The Economy-Wide Rebound Effect and Climate Policy Effectiveness in a Multiregional General Equilibrium Framework

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Abstract

The insights about an increased energy consumption following efficiency improvements from technical progress, proposed initially by Jevons (1866), have significant implications on the effectiveness of energy efficiency policies. Moreover, the essential role of energy and its efficiency either in economic development or in climate change mitigation might have different and sometimes contradictory outcomes. On the one hand, economic development is closely related to an increasing use of energy while on the other hand, the rising demand for energy might be related to an increased use of fossil fuels or other polluting activities with negative consequences on the environment and climate. Therefore, rebound effects should be taken into account for policy design and assessment.

In this context, there are two main concerns for climate policy regarding the rebound effect and economic development. First, the negative implications of the rebound effect might reduce the effectiveness of energy efficiency improvements, as shown by the empirical evidence. This could lead to disregard the promotion of efficiency and technology transfer policies related to technical progress and a more efficient use of energy. Second, curbing greenhouse gas emissions through reduced economic growth creates an obstacle in reaching a global agreement to deal with global warming. Nevertheless, appropriately considering the rebound effect in policy design could provide an opportunity to address both concerns at the same time.

The extent of how much an energy efficiency improvement might be taken back because of the Jevons' paradox, also called the Khazoom-Brookes postulate, has been theoretically analysed considering different functional formulations. It has also been tested empirically for specific sectors using different methodologies through historical data analysis, econometric estimations, and numerical simulations, most of them highlighting the importance of rebound effects.

The economy-wide rebound effect has been studied using a general equilibrium framework both from a theoretical and a numerically perspective. One of the advantages of using CGE models is

that it allows providing a counterfactual scenario that is used to calculate better estimates. However, most of the studies rely on an autonomous technical change specification, which makes it difficult to tackle the endogenous aspect of induced energy efficiency. In addition, the existent CGE studies have focused on single countries, applying simultaneous energy efficiency improvements in the use of different kinds of energy across several productive sectors at the same time. Therefore, the corresponding rebound estimates show a compounded-aggregated effect without differentiating the particular source related to a specific energy commodity. Furthermore, there is a lack of an analysis using a global equilibrium model including additional feedback channels through international trade and knowledge accumulation.

This paper is a first attempt to contribute to the rebound effect literature adopting a general equilibrium approach enhanced with international trade flows and endogenous technical change based on a stock of knowledge. This allows accounting for technical progress and policy-induced behaviour triggered through price signals. In particular, the paper aims are: i) to provide an analysis of the economy-wide rebound effect by means of a multi-region and multi-sector dynamic recursive model, ii) to estimate specific rebound effects considering single energy commodities one at a time and also for each region in the model, and iii) to offer insights about the effectiveness of both energy efficiency and climate policies at the regional level and by type of energy to select potential effective combinations for climate and development policy implementation.

Results suggest that short-run rebound effect estimates in general equilibrium are higher compared to direct rebound empirical estimations based on partial equilibrium. Regarding capital-energy substitution, lower elasticities produce also lower rebounds. In addition, the rebound effect seems to be more sensible to lower elasticities of supply for fossil fuels and inter-fuel substitution than to substitution between capital and energy. Within the majority of industries, a carbon tax policy is much more effective than energy efficiency use policies, due to a lower rebound. However there are some exceptions depending on the sector and country. This should be taken into account when designing climate and energy efficiency policies.

The paper is structured as follows: section 2 introduces a set of definitions found in the literature to select the most appropriate ones in order to estimate the economy-wide rebound. Section 3 presents a summary of the different studies found in the literature. Section 4 offers a brief description of the CGE model used along with the scenarios selected for a sensitivity analysis. Section 5 shows estimates for the short and long-run economy-wide rebound from the CGE model taking into account energy efficiency and climate policies. Section 6 concludes.