A Perspective on 'Rebound' Effects and Demand/Supply Equilibrium

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'Rebound' effects associated with demand and supply equilibrium changes have been re-discovered numerous times, often with the addition of new terminology (such as 'Jevon's Paradox' or 'consequential life cycle assessment'). This short piece is intended to provide a perspective on estimating such effects using several applications.

Neo-classical micro-economic theory develops the role of price and income elasticity of demand (Henderson and Quandt 1958; Samuelson 1947). Without other changes, a price reduction in a particular product results in increased demand both due to the reduction in price itself and an increase in available income by a consumer. Cross-price elasticities suggest that demand for other goods may also increase or decrease. In this theory, greater energy efficiency would be reflected in reductions in the price paid for energy per unit of service delivered, where a unit of service might be distance traveled or heating provided. Of course, if the approach to increasing energy efficiency also affects other product attributes of importance to the consumer, effects on consumer willingness to pay and the resulting rebound effect may be more complex.

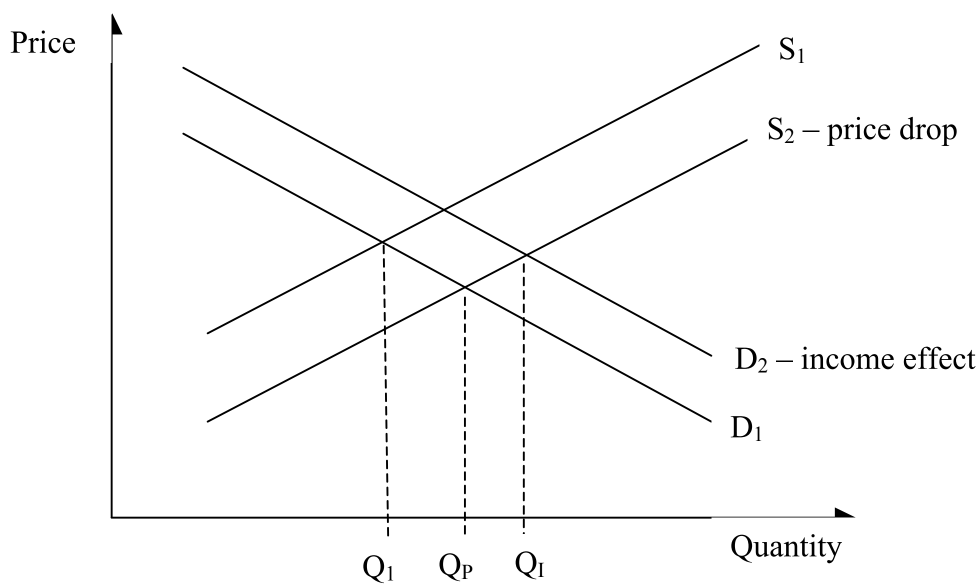

Figure 1: Demand and Supply Changes in Response to a Technology Improvement

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Figure 1 shows the demand-supply equilibrium effects of a price decline for a product. The original equilibrium is at the intersection of the existing demand (D_1) and supply curves (S_1) with quantity Q_1. An efficiency technology reduces the price of the product, shifting the supply curve down to S_2 and increasing demand to Q_P. Because the consumer has additional disposable income after the price reduction, there is an income effect that tends to increase demand at any price level, resulting in the demand curve shift to D_2 and quantity Q_I. As a result, the quantity of the product demanded further increases. (In practice, the additional disposable income might be spent partially or entirely on other goods. These other purchases might have energy requirements and greenhouse gas emissions themselves.) In contrast, a fixed demand and supply model would have a horizontal supply curve and a vertical demand curve, with a price decline resulting in savings at the same level of demand and with no rebound.

Selected Examples from Carnegie Mellon

Blackhurst (2011) summarized a number of demand studies of rebound effects for residential heating and found a wide range of estimates. He proposed a typical range of 10 to 30% increase in energy demand relative to predicted energy savings from technology improvements and used these price elasticities in an analysis of carbon emission management plans in metropolitan areas.

