A Microeconomic Framework for Evaluating Energy Efficiency Rebound and Some Implications

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Improving the efficiency with which we use energy is often argued to be the most cost-effective way to reduce energy use and greenhouse gas (GHG) emissions. Yet, such improvements usually lower the cost of using energy-intensive goods and may create wealth from the energy savings, both of which tend to increase energy use, known as the "rebound" effect. With increased focus on reducing GHG emissions, the size of rebound and the net effect of energy efficiency policies have again become central policy questions. There are wide disagreements about the magnitude of energy efficiency rebound, with efficiency advocates sometimes arguing that it is just a few percent of the efficiency gains and detractors sometimes asserting

that rebound completely offsets any savings from energy efficiency improvements (a phenomenon known as “backfire”).

Differing views on energy efficiency rebound, however, seem to stem as much from the lack of a common framework for the analysis as from different estimates of key parameters. In this paper, I present a theoretical framework that parses rebound into the economic concepts of income and substitution effects. The framework captures the wide range of rebound effects that have been termed direct, indirect, re-spending, and transformational rebound, among others. It does not capture economy-wide impacts, such as the potential impact of energy efficiency in lowering energy prices, which I discuss separately.

Using the framework, I investigate two common phenomena that are nearly always ignored in rebound analysis: energy prices that are above marginal cost and consumers making non-optimizing choices. The paper points out that when energy is priced above marginal cost, a decision to invest in energy efficiency may make the consumer better off financially, but the lost energy sales make the seller worse off by the difference between price and their marginal cost.

Ignoring this negative income effect on sellers will tend to overstate rebound. Prices above marginal cost are very common for electricity and natural gas due to the need to recover significant fixed costs. They are also common in transportation fuels due to high taxes, in which case a decline in energy consumption lowers revenues to the tax collector (lowering public services or requiring that other taxes rise).

The paper also highlights the tension between the rebound calculations based on the notion that consumers carefully re-optimize in response to lower energy service costs and the common idea that consumers fail to invest in energy efficiency because they pay little attention to energy costs. For instance, if a consumer doesn't install energy efficient lighting because he/she doesn't recognize the cost of having lights on, then a regulation requiring more efficient bulbs seems unlikely to induce her to leave the lights on much more. Conversely, if consumers are very good optimizers already, then new energy standards are more likely to create negative income effects, which reduces rebound.

I then explore the implications of this framework for measurement of rebound, examining rebound from improved auto fuel economy and lighting efficiency. The illustrative calculations I carry out suggest that rebound that more than offsets the savings from energy efficiency – backfire – is unlikely, but rebound that significantly reduces the net savings from at least these energy efficiency improvements – possibly by 10% to 40% – is quite plausible.

The framework I present here could be adopted in studying rebound and net energy savings from a wide variety of energy efficiency policies. It could also help guide critiques of studies that consider only part of the rebound picture, such as failing to account for the full income effect when price differs from marginal cost or failing to account for the full substitution effect by omitting consideration of the energy savings when a consumer buys less of some other good in order to buy more of the good that has become more energy efficient.

Energy efficiency improvements are often 20%-40% of industrialized countries' plans for reducing GHG emissions. Understanding and measuring rebound accurately is critical in assessing how achievable those plans are.