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Does more energy consumption bolster economic growth? An application of the nonlinear threshold regression model ☆

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Abstract

This paper separates data extending from 1971 to 2002 into the energy crisis period (1971–1980) and the post-energy crisis period (1981–2000) for 82 countries. The cross-sectional data (yearly averages) in these two periods are used to investigate the nonlinear relationships between energy consumption growth and economic growth when threshold variables are used. If threshold variables are higher than certain optimal threshold levels, there is either no significant relationship or else a significant negative relationship between energy consumption and economic growth. However, when these threshold variables are lower than certain optimal levels, there is a significant positive relationship between the two. In 48 out of the 82 countries studied, none of the four threshold variables is found to be higher than the optimal levels. It is inferred that these 48 countries should adopt a more aggressive energy policy. As for the other 34 countries, at least one threshold variable is higher than the optimal threshold level and thus these countries should adopt energy policies with varying degrees of conservation based on the number of threshold variables that are higher than the optimal threshold levels.
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1. Introduction

On February 2, 2007, a report from the Intergovernmental Panel on Climate Change (IPCC) indicated that global atmospheric concentrations of carbon dioxide (CO_2), methane, and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial levels determined from ice cores spanning many thousands of years. The increase in CO_2 has mainly originated from the use of fossil fuels and partly from the changes in land use. The emissions of CO_2 and other gases from burning fossil fuels and other processes trap heat from the sun in the atmosphere, much like a greenhouse. Global warming, of course, raises the temperature in the air and in the ocean, and raises the sea level as well. Without properly controlling for the phenomenon, serious consequences on the eco-system and the extinction of many creatures will be unavoidable. The IPCC report places the blame for global warming mainly on the release of CO_2 from the use of fossil fuels.

Fossil fuels are a major source of energy for industrial production, residential consumption, and transportation.[1] It is obvious that energy use plays an important role in our daily lives and economic activities. Since the fossil fuels are relatively cheap and readily available, part of the benefit

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[1]Fossil fuels account for about 90% of energy use in the world today. Petroleum accounts for the largest share at 40%, followed by coal at 24% and natural gas at 22%. Fossil fuels are currently among the most economically available sources of power for both residential and commercial uses.

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from a greater use of fossil fuels is the increase in production and living standards. These benefits, however, must be offset, to some extent, by a negative externality that arises from an increase in global warming and environmental pollution.

Whether or not the increased economic benefits from energy consumption will outweigh the negative externality depends on the empirical evidence of a positive causal relationship between energy consumption and economic growth. If the empirical evidence indicates that energy consumption (in terms of the growth rate) Granger-causes economic growth, it is suggested that a more aggressive energy policy should be followed. On the other hand, if economic growth Granger-causes energy consumption or there is no causal relationship between energy consumption growth and economic growth, the policy-maker should implement a more conservative energy policy since energy consumption may not bring about economic growth but may increase CO_2 emissions into the atmosphere and accelerate global warming.[2]

Granger causality has been widely used in the literature in analyzing the relationship between energy consumption and economic growth. Kraft and Kraft (1978) discovered that economic growth leads energy consumption. Employing the same US data, however, Stern (2000) found that energy consumption leads economic growth. Therefore, two conflicting empirical results for the same country using the same data were found. Furthermore, Akarca and Long (1980), Yu and Jin (1992), and Soytas and Sari (2003) discovered that there is no causal relationship between energy consumption and economic growth. In addition, Lee (2005) showed that a feedback relationship existed between the two.[3] Such inconsistent results were also found in emerging countries such as Taiwan and South Korea. The main reason for the inconsistencies may involve using different periods in time series data, obtaining an insufficient sample, or failing to take into account the nonlinearity due to certain country-specific factors. In addition, using the Granger-causality approach to investigate the causal relationship between energy consumption and economic growth in the previous literature led to three possible problems: (a) whether or not the yearly data were sufficient to represent the long-term relationship between the two; (b) the inability of the yearly data to eliminate the problems of short-term fluctuations due to business cycles and structural change; and (c) the failure to delineate countries with special features in terms of different causal relationships.

Since the relationship between energy consumption and economic growth is inherently a long-term one, a biased estimate may be the result of an insufficiently large sample size in the time series, the existence of structural changes, or short-term economic fluctuations. Another reason for the inconsistent empirical results may emanate from the omission of specific characteristics in certain countries affecting the relationship between energy consumption and economic growth (Soytas and Sari, 2006). For example, high CO_2 emission countries may be characterized by an overuse of energy or a lack of regulations to enforce proper energy consumption. As a result, the environmental damage from energy use may outweigh the benefits from economic growth. To tackle the insufficient sample size problem, many researchers have used the panel data approach. Lee and Chang (2007a) separated the data used into 18 developing countries and 22 developed countries and employed a dynamic panel data (DPD) approach to test the causal relationship between energy consumption and economic growth. He discovered that economic growth leads energy consumption growth in the developing countries, while in the developed countries there is a feedback relationship between the two. Huang et al. (2008) used panel data for 82 countries and grouped the data into four categories based on the income levels defined by the World Bank: low-income group, lower middle-income group, upper middle-income group, and high-income group. They employed the DPD approach to investigate Granger causality. They discovered that (a) in the lower and upper middle-income groups, economic growth leads energy consumption positively; (b) in the high-income group, economic growth leads energy consumption negatively; and (c) in the low-income group, no causal relationship exists between energy consumption and economic growth. Their conclusion—a reduction in energy use in the high-income group—was consistent with the policy of decreasing the use of fossil fuels (e.g., extending the summer daylight time and the more extensive use of fluorescent lighting).

By grouping on the basis of the difference in the degree of economic development in their research, Lee and Chang (2007a) and Huang et al. (2008), in effect, assume a nonlinear relationship between energy consumption and GDP. Moon and Sonn (1996) employed an endogenous growth model to infer that the economic growth rate rises initially with productive energy expenditure but subsequently declines. In other words, there is an inverse U-shaped nonlinear relationship between energy consumption and economic growth as was evidenced by their empirical results from the yearly data extending from 1968 to 1989 in Korea. Lee and Chang (2007b) used the level of total energy consumption as a threshold variable to investigate the existence of a nonlinear relationship under the one-sector and two-sector growth models. The empirical result from the 1955–2003 annual data in Taiwan indicates that there is an inverse U-shaped relationship between energy consumption growth and economic growth. That is, the relationship between energy consumption and economic growth indicated above is nonlinear and the traditional linear model is no longer appropriate.

[2]With fossil fuels as a major source of energy consumption, they may promote economic growth, pollute the environment, and also deplete the available resources. Therefore, there is a nonlinear relationship between energy consumption and GDP growth.

[3]For the empirical literature on the causal relationship between energy consumption and economic growth, refer to Stern and Cleveland (2003).

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