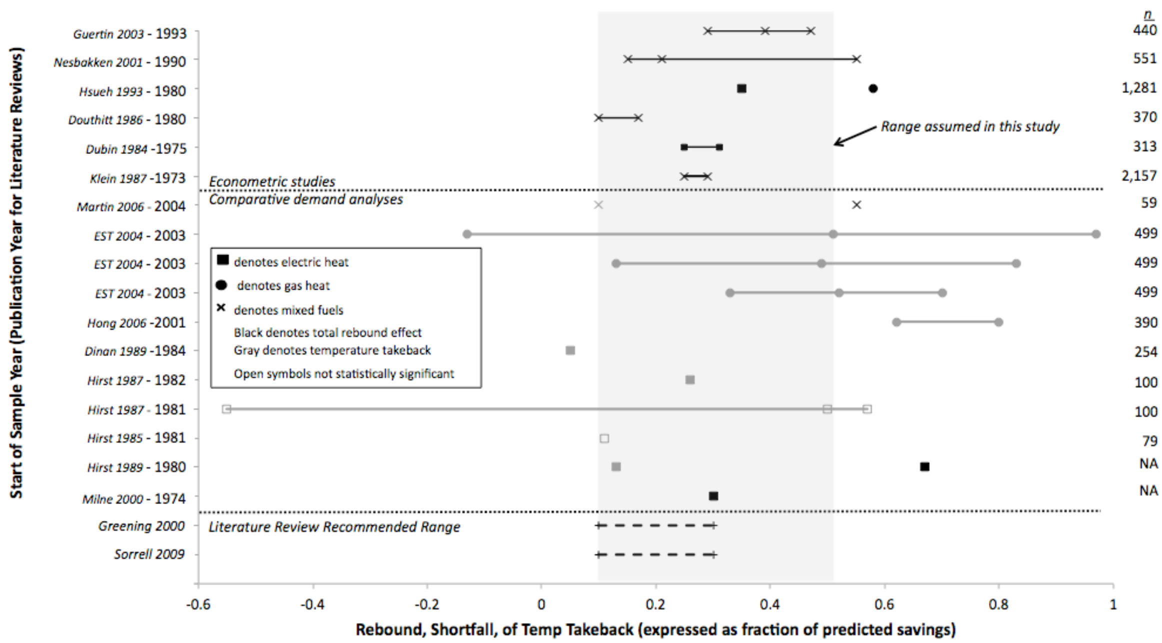
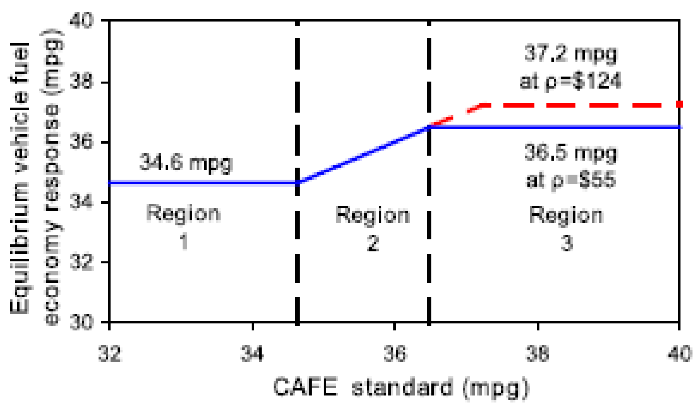


Figure 2: Summary of Residential Heating Rebound Effects

In a comparative study of brownfield and greenfield developments in the United States, Mashayekh et. al. (2011) found that brownfield developments were closer to city centers, had fewer vehicle trips per person and had higher residential densities. Everything else being equal, we might expect lower energy use and greenhouse gas emissions per person as a result. Rebound effects would reduce this expected savings, as savings are spent on other products. For example, Shammin et. al. (2010) found that residing in compact cities might reduce energy use up to 80%, but that actual reductions are only 20% based on analysis of consumer expenditure data. Note that the travel cost savings of brownfields are real, but the resulting environmental benefits are mitigated by income effects.

Demand/supply equilibrium effects may also occur in response to ‘shadow prices’ imposed by regulatory requirements. In a study of vehicle design decisions in response to Corporate Average Fuel Economy regulations, Shiau, Michalek and Hendrickson (2009) found that profit maximizing vehicle manufactures would either choose to ignore, comply or come out of compliance, depending on the standard and penalties. As shown in Figure 3, the company would comply in Region 1 and 2 to the standard, but not in Region 3 as the cost of compliance exceeds the penalty cost. As a result, the fuel economy improvement included in the CAFE standard in Region 3 might not be attained. This study used a mixed logit model of vehicle choice by consumers and examined design and pricing responses of oligopolistic single-product firms to CAFE policy in Nash equilibrium.



Thus, we can conclude that price and income effects certainly exist, reducing the actual savings attained from price declines or technology improvements. Tools useful in estimating these effects include price and income elasticities (as in Figure 2), demand/supply equilibrium (as in Figures 1 and 3), and consumer expenditures surveys. The functional form assumed for demand functions will have a significant impact on the estimates of rebound effects.

References

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