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Nuclear energy consumption and economic growth in nine developed countries

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ABSTRACT

This article attempts to test the causal relationship between nuclear energy consumption and real GDP for nine developed countries for the period 1971-2005 by including capital and labour as additional variables. Using a modified version of the Granger causality test developed by Toda and Yamamoto (1995), we found a unidirectional causality running from nuclear energy consumption to economic growth in Japan, Netherlands and Switzerland; the opposite uni-directional causality running from economic growth to nuclear energy consumption in Canada and Sweden; and a bi-directional causality running between economic growth and nuclear energy consumption in France, Spain, the United Kingdom and the United States. In Spain, the United Kingdom and the USA, increases in nuclear energy consumption caused increases in economic growth implying that conservation measures taken that reduce nuclear energy consumption may negatively affect economic growth. In France, Japan, Netherlands and Switzerland increases in nuclear energy consumption caused decreases in economic growth, suggesting that energy conservation measure taken that reduce nuclear energy consumption may help to mitigate the adverse effects of nuclear energy consumption on economic growth. In Canada and Sweden energy conservation measures affecting nuclear energy consumption may not harm economic growth.

1. Introduction

The high degree of concentration of energy supply sources where over 68% of oil is concentrated in the volatile region of the Middle East, and where 67% of gas reserves are concentrated in Russia, clearly involves risks in terms of the reliability of the supply of energy needs for many energy-importing countries (World Coal Institute, 2006; Fiore, 2006; Toth and Rogner, 2006; Elliot, 2007; Ferguson, 2007; World Energy Council, 2007; Gnansounou, 2008; Squassoni, 2009; Tol et al., 2009). Since the 1973 oil crisis, supply security has become a primary concern for many oil-importing countries and this insecurity has made the search for alternative sources of cheap domestic energy supply one of the main deriving forces behind the energy policy of many energy importing countries (Toth and Rogner, 2006). Diversifying the sources of energy and finding a stable, safe and clean energy supply have become one of the main priorities of energy policy for many countries (see, Fiore, 2006; Toth and Rogner, 2006; Elliot, 2007; Ferguson, 2007). As part of their strategy of increasing energy security, many countries have built nuclear power plants not only to reduce dependence on imported oil but also to increase the supply of secured energy and also to minimize the price volatility associated with oil imports (Toth and Rogner, 2006; Vaillancourt et al., 2008). The advantage of nuclear energy has also become even more pressing as a result of the Kyoto Agreement that requires signatories to cut back substantially on their emissions of CO_2 in order to reduce global warming (Becker and Posner, 2005). Many believe that nuclear energy, as a virtually carbon free source of energy, is one of the solutions to global warming and energy security (Elliot, 2007; Ferguson, 2007). Hence, serious concerns over rising fossil fuel prices, energy security, and greenhouse gas emissions have brought the importance of nuclear energy to the forefront of the wider issue of the energy debate. As the IEA notes, nuclear energy is attracting new interest for increasing the diversity of energy supplies, for improving energy security, and for providing a low-carbon alternative to fossil fuels (International Energy Agency, IEA, 2008). Thus, the importance of nuclear energy as a potential source of energy security and as a virtually carbon free source of energy necessitates not only further research but also the use of alternative testing methodologies to examine the causal relationship between nuclear energy consumption and economic growth.

In a recent bivariate study on the causal relationship between nuclear energy consumption and economic growth, Yoo and Ku (2009) suggest that future research should investigate causal relationships using a more generalized multivariate system. In this paper, we do exactly that. Specifically, we examine the casual relationship between nuclear energy consumption and real GDP in nine developed countries for the period 1971-2005 which also includes capital and labor as additional variables. We include capital and labor as additional variables because nuclear energy alone might not be strong enough to spur economic growth. Further, exclusion of a

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relevant variable(s) makes the estimates not only biased as well as inconsistent but also no-causality in a bivariate system can result from neglected variables (Lütkepohl, 1982). It is possible that the introduction of a third or a fourth variable in the causality framework may not only alter the direction of causality but also the magnitude of the estimates (Loizides and Vamvoukas, 2005). In addition, since a four-variable case incorporates more information than a bivariate case, the causal inference drawn may be more reliable (Loizides and Vamvoukas, 2005). Thus, the previous bivariate causality tests between energy consumption and economic growth may be invalid due to the omission of important variables affecting both energy consumption and economic growth.

In this paper the empirical evidence is carried out using the procedure developed by Toda and Yamamoto (1995, hereafter TY) which is valid regardless of whether a series is I(0), I(1) or I(2), non-cointegrated or cointegrated of any arbitrary order. Secondly, unlike previous studies, this paper attempts to quantify how much feedback exists from one series to the other using the recently developed generalized forecast error variance decomposition technique proposed by Pesaran and Shin (1998) which is invariant to the ordering of the variables (see Payne, 2002).

The rest of the paper is structured as follows. In Section 2 we give a brief account of the role of nuclear energy followed in Section 3 by a short summary of the empirical literature. In Section 4 we present a short description of the methodology used, while the empirical evidence is discussed in Section 5. The summary and the concluding remarks are presented in Section 6.

