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Assessing the rebound effect using a natural experiment setting: Evidence from the private transportation sector in Israel

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HIGHLIGHTS

- Subsidizing energy-efficient cars has become a popular policy in many countries.
- We are unaware of studies identifying rebound via cars' subsidization policy.
- We explored a rebound in light of such a policy in Israel.
- Household expenditure survey data, fuel prices and car characteristics were employed.
- We found an average rebound effect of 40%.

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ABSTRACT

Subsidizing energy-efficient technologies is considered by energy and environmental organizations to be one of the most effective policies for decreasing energy consumption. In the transportation sector such policies are becoming ever more popular, and have been implemented in a considerable number of countries in recent years. Because these policies promote energy-efficient cars with lower usage costs, they may rebound and increase the distances traveled by households that have switched to energy-efficient cars. From an econometric perspective, a subsidization policy can be used as a valid instrument to identify the households' choice of energy efficiency levels of the cars they own. This identification, in turn, can be utilized to account for endogeneity in the estimation of a rebound effect. The present study uses a natural experiment setting of such a policy implemented in Israel in 2009. The empirical results indicate a fairly large average rebound effect of 40%. The results also indicate that while the policy indeed encouraged the purchase of energy-efficient cars, households that bought a new or used car during the surveyed period did not generate a rebound effect of a different magnitude compared with other households that did not. We discuss the implications of our findings.

1. Introduction

Energy-consuming products have long been a key component in human progress, and are indeed one of the factors best characterizing life in the developed world. Energy supply has thus become a major concern for policy makers, as has the need for policies that moderate the different types of damage resulting from extensive energy consumption, such as greenhouse gas (GHG) emission, air pollution and its associated health problems, resource depletion, etc. (International Energy Agency (IEA), 2008a). In 2008, the IEA published a set of 25 policy recommendations in priority areas (e.g., transportation, industry, and buildings) to aid IEA member countries to address energy, environmental, and economic challenges driven by extensive energy consumption (International Energy Agency (IEA), 2008b). A major policy recommendation for all the priority areas was to subsidize energy-efficient products, and thereby to incentivize consumers to purchase these products. It was subsequently shown

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that energy-efficiency policies do indeed play a crucial role in curbing energy usage (Gillingham et al., 2013). However, as an energy-consuming product becomes more efficient using it becomes cheaper, which provides an incentive to increase the usage of this product. Consequently, the potential energy savings from the switch to energy-efficient products are offset, and actual savings in energy are lower than expected (e.g., Berkhout et al., 2000; de Haan et al., 2006; de Haan et al., 2009). In light of these findings, there is an ongoing debate as to whether this rebound effect should be a key consideration in policies that promote energy efficiency (Frondel and Vance, 2013; Khazzoom et al., 1990) or whether this effect is minor (Gillingham et al., 2013).

The rebound effect varies among different products, technologies, and users, and its occurrence and magnitude are thus difficult to predict. Consequently, when designing policies that encourage consumers to adopt energy-efficient products (e.g., cars, light bulbs, refrigerators, and air-conditioners), policy makers generally fail to account for the potential increase in energy consumption (Geller et al., 2006). The present study (1) examines the potential effects of policy measures designed to incentivize energy efficiency through subsidizing energy-efficient products, and (2) uses the policy to identify households' decision regarding the energy efficiency of their car. This identification, in turn, enables the estimation of a potential rebound effect in transportation while accounting for endogeneity in choice of car. Specifically, we aim to estimate a rebound effect in light of a policy that effectively decreases, through subsidization, the prices of energy-efficient cars. The importance of this study lies in its contribution to assessing the rebound effect in transportation, with the attendant far-reaching health, environmental, and economic implications, as discussed next.

1.1. Energy efficiency in transportation

Transportation accounts for about one quarter of energy-related global GHG emissions and about one fifth of global energy use. Transportation-related emissions are associated with increased risks of lung cancer, heart disease, and adverse pregnancy outcomes (World Health Organization, 2010). Recent reports reveal that OECD countries spent about 1 trillion US$ in 2010 on addressing health damages resulting from transportation emissions (Organization for Economic Co-operation and Development (OECD), 2014). Moreover, transportation-related energy use and GHG emissions are expected to rise by nearly 26% by 2030, and by more than 60% by 2050 (International Energy Agency (IEA), 2015; see also Kahn Ribeiro et al., 2007).

