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Causal relationship between nuclear energy consumption and economic growth: A multi-country analysis

Seung-Hoon Yoo [a,*], Se-Ju Ku [b,1]

[a] Department of International Area Studies, Hoseo University, 268 Anseo-Dong, Cheonan, Chungnam 330-713, Republic of Korea
[b] Department of Economics, Korea University, 5-1 Anam-Dong, Sungbuk-Ku, Seoul 136-701, Republic of Korea

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ABSTRACT

This paper attempts to investigate the causal relationship between nuclear energy consumption and economic growth using the data from six countries among 20 countries that have used nuclear energy for more than 20 years until 2005. To this end, time-series techniques including the tests for unit roots, co-integration, and Granger-causality are employed to Argentina, France, Germany, Korea, Pakistan, and Switzerland. The main conclusion is that the causal relationship between nuclear energy consumption and economic growth is not uniform across countries. In the case of Switzerland, there exists bi-directional causality between nuclear energy consumption and economic growth. This means that an increase in nuclear energy consumption directly affects economic growth and that economic growth also stimulates further nuclear energy consumption. The uni-directional causality runs from economic growth to nuclear energy consumption without any feedback effects in France and Pakistan, and from nuclear energy to economic growth in Korea. However, any causality between nuclear energy consumption and economic growth in Argentina and Germany is not detected.

1. Introduction

Sustainable electricity supply is one of the driving forces in a nation's economic development because the shortage of power supply can force hundreds of industries to close. One of the sources that play a large role in electricity generation is nuclear energy. Actually, many countries use nuclear energy to generate electricity. According to International Energy Agency (2008), the proportion of nuclear energy in total domestic electricity generation is 79.1%, 46.7%, 46.7%, and 37.0% in France, Sweden, Ukraine, and Korea, respectively in 2006. Moreover, nuclear energy share of worldwide electricity generation has been changed from 3.3% in 1973 to 14.8% in 2006 while the oil share declined from 24.7% to 5.8% and there were no big changes in other fuels such as coal and gas over the same period of time.

Nuclear energy is considered as an alternative to cope with the high oil price and reduce the dependence on foreign countries for the energy in some countries. Nuclear power plants are capital-intensive, and nuclear power generating costs are less vulnerable to fuel-price changes than coal or gas fired generation. In addition, uranium resources are abundant and widely distributed around the globe. Therefore, nuclear power plants are most attractive where energy demand growth is rapid, alternative resources are scarce, energy supply security is a priority, and nuclear power is important for reducing air pollution and greenhouse gas emissions. One or more of these features characterize China, India, Japan, and Korea, where most current construction is taking place (Toth and Rogner, 2006). Therefore, nuclear energy will continue to hold its position as one of the sources of electricity generation, with regard to the security of energy supply and environmental conservation.

Many researchers and policy makers have had interest in the relationship between energy resources and economic growth for the past three decades, and numerous studies have been conducted to examine the relationship between the two. The overall findings show that there is a strong relationship between consumption on energy resources and economic growth. For an overview of previous studies, see Table 1 given in Chiou-Wei et al. (2008). In the case of nuclear energy, Schurr (1983) has detected a positive relationship between nuclear energy abundance and economic growth. However, there have been few studies specifically addressing the causal relationship between nuclear energy consumption and economic growth. There has been only one study of Yoo and Jung (2005) that found uni-directional causality running from nuclear energy consumption to economic growth in Korea.

Generally, the fact that there exists a strong relationship between nuclear energy consumption and economic growth does

* Corresponding author. Tel.: +82 41 560 8344; fax: +82 41 563 0135.
E-mail addresses: shyoo@hoseo.edu (S.-H. Yoo), heroseju@korea.ac.kr (S.-J. Ku).
[1] Tel.: +82 2 3290 2217; fax: +82 2 3290 2535

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Table 1
Summary of countries used in this study.

Countries	*Study periods*	Nuclear energy consumption (2005, unit: TWh)
Argentina	1974–2005	6.9
Brazil	1984–2005	9.9
Bulgaria	1980–2005	18.5
Canada	1971–2005	92.0
Finland	1977–2005	24.1
France	1965–2005	452.6
Germany	1971–2005	163.0
Hungary	1983–2005	13.8
India	1969–2005	17.8
Japan	1966–2005	293.0
Korea	1977–2005	146.9
Netherlands	1969–2005	4.0
Pakistan	1972–2005	2.6
Slovakia	1984–2005	17.7
South Africa	1984–2005	12.9
Spain	1968–2005	57.5
Sweden	1969–2005	72.4
Switzerland	1969–2005	23.2
United Kingdom	1965–2005	81.6
USA	1965–2005	823.1

Source: BP (2008).

not necessarily imply a causal relationship.[2] The relationship may very well run from nuclear energy consumption to economic growth, and/or from economic growth to nuclear energy consumption. These causality issues, therefore, suggest the need to carry out further investigations. A major question concerning this issue is which variable should take precedence over the other—is nuclear energy consumption a stimulus for economic growth or does economic growth lead to nuclear energy consumption?

