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Industrial energy demand and energy efficiency – Evidence from Sweden☆

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ABSTRACT

This paper estimates firm level energy demand and energy efficiency for 14 sectors in Swedish manufacturing using stochastic frontier analysis (SFA). We derive sector level energy demand frontiers that account for firm specific heterogeneity. Results show that there is potential to improve energy efficiency for fuel and electricity use in all sectors; energy intensity is not an appropriate proxy for energy efficiency; the EU ETS had a modest or no effect on Swedish firms' efficient use

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of energy during the first trading phase and the beginning of the second, indicating that the carbon permit price was too low to generate the necessary incentives for energy efficiency investments.

Keywords:
Energy demand
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Manufacturing industry
Stochastic frontier analysis
True random effects

1. Introduction

Essential to the European strategy for sustainable growth is the climate/energy target "Triple 20 by 2020", which focuses partly on an energy efficiency target (EC, 2010). The target is to increase energy efficiency in EU by 20 percent by 2020 compared to the base year 2008. According to EC (2011, p. 2): "*In many ways, energy efficiency can be seen as Europe's biggest energy source*".

The main purpose of this study is to evaluate energy efficiency in Swedish manufacturing. An important question is whether there is a potential to increase efficiency and, therefore, whether there is a potential to contribute to the EU energy efficiency target. In this context, it is important to reflect closer upon the concept of energy efficiency and how it can be measured. In academics there is a widespread consensus about the potential problems of using energy intensity (the ratio of energy use to output) as a measure of energy efficiency, while in the political arena and public debate, associating energy intensity to energy efficiency is common practice. However, few studies reflect upon this or give some empirical evidence on the matter. Therefore, a sub-aim of this study is to investigate whether energy intensity may serve as an adequate measure of energy efficiency in Swedish industry.

According to EC (2011, p. 2), increasing energy efficiency technically "[. . .] *means using less energy inputs while maintaining an equivalent level of economic activity or service*, [. . .]".[4] This could be interpreted as energy efficiency being synonymous to energy intensity. That is, for an industry firm this may, e.g., entail lowering the ratio of energy input to value added produced (Bhattacharyya, 2011, p. 54). But using energy intensity indicators as measures of energy efficiency may be less suitable as it requires strong assumptions regarding factors not related to efficiency. For instance, energy intensity will not correctly reflect variation in energy efficiency between countries if, e.g., the fuel mix and weather vary between countries (Ang, 2006). For the same reason, energy intensity may be a bad proxy for variation in energy efficiency across industries and firms, since energy demand in production may vary depending on what exactly is produced, restrictions that they are facing, technology, etc.[5]

In an attempt to overcome some of the problems related to energy intensity as a proxy for energy efficiency, following Boyd (2005) and Filippini and Hunt (2011) we utilize the parametric Stochastic Frontier Analysis (SFA) approach.[6] This means that energy efficiency is estimated as efficiency following the literature on productive efficiency.[7] The concept of energy efficiency is then well grounded in production theory, providing a solid base for interpretation.

[4] Energy saving, or energy conservation, is a broader concept than energy efficiency, as it not only refers to more efficient use of energy, but also to reduced use of the level of energy (EC, 2011).

[5] Energy efficiency indicators can be defined at different levels of economic activities, see, e.g., Patterson (1996) for a discussion. Also, Ang (2006) provides a brief review on the development of energy efficiency indicators.

[6] The stochastic frontier approach was simultaneously introduced by Aigner et al. (1977) and Meeusen and van den Broeck (1977).

[7] For an introduction to the concept of frontier analysis and efficiency, see e.g., Coelli et al. (2005), Färe and Grosskopf (2003), or Kumbhakar and Lovell (2000).