Between 2008 and 2014, the IEA's World Energy Outlook consistently advocated that improving the energy efficiency of new cars should be the dominant policy for reducing GHG emissions and saving energy (International Energy Agency (IEA), 2008–2014). A 2010 IEA brief reported that the subsidization of energy-efficient cars had indeed become a widely-used energy-efficiency policy, and that such incentives had been implemented by some IEA member states, including Japan, the Netherlands, the UK, Ireland, Korea, and the USA (International Energy Agency (IEA), 2010). Yet, despite its widespread implementation, such a subsidization policy has not been sufficiently scrutinized to determine its potential consequences.

Whereas energy-efficient cars are expected to increase distance traveled because of lower usage costs, such a prediction should be made with caution, because a reverse causality is possible – namely, that consumers who drive long distances may choose to purchase an energy-efficient car, and such a choice cannot represent a rebound effect. Accordingly, some scholars treat consumers' choice regarding their car's energy efficiency as an additional decision variable (i.e., as an endogenous variable) (Greene et al., 1999; Puller and Greening, 1999; Small and Van Dender, 2007). An additional factor that is central to consumer decisions regarding whether to purchase an energy-efficient car is the price of fuel. Specifically, the history of fuel prices affects the choice of purchasing energy-efficient cars (Puller and Greening, 1999).

A fairly recent meta-analysis review of previous studies reported a range from −0.4 to −0.8 of fuel consumption elasticity with respect to price and a range from −0.2 to −0.3 of distances traveled with respect to price (Litman, 2013). Nonetheless, Frondel et al. (2008) reported an elasticity of −0.6 for both fuel consumption and distances traveled with respect to price. One of the implications of a high price elasticity is that fuel pricing policies (i.e., increasing the tax) are relatively effective in decreasing consumers' demand for fuel and in reducing distances traveled; particularly, when the price elasticity is high, policies that increase energy efficiency and effectively reduce the cost of travel are likely to generate a substantial rebound effect (Litman, 2013). However, we are unaware of studies assessing the consequences of policies that subsidize the purchase of energy-efficient cars. Thus, further investigation is needed to determine whether the effect on distance traveled of a policy that subsidizes energy-efficient cars differs from that resulting from a policy of increasing the price of fuel.

1.2. The direct rebound effect

Studies have identified three main types of rebound effects (e.g., Berkhout et al., 2000; Greening et al., 2000; Sorrell and Dimitropoulos, 2008): (1) direct rebound effect – an increase in the use of the focal product, caused by the decrease in its usage costs, (2) indirect rebound effect – an increase in demand for other products or for the use of other products, due to an increase in disposable income caused by the decrease in the focal product's usage costs, and (3) macro-level rebound effect – a structural effect on the economy caused by changing demand, production, and distribution patterns resulting from the decrease in usage costs of an energy efficient product. For reviews on the various possible consequences of rebound effects, see Greening et al. (2000) and Sorrell and Dimitropoulos (2008). The present study focuses on the direct rebound effect in private transportation, namely, the potential increase in distance traveled due to the usage of more energy-efficient cars.

It is customary to measure the magnitude of the direct rebound effect as a percentage of the potential energy savings, namely,

$$Rebound effect(\%)=\frac{100(Calculated Savings - Actual Savings)}{Calculated Savings}.$$

For example, a rebound effect of 30% means that only 70% of engineers' predictions of energy savings following an improvement in energy efficiency were actually achieved. In other words, increased consumption offsets 30% of the expected energy savings. Scholars estimating the rebound effect for private transportation have reported a wide range of magnitudes. For example, Small and Van Dender (2007) found a short-run rebound of 4.5% and a long-run rebound of 22%, whereas Frondel et al. (2008) reported an average rebound of 56–66%. Based on a meta-analysis of 36 studies, Sorrell et al. (2009) suggested a long-run rebound effect for private transportation of 10–30% in OECD countries.

However, some of these estimates do not consider the likelihood of endogeneity in the consumers' decision to own an energy-efficient car. While it is expected that individuals who drive more would purchase an energy-efficient car, instrumental variables for solving this measurement problem are scarce. To the best of our knowledge, no studies to date have examined the rebound effect using a policy that subsidizes energy-efficient cars as a