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Nuclear energy consumption and economic growth in OECD countries: Cross-sectionally dependent heterogeneous panel causality analysis

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ABSTRACT

The purpose of this study is to determine the direction causality between nuclear energy consumption and economic growth in OECD countries. The empirical model that includes capital and labor force as the control variables is estimated for the panel of fourteen OECD countries during the period 1980–2007. Apart from the previous studies in the nuclear energy consumption and economic growth relationship, this study utilizes the novel panel causality approach, which allows both cross-sectional dependency and heterogeneity across countries. The findings show that there is no causality between nuclear energy consumption and economic growth in eleven out of fourteen cases, supporting the neutrality hypothesis. As a sensitivity analysis, we also conduct Toda–Yamamoto time series causality method and find out that the results from the panel causality analysis are slightly different than those from the time-series causality analysis. Thereby, we can conclude that the choice of statistical tools in analyzing the nature of causality between nuclear energy consumption and economic growth may play a key role for policy implications.

1. Introduction

Determining the direction of causality between energy consumption and economic growth provides important inferences in establishing sound energy policies. A vast literature thereby has been documented on casual relationships between economic growth and consumption of energy sources (electricity, coal, natural gas, and oil) in last two decades.[1] The empirical literature has now been focusing on examining the nature of causality between nuclear energy consumption and economic growth due to the fact that nuclear energy is an important source for increasing diversity of energy supplies, for improving energy security, and for providing a low-carbon alternative to fossil fuels (Wolde-Rufael and Menyah, 2010). The importance of nuclear energy has been increasing as a result of its advantages by producing heat and electricity without emitting carbon-dioxide into the atmosphere at the power plant level (OECD, 2005). Increasing importance of nuclear energy leads researches to question to what extent nuclear energy consumption affects economic growth. Investigating the relationship between nuclear energy consumption and economic growth is insightful for understanding the logical reason of investing in nuclear energy for economical concern or for environmental and social concerns.

This study aims at determining the direction causality between nuclear energy consumption and economic growth by means of panel causality analysis, which allows us to account for both cross-sectional dependency and cross country heterogeneity. In the empirical analysis, we concentrate on OECD countries that seventeen of thirty three OECD countries have nuclear energy capacity, which produce 85% of world's total nuclear energy production. The empirical model is augmented with the control variables – capital and labor force – in order to avoid omitted variable bias due to the point of view that nuclear energy consumption might not alone stimulate economic growth (Wolde-Rufael and Menyah, 2010). The causality analysis that is applied to the panel of fourteen OECD countries for the period 1980–2007 finds out that neither nuclear energy nor economic growth is the cause of each other in eleven out of fourteen cases, supporting the neutrality hypothesis. As a sensitivity analysis, we compare the results from the panel causality analysis with those from Toda–Yamamoto causality approach, which is not able to take into account for cross-sectional dependency and obtain that the results from the panel causality test are different than those from the time-series causality test.

In detecting the existence of causality, we rely upon a panel causality approach instead of time series methods since panel

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[1] See Ozturk (2010) and Payne (2010) for a recent survey on the energy consumption and economic growth nexus.

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Table 1
Summary of empirical literature.

	Country	Period	Methodology	Results
Time series studies				
Yoo and Jung (2005)	Korea	1977–2002	VECM	NE→Y
Payne and Taylor (2010)	USA	1957–2006	TY approach	NE≠>Y
Menyah and Wolde-Rufael (2010)	USA	1960–2007	TY approach	NE≠>Y
Wolde-Rufael (2010)	India	1969–2006	TY approach	NE→Y
Yoo and Ku (2009)	Six countries	1965–2005	VECM	NE→Y: Korea Y→NE: France, Pakistan NE↔Y: Switzerland NE≠>Y: Argentina, Germany
Lee and Chiu (2011)	Six countries	1965–2008	TY approach	NE↔Y: Canada, Germany, UK Y→NE: Japan NE≠>Y: France, USA
Wolde-Rufael and Menyah (2010)	Nine countries	1971–2005	TY approach	NE→Y: Japan, Netherlands, Switzerland Y→NE: Canada, Sweden NE↔Y: France, Spain, UK, USA
Panel data studies				
Apergis and Payne (2010)	Sixteen countries	1980–2005	Panel VECM	NE↔Y: short-run NE→Y: long-run
Apergis et al. (2010)	Nineteen countries	1984–2007	Panel VECM	NE→Y: short-run NE↔Y: long-run

