How High the Rebound? Evidence for German Households

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As countries across the world grapple with the question of how to reduce consumption of fossil fuels without compromising economic growth, improvements in energy efficiency are frequently turned to as a cost-effective means for promoting both environmental stewardship and energy security. To this end, the European Commission enacted new legislation in 2009 that sets limits on the allowable per-kilometer carbon dioxide (CO2) emissions of newly registered automobiles. Resembling the U.S. Corporate Average Fuel Economy (CAFE) standards, this regulation includes legally codified targets for the maximum CO2 discharges per kilometer that increase with the vehicle mass. Specifically, the standards have been set such that a fleet-wide average of 130 grams CO2/km by 2015 is achieved. As noncompliance with the allowable emissions will result in heavy fines starting in 2012, the Commission expects that this measure will induce considerable incentives for the development of fuel-saving technologies.

The Magnitude of the Rebound Effect—A Controversial Issue

A critical issue in gauging the merits of fuel efficiency standards concerns how consumers adjust to altered unit costs of car travel. While higher fuel prices—as implied by soaring oil prices or increased taxes—raise these costs, improved efficiency effectively reduces them, thereby stimulating the demand for car travel. Such a demand increase is referred to as the direct rebound effect, as it offsets—at least partially—the reduction in energy demand that results from an increase in efficiency.

Though the basic mechanism underlying the rebound effect is widely accepted, its magnitude remains a contentious question. Recent work on short-run estimates by West (2004) and Frondel, Peters, and Vance (2008), who use household-level pooled and panel data from the United States and Germany, puts the estimated rebound effect at the high end of this range, averaging between 87 percent and 57 percent, respectively. This would imply that the relative reduction in fuel consumption due to a 100 percent increase in efficiency is only on the order of 13 to 43 percent, while the remainder of 57 to 87 percent of the efficiency improvement is offset by behavioral changes, most notably mobility demand increases.

Aside from differences in the estimation methods employed and in the level of data aggregation, one major reason for the diverging results of the empirical studies is that there is no unanimous definition of the direct rebound effect. Instead, several definitions have been employed in the economic literature as determined by the availability of price and efficiency data. The most natural definition of the direct rebound effect is based on the elasticity of the demand for a particular energy service, such as conveyance, with respect to efficiency. An efficiency elasticity of 0.5, for instance, means that a 1 percent increase in efficiency would imply an increase in travel demand of 0.5 percent.

Because of challenges in finding data containing an exogenous source of variation in measures of efficiency, empirical estimates of the rebound effect are frequently based on alternative, yet not equivalent rebound definitions, such as the negative of the fuel price elasticity of fuel consumption. The use of this definition reflects the fact that the direct rebound effect is, in essence, a price effect, which works through shrinking service prices: It represents the behavioral response to varied unit costs of energy services such as car traveling due to an improvement in fuel efficiency. On the basis of fuel price elasticities and direct measures of fuel efficiency, Frondel, Peters, and Vance (2008) estimate the rebound effect for the mobility behavior of German households and obtain robust results across rebound definitions and estimation methods. Their findings, drawn from data spanning 1997 through 2005, corroborate the effects obtained from other household-level studies, which are generally larger than those from aggregate time-series data.

Robust Rebound Effect Estimates for German Households

Using standard econometric methods such as Ordinary Least Squares (OLS) and panel estimators (e.g. Wadud, Graham, and Noland 2010), more recent research has addressed heterogeneity in the responsiveness of households to changes in prices and efficiency by interacting these variables with geographic and sociodemographic attributes. This is the common approach to allow for different effects by income groups or other demographics. One potentially restrictive feature of these methods is that they preclude the ability to estimate differential effects of an explanatory variable, such as fuel prices, at different points in the distribution of a dependent variable, such as miles driven. Quantile regression avoids this restriction by allowing estimation of the rebound effect at different points of the distribution of the dependent variable in order to obtain potentially divergent rebound effects for those households that drive a lot versus for those that drive very little

