***Heterogeneity in the Rebound: Further Evidence for Germany***

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## Overview

To maintain climate protection policy on track, in 2009 the European Commission enacted new legislation under the auspices of Regulation No. 443/2009 to reduce the per-kilometer CO2 emissions of newly registered automobiles. This regulation includes legally codified targets for the maximum CO2 discharges per kilometer that are allowed to increase with the mass of vehicles. As non-compliance 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 (Frondel, Schmidt, and Vance 2010). Even if this directive were to be effective indeed in improving the fuel efficiency of automobiles, a critical question in gauging the merits of such policy measures 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 demand increases are referred to as the rebound effect, as it offsets 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.

Using quantile-regression methods and a panel of household travel diary data collected in Germany between 1997 and 2009, this study investigates the heterogeneity of the rebound effect in private transport. With the average rebound effect being in the range of 57% to 67%, our results are in line with a recent German study by Frondel, Peters, and Vance (2008), but are substantially larger than those obtained from other studies. Furthermore and strongly depending on the households’ traveling intensity, our quantile-regression results indicate large differences in the fuel price elasticities that are typically employed to identify the rebound effect. While the magnitude of fuel price elasticities, and hence, of the rebound effects is large for households that drive less, the opposite is true for households that intensively use their automobiles.

## Methods

We estimate the following model specification, where the logged monthly vehicle-kilometers traveled, ln(*s*), is regressed on logged fuel prices, ln(*pe*), and a vector of control variables **x**:



Subscripts *i* and *t* are used to denote the observation and time period, respectively. ξ*i* denotes an unknown individual-specific term, and ν*it* is a random component that varies over individuals and time. On the basis of this model, the rebound effect is obtained by the negative estimate of the coefficient *αpe* that is associated with logged fuel prices.

In contrast to OLS and classical panel estimation methods, which focus on the conditional expectation



and yield a uniform rebound effect given by the negative of the coefficient α*pe*, quantile- regression approaches aim at providing a more complete picture of the relationship between the outcome variable and the regressors at different points in the conditional distribution of the dependent variable, thereby allowing for more flexibility in the estimation of rebound effects:



where τmay take on values between zero and unity, *Qτ* (*./.*) denotes the conditional quantile function,  is the inverse of the distribution function of ε*it*, and α*pe*(*τ*) indicates the variability in the households’ responses to fuel price changes, depending upon the level of travel.

## Results

## Our quantile estimation results show that the rebound effect, lying in the range of 56% to 90%, is large for households that drive less while the opposite is true for households that intensively use their automobiles.

## Conclusions

Although increased efficiency confers economic benefits in its own right, its effectiveness in reducing fuel consumption and pollution critically depends on how consumers alter behavior in response to cheaper energy services due to improved efficiency. To the extent that service demand increases via rebound effects, gains in reducing environmental impacts and energy dependency will be offset. The results presented in this paper, based on the analysis of a German household panel, suggest that the size of this offset is potentially quite large and heterogeneous with respect to the level of households travel demand. Our results therefore indicate that the current emphasis on efficiency as the principal means for policy-makers to address environmental challenges may be misplaced. Given the strong responses to prices found here, price-based instruments such as fuel taxes would appear to be a more effective policy measure.

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