2. The role of nuclear energy

Nuclear energy is one of the major sources of energy for many countries (see Fiore, 2006; Toth and Rogner, 2006). In the 1970s almost 25% of global electricity was generated from oil with nuclear energy accounting for only 3%. By 2002 while the global electricity supply from oil declined to 7.2%, nuclear energy expanded to 16.6% where it absorbed 75% of the decline in oil's share (see Toth and Rogner, 2006). As Fig. 1 shows, electricity production from nuclear sources as a share of total electricity production has significantly increased over the last three decades. In 2005 electricity production from nuclear sources as a share of total electricity production was

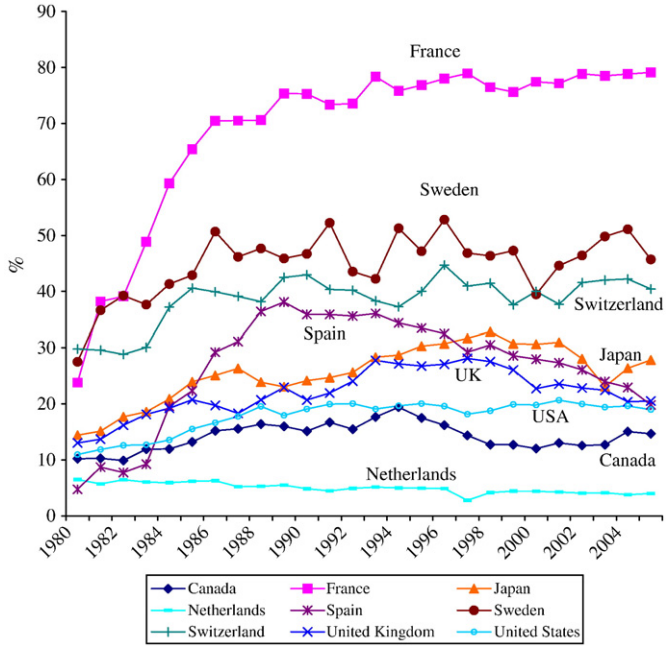

Fig. 1. Electricity production from nuclear sources (% of total electricity production).

14.6% in Canada, 79.1% in France, 27.9% in Japan, 19.8% in Spain, 45.7% in Sweden, 40.4% in Switzerland, 20.9% in the UK, and 19.0% in the USA (World Bank, 2008). Only in the Netherlands did the share of electricity production from nuclear sources as share of total electricity production declined from 6.2% in 1975 to 4.0% in 2005.

Despite the controversies surrounding the nuclear energy sector, nuclear energy will remain a significant part of the energy needs of many countries and it is expected to be an important part of the strategy towards sustainable energy development (see Toth and Rogner, 2006; IEA, 2008). A scenario developed by the IEA (2003) projects very high annual growth rates for nuclear power, especially between 2020 and 2040, implying a 14-fold increase in global nuclear energy production between 2000 and 2050 (see Toth and Rogner, 2006). Yet this will only increase the global proportion of nuclear energy use from 16% to about 20%. However, according to Fiore (2006) the development of the nuclear project ITER (International Thermonuclear Experimental Reactor) will bring about a new era of nuclear fusion engineering. This technology, which is expected to be available in 2050, will have the potential of meeting the world energy needs for approximately a billion years (Fiore, 2006).

In addition to being an important source of energy, nuclear energy also has the potential for lowering greenhouse gas emissions produced by the electricity sector. According to the Nuclear Energy Agency (2002), over the past 40 years, nuclear power plants have already played a major role in lowering the amount of greenhouse gases produced by the electricity sector in OECD countries. Without nuclear power, OECD power plant emissions of carbon dioxide would have been about one-third higher than they are at present. This is an annual saving of some 1,200 million tonnes of carbon dioxide, or about 10% of total CO_2 emissions from energy use in the OECD (Nuclear Energy Agency, 2002). The European Union (2006) also believes that Europe would not have been able to make any significant impact on reducing CO_2 emissions without relying on nuclear energy.

While the combination of several factors mentioned above makes nuclear energy a creditable alternative source of energy and one of the potential panaceas for greenhouse gas reduction, its enormous risks are also equally substantial (see, Fiore, 2006; Toth and Rogner, 2006; Elliot, 2007; Ferguson, 2007; World Energy Council, 2007; Squassoni, 2009). These include high cost, proliferation of dangerous materials, nuclear terrorism, operation safety and radioactive waste disposal (see, Toth and Rogner, 2006; IEA, 2008). As a result of the fear of nuclear proliferation and health risks, some countries have indicated phasing out their nuclear power stations as a source of future energy. In the USA, ever since the meltdown at Three Mile Island in 1979, no new nuclear plant has been licensed. Italy and Spain remain opposed to new nuclear reactors (Fiore, 2006; Ferguson, 2007). However, of late, in view of the energy challenge facing these countries, they are now either reconsidering nuclear energy or they might delay or abandon phasing out nuclear power plants to meet the energy demand and climate changes challenges facing them (Squassoni, 2009). In contrast, Canada, the UK and the USA have plans to expand their nuclear energy programs (Squassoni, 2009).

3. Brief literature review

There is now a vast literature that deals with the relationship between energy consumption and economic growth (Chontanawat et al., 2008; Lee et al., 2008; Payne, 2009a, b, 2010; Ozturk, in press). Yet, there seems to be no consensus regarding the direction of causality between energy consumption and economic growth. There is ample evidence to support all the four competing hypotheses. For some countries there is a bi-directional causality while for others there is no causality at all. Still for some countries there is a unidirectional causality running from energy consumption to economic growth while for others there is the opposite causality running from economic growth to energy consumption.