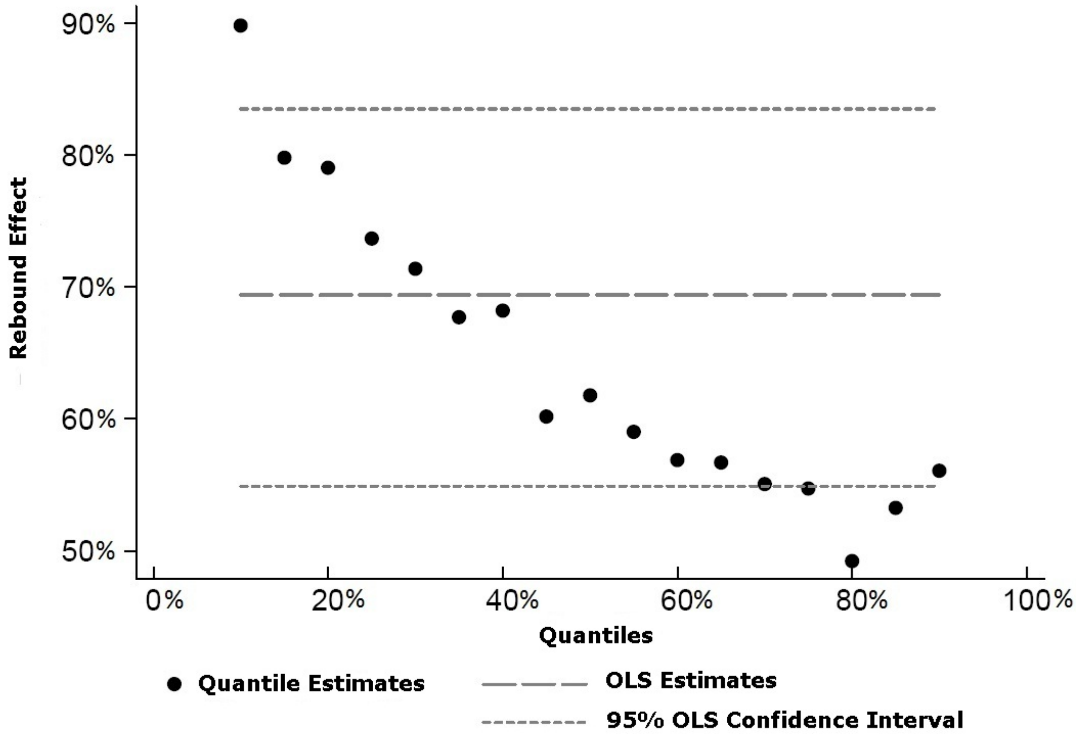
Further investigating the individual mobility of German households with an expanded dataset extending to 2009, Frondel, Ritter, and Vance (2010) employ this technique to explore heterogeneity in the rebound effect according to driving intensity. They find that the magnitude of the estimated rebound effect depends inversely on the households' driving intensity: Households with low vehicle mileage exhibit rebound effects that are significantly larger than for those households with high vehicle mileage (Figure 1).

For instance, households with a driving intensity in the 10 percent decile of the distances traveled exhibit a rebound effect of about 90 percent, which is substantially larger than the rebound effect of about 50 percent found for households from the 80 percent decile. Consistent with intuition, for households that are highly dependent on the automobile, the increase in the distance traveled due to lowered mobility cost (for example, as a consequence of efficiency improvements) is lower than that of households with a low individual mobility demand. All in all, the estimated rebound effects are relatively high, irrespective of driving intensity. The median regression rebound estimate amounts to 62 percent, which is roughly of the same order as the mean estimate of some 60 percent obtained by Frondel, Peters, and Vance (2008).

Conclusion

On the basis of these findings, the European Commission's increased reliance on per-kilometer emission mandates as a key instrument for reducing total emissions from transport should be met with skepticism. We would instead concur with Sterner (2007) that fuel taxes should continue to play an important role in climate policy. Unlike fuel efficiency standards, fuel taxes directly confront motorists with the cost of driving, which not only encourages the purchase of more fuel efficient vehicles, but also has an immediate impact on driving behavior. We thus regard the Commission's recently proposed and highly controversial draft on a new Energy Tax Directive as a step in the right direction. This draft envisages to tax fuels based on their energy content and, hence, the related CO2 emissions.

Figure 1. Quantile-Regression Results for the Rebound Effect



Further Reading

Frondel, M., N. Ritter, and C. Vance. 2010. Heterogeneity in the Rebound Effect – Further Evidence for Germany. Ruhr Economic Papers No. 227. RWI.

Frondel, M., J. Peters, and C. Vance. 2008. Identifying the Rebound: Evidence from a German Household Panel. *The Energy Journal* 29(4): 154–163.

Graham, D.J. and S. Glaister. 2004. Road Traffic Demand Elasticity Estimates: A Review. *Transport Reviews* 24(3): 261–274.

Sterner, T. 2007. Fuel Taxes: An Important Instrument for Climate Policy. *Energy Policy* 35: 3194–3202.

Wadud, Z., G.J. Graham, and R.B. Noland. 2010. Gasoline Demand with Heterogeneity in Household Responses. *The Energy Journal*, 31 (1): 47–74.

West, S. E. 2004. Distributional Effects of Alternative Vehicle Pollution Control Policies. *Journal of Public Economics* 88(3–4): 735–757.