Evidence on either direction will have a significant bearing upon policy. For example, if there is uni-directional causality running from nuclear energy consumption to economic growth, a reduction in nuclear energy consumption could lead to a fall in economic growth. On the other hand, if uni-directional causality runs from economic growth to nuclear energy consumption, it could imply that policies for reducing nuclear energy consumption may be implemented with little or no adverse effects on economic growth. Lastly, no causality in either direction would indicate that policies for increasing nuclear energy consumption do not affect economic growth.

Public policy makers in nuclear energy-using countries have shown a great deal of interest in the role that nuclear energy consumption plays in economic growth. The nuclear infrastructure of them is becoming an increasingly important component of the economy. To proactively cope with the increased demand for nuclear energy that accompanies rapid economic growth, they should endeavor to uncover the causal relationship between nuclear energy consumption and economic growth and to formulate appropriate nuclear policies. This task has become one of the most important ones for them in the present and in the near future.

The purpose of this paper is to investigate the causality between nuclear energy consumption and economic growth using a multi-country analysis based on data from six countries, and to derive policy implications from the results. To this end, we attempt to carefully consider causality issues by applying the time-series techniques of Granger-causality to the countries that have used nuclear energy for more than 20 years until 2005. The methods adopted in the present study are as follows. First, stationarity and co-integration are tested. Then, if co-integration is detected, error-correction models are estimated; otherwise, the standard Granger-causality method is executed. Finally, the *F*-test is performed to gauge the joint significance levels of causality between nuclear energy consumption and economic growth. In the analysis, suitable information criteria are employed to select the optimum lag in lieu of an arbitrary choice of lag length.

The message of this paper is all the more useful, to the best of our knowledge, because this is the first empirical study that explores whether or not the causalities between nuclear energy consumption and economic growth exist in a multi-country setting. The remainder of the paper is organized as follows. Section 2 presents an overview of the methodology adopted here. Section 3 explains the data employed and reports the empirical findings. Some concluding remarks are made in the final section.

2. Methodology

2.1. Granger-causality and stationarity

The first method of testing for the direction of causality was proposed by Granger (1969). The Granger-causality test is a convenient and very general approach for detecting any presence of a causal relationship between two variables. The test is quite simple and straightforward. A time-series (X) is said to Granger-cause another time-series (Y) if the prediction error of current Y declines by using past values of X in addition to past values of Y. The Granger-causality test is selected in this study over other alternative techniques because of the favorable Monte Carlo evidence reported by Geweke et al. (1983), particularly for small samples in empirical studies.

To conduct the Granger-causality test, the time-series of the variables are required to be stationary. It has been shown that the use of non-stationary data in causality tests can yield spurious causality results (Stock and Watson, 1989). Therefore, following Engle and Granger (1987), we first test the unit roots of X and Y to confirm the stationarity of each variable. This is done by using the Phillips–Perron (PP) (Phillips and Perron, 1988) test over alternative tests, in that the PP test is known to be robust for a variety of serial correlations and time-dependent heteroscedasticities. If any variable is found to be non-stationary, we must take the first-difference and then apply the causality test with the differenced data.

2.2. Co-integration

The concept of co-integration can be defined as a systematic co-movement among two or more economic variables over the long run. If each of X and Y is non-stationary and co-integrated, then any standard Granger-causal inferences will be invalid and a

[2] An anonymous reviewer indicated that the adoption and expansion of nuclear energy might be determined by non-economic factors like politics rather than economic ones. The authors think that many countries still consider nuclear energy as its main power generation, because the use of nuclear energy is economical and beneficial to the national growth. Thus, nuclear energy share of worldwide electricity generation has increased despite the oil share decline. New nuclear power plants seem very attractive to most of the countries where energy demand is rapidly growing, alternative resources are scarce, and energy supply security is on a high priority. Specifically, in India, Grover and Chandra (2006) presented that the nuclear contribution towards the electricity generation should increase from the present 3% to about a quarter of the total to meet the projected higher demand. The Republic of Korea has been investing many resources into nuclear energy R&D projects, and is currently on the status of exporting its own know-how to the other countries. In USA, nuclear energy already took the 20% of the total electricity generation in 2007, and in Sweden, it contributed to 46.7% in total. Therefore, nuclear energy would be still one of the important sources of electricity generation and nuclear energy consumption has something to do with economic growth in many countries.