RESEARCH HIGHLIGHTS

Output and Attribute-Based Carbon Regulation Under Uncertainty

by Ryan Kellogg

Can the flexibility benefits of output and attribute-based regulations outweigh the costs imposed by the incentives they generate to produce too much output and over-sized products?

Context

Economists frequently tout carbon taxes and cap-and-trade programs as the most efficient ways to reduce carbon emissions because they directly put a price on carbon. At the same time, economists often view other forms of regulation—such as output-based standards that regulate emissions as a function of output, or attribute-based fuel economy standards that allow larger vehicles with a bigger footprint to have greater emissions—as less efficient because they encourage excessive output and vehicle size (Ito and Sallee, 2018).

Existing research on the efficiency of output-based and attribute-based regulations has largely assumed that the economic environment is certain. In practice, however, regulators often face tremendous uncertainty about the future when they establish carbon regulations. Consider fuel economy standards: The cost of complying with a fixed miles-per-gallon standard is influenced by gasoline prices and the demand for vehicles, among other factors. Similarly, in the electricity sector the cost of complying with an emissions cap will be determined by the prices of low- versus high-carbon fuels and by consumers' demand for power.

Thus, consumers' and firms' cost of compliance with a fixed emissions cap may depart considerably from what regulators expected when they initially set the standard. Output and attribute-based standards can help dampen compliance cost fluctuations because they allow emissions to vary following fuel price shocks or demand shocks. For instance, if there is a substantial increase in the demand for power (due perhaps to a very hot summer or to an economic boom), an output-based standard can avoid a large spike in compliance cost by allowing both output and emissions to increase.

Method

To answer this question, Kellogg develops a simple economic model of supply and demand for goods—such as vehicles or electricity—that generate carbon emissions. Absent regulation, the level of emissions and the good's output (or attributes) are affected by shocks to both fuel prices and consumer demand. The environmental regulator must set an emissions standard before knowing the shocks. Kellogg then quantitatively applies the model to both fuel economy standards and the U.S. electricity sector.

> "At the time when a regulator is setting a policy, it's very hard for them to predict how the price of fuel or the demand for the good might change over the life of the policy. This uncertainty makes creating rules with a fixed cap on emissions difficult and risky in the sense that they may either become more expensive or possibly much cheaper than expected, in which case you miss out on low-cost emissions reduction. In a highly-uncertain landscape like this, that uncertainty should be considered when designing a policy."
>
> **RYAN KELLOGG,**
> **PROFESSOR, HARRIS SCHOOL OF PUBLIC POLICY**

Key Findings

- When there is uncertainty about future demand for the good's output or the value of one of its attributes (e.g., vehicle footprint), at least some amount of output or attribute-basing improves expected welfare relative to a "flat" emissions standard. Substantial output-basing, or even an intensity standard (which regulates emissions proportionately to output), can improve economic efficiency when uncertainty about future demand is large relative to the damages caused by emissions.
- Uncertainty about fuel prices alone cannot justify output or attribute-based standards on economic efficiency grounds.
- For attribute-based fuel economy standards, uncertainty about future demand for vehicle size is so small that the optimal footprint-based standard is essentially flat. Thus, accounting for uncertainty does not substantially alter the conclusions of Ito and Sallee (2018) that footprint-based fuel economy standards are inefficient.
- Uncertainty about the future demand for electricity is large, so that an intensity standard—such as the rate-based standards envisioned by the Obama-era Clean Power Plan--can potentially out-perform a fixed emissions standard. Under a flat standard, uncertainty implies that the standard has a high risk of never binding (if demand is low or the price of low-carbon fuels is low) or of imposing a very high abatement cost (if demand is high or the price of low-carbon fuels is high).
- A tax on carbon yields strictly greater expected welfare than flat, output-based, or attribute-based standards, since the tax eliminates abatement cost uncertainty while avoiding distortions to output or to goods' attributes. The same is true of an emissions cap that is indexed to exogenous sources of uncertainty (such as fuel prices or GDP) rather than to endogenously-determined objects such as goods' output or attributes.

CLOSING TAKE-AWAY

In most cases, a fixed emissions standard, such as a cap-and-trade program, delivers greater welfare benefits than output or attribute-based standards. At least one exception is in the electricity market, where uncertainty about the demand for electricity is so large that an intensity standard—such as one that is rate based—may be the smarter policy choice. In all scenarios, a carbon tax delivers the greatest welfare benefits.

The Energy Policy Institute at the University of Chicago (EPIC) is confronting the global energy challenge by working to ensure that energy markets provide access to reliable, affordable energy, while limiting environmental and social damages. We do this using a unique interdisciplinary approach that translates robust, data-driven research into real-world impacts through strategic outreach and training for the next generation of global energy leaders.