→, ↔, and ≠> represent unidirectional, bidirectional, and no causality, respectively. NE: nuclear energy consumption. Y: real income. VECM: vector error correction model. TY: Toda–Yamamoto approach to Granger causality.

analysis produces more reliable and statistically powerful results than time series analysis by combining information from both cross-section and time dimensions. Unlike the previous panel data studies on the nuclear energy–economic growth nexus, we first test for cross-sectional dependency and heterogeneity across countries due to the fact that ignoring cross-sectional dependency and country specific heterogeneity in a panel causality analysis are potential sources of misleading inferences regarding the direction of causality. Even though time series approaches to causality are able to modeling cross-county heterogeneity, they are not able to take into account cross-sectional dependency across countries. It is the well-known fact that OECD countries are highly integrated and thereby a shock in one country is easily transmitted to other countries through international economic interrelationships. By accounting for cross-sectional dependency across countries, this study differs from the previous studies in the literature and thereby is novel to the nuclear energy–economic growth nexus.

We organize the rest of paper as follows. The next section summarizes the hypotheses related to energy consumption and economic growth as well as the empirical literature on the nuclear energy consumption and economic growth nexus. Section 3 is devoted to describe the data, to outline the econometric methods, and to interpret the empirical results. Finally, Section 4 provides a brief summary of the study and the concluding remarks.

2. Hypotheses and literature

There are four hypotheses regarding the nature of causality between energy consumption and economic growth. According to the growth hypothesis, energy consumption directly causes economic growth if there is unidirectional causality from energy consumption to economic growth. The growth hypothesis also implies an indirect way from energy consumption to economic growth if energy consumption is a complement to labor and capital in the production process. The conservation hypothesis postulates unidirectional causality from economic growth to energy consumption, implying that energy conservation policies do not adversely impact economic growth. The feedback hypothesis is supported with bidirectional causal relationship between energy consumption and economic growth. In this case, energy consumption and economic growth are associated with each other in a complementary way. Finally, the case of non-causality between energy consumption and economic growth supports evidence on the neutrality hypothesis, which implies non-sensitivity of economic growth (energy consumption) to energy consumption (economic growth).

Since the focus of this study is on the nuclear energy consumption and economic growth relation, we herewith concentrate on reviewing the empirical studies in this regard and summarize the literature in Table 1. In an early study Yoo and Jung (2005) found bidirectional causality from nuclear energy consumption to economic growth in Korea. The single county time series literature was extended by Payne and Taylor (2010) who supported the neutrality hypothesis for the USA. This result was substantiated by the study of Menyah and Wolde-Rufael (2010) in which the model estimated by Yoo and Jung (2005) extended by the inclusion of renewable energy consumption and CO_2 emission. Another single country study was carried out by Wolde-Rufael (2010) for India using real gross fixed capital formation as the control variable. In line with Yoo and Jung (2005), the evidence on the growth hypothesis was supported.

In addition to the single country time series studies, some of the recent studies carried out multi-country time series analysis to provide cross-country evidence. Yoo and Ku (2009) investigated the relationship for six countries and found causality from economic growth to nuclear energy consumption in France and Pakistan that is in the opposite direction for Korea, feedback relationship for Switzerland, and the neutrality for Argentina and Germany. Lee and Chiu (2011) considered six highly industrialized countries and indicated bidirectional causality for Canada, Germany, and United Kingdom (UK); non-causality for France and the USA; one-way causality running from economic growth to nuclear energy consumption for Japan. By employing the same method, Wolde-Rufael and Menyah (2010) analyzed the direction of causality in nine industrialized countries. In contrast to Lee and Chiu (2011), they found causality running from nuclear energy to economic growth for Japan, Netherlands, and Switzerland; unidirectional causality from economic growth to nuclear energy for Canada and Sweden; bidirectional causality for France, Spain, the UK, and the USA.