the RFS than from carbon pricing was less likely to vote for the Waxman-Markey bill. Furthermore, the Congressman was more likely to get campaign contributions from organizations that opposed Waxman-Markey if the Congressional district's simulated gains from the RFS were larger. These results suggest a political-economy-based explanation for the popularity of externality-reduction policies that are not as economically efficient as Pigouvian taxes.

Summary

The U.S. has historically relied on performance standards to reduce externalities associated with the transportation sector. My work has tried to better understand how performance standards affect the economic cost of emission reductions, incentives for innovation, and the distribution of winners and losers. Future work should investigate these issues for other alternatives to Pigouvian taxes, such as subsidies, and allow for additional potential market failures.

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[1] *This is in stark contrast to other developed countries, such as those in Europe, that have also relied on higher fuel taxes. For a discussion of this, see C. R. Knittel, "Reducing Petroleum Consumption from Transportation," NBER Working Paper No. 17724, January 2012, and* Journal of Economic Perspectives, *26 (1), 2012, pp. 93–118, and C. R Knittel, "The Energy-Policy Efficiency Gap: Was There Ever Support for Gasoline Taxes?" NBER Working Paper No. 18685, January 2013, and* Tax Policy and the Economy, *forthcoming.* Return to text

[2] *S. P. Holland, J. E. Hughes, and C. R. Knittel, "Greenhouse Gas Reductions under Low Carbon Fuel Standards?" NBER Working Paper No. 13266, July 2007, and* American Economic Journal: Economic Policy, *1 (1), 2009, pp. 106–46.*
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[3] *S. P. Holland, J. E. Hughes, C. R. Knittel, and N. C. Parker, "Unintended Consequences of Transportation Carbon Policies: Land-Use, Emissions, and Innovation," NBER Working Paper No. 19636, November 2013 and* Energy Journal, *forthcoming.* Return to text

[4] *We also simulate the implications of the previous biofuel subsidies.* Return to text

[5] *There are roughly 400 million acres of cropland in total. http://www.census.gov/prod/2011pubs/12statab/agricult.pdf*
Return to text

[6] *For a discussion of competing views, see T. Searchinger, R. Heimlich, R. A. Houghton, F. Dong, A. Elobeid, J. Fabiosa, S. Tokgoz, D. Hayes, and T.-H. Yu, "Use of U.S. Croplands for Biofuels Increases Greenhouse Gases Through Emissions From Land-Use Change,"* Science, *319 (5900), 2008, pp.1238–40.*
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[7] *S. P. Holland, J. E. Hughes, C. R. Knittel, and N. C. Parker, "Some Inconvenient Truths About Climate Change Policy: The Distributional Impacts of Transportation Policies," NBER Working Paper No. 17386, September 2011, and* Review of Economics and Statistics, *forthcoming.*
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