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A general equilibrium assessment of rebound effects

Sverre Grepperud[a,]*, Ingeborg Rasmussen[b]

[a]Center for Health Administration, University of Oslo, NO-0027 Oslo, Norway
[b]ProSus, Norwegian Research Council, Sognsveien 70, N-0855 Oslo, Norway

Abstract

In this paper we use a general equilibrium model applied to a national economy (Norway) to explore the potential for energy efficiency improvements to trigger economic forces that offset potential savings from using more efficient technologies (rebound effects). Two types of energy efficiency improvements (electricity and oil) are introduced into various sectors of the economy. Our results suggest significant and surprising differences across sectors concerning both energy use and consequences for the build-up of greenhouse gases. Rebound effects are found to be quite significant for manufacturing sectors since long-term consumption of energy undergoes minor reductions or increases in response to efficiency improvements. In other sectors, rebound effects appear to be weak or almost absent.

JEL classifications: Q25; Q43; Q48

Keywords: Energy saving; Rebound effects; Macroeconomic implications; CO_2-emissions

1. Introduction

The application of efficiency improvements, in order to achieve reductions in pollution and resource consumption, has been on the political agenda since the early 1970s and is now frequently suggested as a measure towards the realisation of a sustainable development (see e.g. World Commission on Environment and Development, 1986; United Nations, 1995; Organisation for Economic Co-operation and Development, 1995, 1998). Recent advocates of efficiency improvements have also

*Corresponding author. Tel.: +47-23-07-53-11; fax: +47-23-07-53-10.
E-mail address: sverre.grepperud@samfunnsmed.uio.no (S. Grepperud).

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introduced new concepts. One example is Eco-efficiency, proposed by the World Business Council for Sustainable Development (1999), used about measures that reduce ecological impacts and resource intensity throughout the life cycle of goods and services. A second example is Factor 10, which appeared in 'The Carnoules Declaration' and called for an increase in current resource productivity by an average factor of 10 during the next 30–50 years, in order to reach sustainability (Wuppertal Institute, 1994).

While emphasising the importance of efficiency improvements, the above literature ignores the possibility of 'take-back' or rebound effects. Rebound effects can be defined as economic forces (demand side effects) that over time weaken the potential (technical) savings associated with efficiency improvements. One important cause of such effects is that higher efficiency reduces energy costs, which again increases demand. Khazzoom (1980, 1986, 1987, 1989) and Khazzoom et al. (1990) all discuss the significance of such effects. Khazzoom questions the adequacy of energy savings programs since greater efficiency could lead to increased, rather than decreased energy demand.[1] Khazzoom (1987) also presents a critique of Lovins (1985) for ignoring rebound effects when savings from more efficient mandated appliances were assessed. This again triggered a debate on the importance of rebound-effects (see e.g. Lovins, 1988; Henly et al., 1988; Khazzoom, 1989).

The controversy reappeared a few years later—now in the context of fossil fuel consumption and greenhouse gas abatement. A forerunner to this debate was a work by Manne and Richels (1990), which analysed the economic costs arising from CO_2-emission limits. This study showed that the autonomous energy efficiency index (AEEI) had a dramatic impact on the economic cost of reducing CO_2-emissions.[2] The same study found that a higher value on the AEEI (higher energy efficiency) would reduce both energy use and greenhouse gas emissions. Brookes (1990) and Greenhalgh (1990) nonetheless believe that widespread improvements in energy efficiency will not by themselves do anything to halt the build-up of greenhouse gases globally. Reductions in the energy intensity of output are associated with increases, rather than decreases in energy demand. Consequently, Brookes (1990) considers efficiency improvements to be an inappropriate way of combating the greenhouse effect. Grubb (1990), however, has challenged his arguments.

Saunders (1992) brought the debate a step further by applying Neo-classical theory in the analysis of the Khazzoom–Brookes' postulate which suggests that 'energy efficiency improvements might increase rather than decrease energy consumption'.[3] Calculations were undertaken in a one-sector growth model with three factors of production (labour, energy and capital) using Cobb-Douglas and nested CES production functions. Saunders (1992) conducted simulations under the assumption of a fixed real energy price and found that efficiency improvements increased the consumption of the resource that was exposed to higher efficiency

[1] Jevons, a 19th century economist, was the first to mention that efficiency gains would increase consumption (Jevons, 1865).

[2] By autonomous is meant a non-price induced efficiency improvement.

[3] Saunders (1992) is of the opinion that Khazzoom bases his arguments on price elasticity arguments while Brookes (1990) takes a more macroeconomic view.