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Exploring the relationship between energy use and economic growth with bivariate models: New evidence from G-7 countries

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Abstract

There is a rapidly growing literature on the interaction between energy use and economic development, with many analysts drawing policy conclusions on the basis of Granger causality tests that involve only an energy and an economic variable. This paper attempts to demonstrate empirically that such studies, although useful for certain applications, may be of limited use for policy purposes. After outlining theoretical and methodological issues associated with such approaches, I apply bivariate energy–economy causality tests for Canada, France, Germany, Italy, Japan, the United Kingdom and the United States, using aggregate and sectoral data and three different modern econometric methods. The results, which are often contradictory or economically implausible, illustrate explicitly that one should be cautious when drawing policy implications with the aid of bivariate causality tests on small samples. I therefore underline the importance of utilizing as large sample sizes as possible and using multivariate models, which are closer to economic theory, accommodate several mechanisms and causality channels and provide a better representation of real-world interactions between energy use and economic growth.

JEL classification: Q4; C3

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1. Introduction

The relationship between energy and the economy has undergone extensive investigation after the two oil crises of the 1970s, focusing mainly on the effect of energy prices on economic activity. In

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a recent paper, for example, Brown and Yücel (2002) provide a survey of the theory and evidence on the macroeconomic impact of energy prices. Apart from price effects, the relationship between energy consumption and economic growth was also explored. The first relevant study dates back to the late 1970s (Kraft and Kraft, 1978). The literature has grown slowly thereafter, and since the early 1990s this relationship has been the subject of a rapidly increasing number of studies. Most of these studies were primarily empirical, focusing on the concept of Granger causality.

Since the seminal paper by Granger (1969), the literature on Granger causality has grown considerably — slowly during the first years and more rapidly in recent years. Among recent applied studies, a significant amount of work has been devoted to addressing the above mentioned question of causality between energy consumption and economic development. Lee (2005, 2006) and Yoo (2006) provide extensive summary tables of results regarding Granger causality between economic growth and energy use or electricity use. Overall, the most thorough review of existing work is that of Chontanawat et al. (2006).

The results from research in this field worldwide are very mixed, with some studies finding unidirectional Granger causality from energy consumption to economic growth or vice versa, others confirming the 'neutrality hypothesis' (i.e. no causality in any direction), and other studies finding bidirectional causality. It is interesting to note that some results vary for the same countries and sample periods and despite the use of similar datasets, depending on the estimation methods that were applied (bivariate or multivariate models, employing different causality techniques). Although it has been attempted to provide economic interpretations for all these results, their diversity indicates clearly that such *ex post* conclusions have to be treated with caution.

Apart from risky economic interpretations of contradictory results, analysts often proceed with deriving implications for energy policy on the basis of their Granger causality tests. If unidirectional causality from energy to the economy is found, a usual conclusion is that limiting energy use (e.g. through energy conservation) would hamper economic growth. A result showing causality running from the economy to energy is said to imply that energy conservation measures may be implemented without putting economic development at risk. Bidirectional causality indicates mutual interdependence of energy and the economy so that in a forecast model both variables should be treated as endogenous. Finally, when the analysis seems to confirm the 'neutrality hypothesis', i.e. no causality between the two variables, the usual explanation is that the economy develops irrespective of energy consumption patterns and vice versa; in such a case economic growth will not affect energy use (probably because of counterbalancing effects), and policies aiming at energy savings may not be detrimental to economic development.

Some analysts point to further and more concrete policy implications. For example, Lee (2006) uses the results of his causality tests between primary energy consumption and GDP per capita to conclude that the United Kingdom, Germany and Sweden "may take greater responsibility to reduce their CO_2 emissions because such a reduction in energy consumption would not significantly affect economic growth". Conversely, in Canada, Belgium, the Netherlands and Switzerland "the enactment of the Kyoto Protocol will actually harm the economy" (pp. 1091–1092).

It is evident that bivariate energy–economy models, despite their usefulness because they can be applied in countries where only limited data are available, represent only a rough approximation of reality. However, the related literature has boomed in recent years[1] and most of these studies employ bivariate approaches and derive policy implications such as those mentioned in the previous paragraphs. Therefore, in this paper I will try to demonstrate, mainly

[1] According to the survey of Chontanawat et al. (2006), about half of the causality studies that have appeared in the literature were published from 2000 onwards.