ENERGY DEMAND DECOMPOSITION AND CO2 EMISSIONS

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Overview

The devastating impact of increasing CO2 emissions resulting from the increasing energy consumption has motivated governments, policy makers and researchers to look for an everlasting solution to reducing energy consumption. Among available options, a strand in the literature suggests energy-capital-labour substitution as a way of reducing energy consumption and subsequently reduces CO2 emissions. As elasticity of substitution implies the responsiveness of the ratio of the inputs to changes in the relative input prices, therefore, an increase in the price of energy via a carbon tax is expected to reduce energy consumption. Again, as substitution becomes much easier, it is easier for producers to substitute other inputs for energy at a low level of carbon tax to achieve a given energy reduction. If the target is to reduce carbon emissions from energy use by increasing energy price via carbon tax, one expects energy-capital-labour substitution to be easy in the real world so that the economic cost of achieving given target of energy use is low. However, there is considerable uncertainty about the extent changes in energy use by increasing energy price reduce CO2 emissions. Secondly, the numerical values of the substitution elasticities seem to be controversial. Therefore, there is a need to generate reliable elasticities of substitution that will be helpful in firms' decisions making. In this paper, the purpose is to generate reliable substitution elasticities and examine the impact of changes in energy demand (via energy-capital-labour substitution) resulting from an increase in energy price on carbon emissions. In particular, we aim to decompose the effects of changes in energy price into substitution and output effects and econometrically examine the roles of these effects on CO2 emissions.

This paper is structured as follows: Section one provides the introduction. The second section presents the theoretical framework and model specifications. Section three describes the data used for the estimations. The empirical results are discussed in section four. The last section presents concluding remarks.

Methods

Drawing on duality theory, this study decomposes changes in energy demand into substitution and income effects using a sector-level data for a sample of 29 European countries over a period of 1995 – 2007. To decompose the changes in energy demand, this study estimates a global translog cost function using multilevel model that controls for country-level variables effects and the cluster-level heterogeneity in the dataset. The study also employs multilevel model in examine the impact of the decomposed changes in energy demand (substitution and income effects) on CO2 emissions. Data for this study are sourced from World Input-Output Database (WIOD), Penn World Table (PT7.1) and High Resolution Gridded Dataset by Climatic Research Unit and Tyndall.

Results

First, our results support the importance of controlling for country-level variables while using sector-level data and there is a strong evidence of substitution possibilities between energy and other inputs but the degree of substitution between energy and labour is greater than that of capital.

Second, as expected theoretically, the own substitution effects arising from increase in energy price are negative suggesting that as energy price increases, firms reduce their energy consumption by substituting other inputs for energy. The output effects are negative, suggesting that energy is not a normal good that increases with output expansion. The output effects are smaller to the substitution effects in absolute terms suggesting that substitution effects dominate while energy price changes.

Third, both substitution and output effects have a negative relationship with CO2 emissions. In absolute terms, substitution effects have a stronger influence on CO2 emissions than output effects.

Lastly, variations in CO2 emissions are more associated with industry differences rather than country differences.

Conclusions

Energy and other factor inputs are substitutes. The substitution effects arising from increase in energy price dominate the output effects. This suggests that in the long run, improvement in the production technology (that is, energy efficiency) from economies of scale without being supported by increase in energy price would appear as a limited mean of reducing CO2 emissions of the production sector. Similarly, reduction in energy use cannot only be achievable by increasing energy prices/taxes and carbon taxes but also by adopting strategy that will lead to increase in the prices of other inputs.

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