# *ASSESSING THE EMISSION CONSEQUENCES OF AN ENERGY REBOUND EFFECT IN PRIVATE CARS IN ISRAEL*

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## Overview

The UN Sustainable Development Goal, SDG 7.3, is to "double the global rate of improvement in energy efficiency by 2030" (UN General Assembly, 2015). To meet this and other energy targets, countries encourage the development and adoption of energy-efficient products. Indeed, one of the ways to fulfil emission goals is by increasing energy efficiency. However, an improvement in the energy efficiency of a product or a service is likely to lead to an increase in the usage of that product or service, a phenomenon known in the economic literature as the direct rebound effect (e.g., Chitnis et al., 2020; Gillingham et al., 2020). A rebound effect often results from a technological advance that improves energy efficiency (Mongo et al., 2021). This improvement could be accelerated by policy measures designed to incentivize advances in technology or to incentivize the adoption of energy-efficient products. In the case of private transportation, the direct rebound effect implies that households will respond to an increase in the energy efficiency of their car by increasing their driving. The literature continuously and effectively addresses many facets of improved energy efficiency and the resulting rebound effect, but the direct connection of a rebound in emission levels is inadequately researched. Understanding the association between an energy rebound and excess pollution is important because of the close association between energy-related pollution, on the one hand, and mortality and morbidity (Chen and Chen, 2021) and climate change (Campbell et al., 2018), on the other. The present study aims to assess the emission consequences of an energy rebound effect in the private car market. The importance of this study lies in its three outcomes: (1) We estimate a rebound effect against the backdrop of continuous energy policy changes. (2) Using household data, we report the direct emission consequences of a rebound resulting from energy efficiency. Emission consequences are not typically reported in this context and reaching conclusions about emission levels from energy rebound data is not trivial. (3) We demonstrate that a reduction of the emission consequences of an energy rebound from private car markets is crucial for meeting national environmental goals.

## Methods

In August 2009, Israel launched an energy-efficiency policy incentivizes consumers to buy energy-efficient cars by setting differential tax reductions on new car purchases corresponding to the car's pollution level. The pollution level of each car was calculated considering five types of pollutant: $CO_2$, CO, $NO_x$, THC, and PM. To maintain the effectiveness of the tax incentives, amendments to the original formula were enacted approximately every two years, making the requirements for obtaining a low score on the pollution scale increasingly stricter with each amendment. We used household expenditure survey data (CBS, 2007-2016), which cover household expenditure on fuel for private transport, a variety of car attributes, and additional household characteristics. We retrieves data on fuel consumption and emissions per kilometer from the Vehicle Certification Agency of the UK Department for Transport. Following Stapleton et al. (2016) and Sorrell et al. (2009), we estimate the direct rebound effect using the negative of the elasticity of demand for kilometers traveled with respect to the fuel cost per kilometer. To address the potential endogeneity of the household's choice of the energy efficiency of their car considering the distances they plan to travel, we use a two-stage model (2SLS) (De Borger et al., 2016). We include in the model variables accounting for the four policy regimes that we identify during the examined period. Accordingly, we estimate a set of four coefficients that correspond to the size of the rebound effect under each of the four policy regimes. Then, using the specific emission values of the car owned by each household, we calculate the added emissions associated with the added kilometers of this household. Finally, to calculate the added emissions emitted by the entire car fleet, we sum the emissions of each pollutant across all households.

## Results

We found that the baseline rebound, i.e., the rebound before the introduction of the policy, was 38%. In the following periods it grew to 52%, 65%, and 89%. We then calculated the additional emission levels associated with these rebound levels. The rebound resulted in the addition of the following quantities of pollutants: 2.3 million additional tons of $CO_2$, 5,008 additional tons of CO, 495 additional tons of $NO_x$, 680 additional tons of THC and 28 additional tons of PM emissions for the duration of the period we examine. Notably, estimates for the emission consequences using "average car" values (that is, the average values across the entire car fleet of emissions per kilometer and kilometers traveled) were almost twice as high. The reason for this gap derives from the co-dependance between car usage and car efficiency. We discuss the implications of this gap in meeting emission goals.

## Conclusions

In the present study, we examine the emission consequences that are associated with an energy rebound effect for five types of car pollutant. We use the introduction in Israel of a policy that incentivized the purchasing of less polluting private cars to calculate the size of the rebound resulting from their increased energy efficiency. We found that the baseline rebound before the policy was 38%. In the following periods it grew to 52%, 65%, and 89%. The rebound is typically discussed in terms of energy usage, and only rarely does the literature seek to reach conclusions about the concomitant changes in emission levels. However, to ensure meeting environmental goals, such derived conclusions are critical. For example, to meet the Paris Agreement, Israel set a target to reduce its per capita GHG emissions to 7.7 tons $CO_2$ equivalent by 2030 (Government of Israel, 2015). We calculated the GHG emission consequences of the rebound at the end of the period to 0.37 tons $CO_2$ per capita, equivalent to 5% of the per-capita country's target. Thus, the extrapolation from energy rebound to emission consequences demonstrates that these consequences are not negligible. More importantly, it emphasizes the need to discuss the effect of the rebound in terms of emissions, and not only in terms of energy savings and losses.

## References


Campbell, P., Zhang, Y., Yan, F., Lu, Z., and Streets, D., 2018. Impacts of transportation sector emissions on future US air quality in a changing climate. Part II: Air quality projections and the interplay between emissions and climate change. Environmental Pollution 238, 918-930.

Chen, F., and Chen, Z., 2021. Cost of economic growth: Air pollution and health expenditure. Sci. Total Environ. 755, 142543.

Chitnis, M., Fouquet, R., and Sorrell, S., 2020. Rebound effects for household energy services in the UK. Energy J. 41(4).

De Borger, B., Mulalic, I., and Rouwendal, J., 2016. Measuring the rebound effect with micro data: A first difference approach. J. Environ. Econ. Manage. 79, 1-17.

Gillingham, K., Rapson, D., and Wagner, G., 2020. The rebound effect and energy efficiency policy. Rev. Environ. Econ. Policy.

Government of Israel, 2015. Israel's Intended Nationally Determined Contribution (INDC). URL. https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Israel%20First/Israel%20INDC.pdf

Mongo, M., Belaïd, F., and Ramdani, B., 2021. The effects of environmental innovations on CO2 emissions: Empirical evidence from Europe. Environ. Sci. Policy 118, 1-9.

Sorrell, S., Dimitropoulos, J., and Sommerville, M., 2009. Empirical estimates of the direct rebound effect: A review. Energy policy 37(4), 1356-1371.

Stapleton, L., Sorrell, S., and Schwanen, T., 2016. Estimating direct rebound effects for personal automotive travel in Great Britain. Energy Econ. 54, 313-325.

UN General Assembly, 2015. Transforming our world: the 2030 Agenda for Sustainable Development, A/RES/70/1. https://www.refworld.org/docid/57b6e3e44.html