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The asymmetric Granger-causality analysis between energy consumption and income in the United States

Aviral Kumar Tiwari

Faculty of Applied Economics, Faculty of Management Studies, The ICFAI University Tripura, Kamalghat, Sadar, West Tripura, Tripura 799210, India

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ABSTRACT

We investigated Granger-causality between variants of the energy consumption sources and Gross Domestic Product (GDP) for the United State of America (USA). To accomplish this objective we utilized a recent approach of asymmetric Granger-causality developed by Hatemi-J for the period January 1973–October 2011. Our results indicated presence of asymmetric Granger-causality between a few variants of energy consumption sources (i.e., Coal Consumption (CC), Natural Gas Consumption (NG), Primary Energy Consumption (PE), and Total Renewable Energy Consumption (TRE)) and GDP (all measured in growth rates). Additionally, when positive shocks are analyzed we found the evidence of unidirectional Granger-causality running from GDP growth rate to growth rate of CC and from growth rate of Total Electricity End Use (EC) to GDP growth rate. Additionally, we find significant evidence of bidirectional Granger-causality between NG and GDP, PE and GDP and TRE and GDP (all measured in growth rates). However, in case of negative shocks we find that the null hypothesis that growth rates in CC and TRE do not Granger-cause GDP growth rate is rejected at 5% level of significance. These results have important implications for research analysts as well as policy makers of the USA economy.

Contents

1. Introduction

Recently, the interest of researchers has shifted to analyzing the direction of Granger-causality between renewable energy sources and economic growth. This motivation comes, in particular, from three major reasons. First, it is expected that consumption of renewable energy sources (RES) will reduce the consumption of those sources of energy (particularly non-renewable i.e., NRES) that are highly contributing to the greenhouse gas emissions (GHGs), especially carbon dioxide (CO_2) emissions, which is considered as the main causes of global warming. Hence, as a consequence, environmental degradation can be minimized or to the extent possible can be reduced. Second, the substitution of non-renewable energy sources with renewable energy sources will occur without harming the economic growth rate of the economies. The third reason is the environmental awareness programs organized by different government or non-government agencies and profit and/or non-profit organizations at national and international levels. In total, the objectives of the studies were whether economic growth of the nation in question Granger-causes renewable energy consumption or vice-versa or there is evidence of bidirectional Granger-causality.

The conduit through which consumption of RES boosts the growth rate of the economy is a debatable topic among researchers and energy analysts. Nevertheless, the plausible mechanism has been explained in quite a few studies. For example, Domac et al. [1] and

E-mail addresses: aviral.eco@gmail.com, aviral.kr.tiwari@gmail.com

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Chien and Hu [2] suggest that renewable energy might increase the macroeconomic efficiency and thereby boost the economic growth process.[1] Masui et al. [3] suggested some effective ways to address the issues related to the climate change; for example, adopting environmentally sustainable technologies, improving energy efficiency, forest conservation, reforestation, water conservation, or energy saving. Abulfotuh [4] suggested considering an immediate change in the composition of an energy resource portfolio due to the escalating demand for energy. Tiwari [5] suggested that the promotion of RES may also be helpful in mitigation of CO_2 emissions. As a consequence, it will reduce the negative impact of global warming on the economic growth. Hence, we expect that RES have great potential to solve a major part of global energy sustainability. In this regard Krewitt et al. [6] suggest that RES could provide as much as half of the world's energy needs by 2050.

Our observation from the exhaustive survey of Payne [7,8][2] and Ozturk [9] indicates that studies in this area have yielded mixed and often conflicting results for both developed and developing countries due to different methods, sample periods, and model specifications employed. Payne [10] found an absence of Granger-causality between renewable or non-renewable energy consumption and real GDP and thus provided support to the neutrality hypothesis for the U.S. during 1949–2006 with the application of the Toda–Yamamoto [11] approach. Bowden and Payne [12], for the U.S., for the period 1949–2006, by using the Toda–Yamamoto [11] approach, found bidirectional Granger-causality between commercial and residential primary energy consumption and real GDP, respectively. Further, their results indicated that industrial primary energy consumption Granger-causes real GDP. Bowden and Payne [13], for the U.S., by using the data from 1949 to 2006 and applying the Toda–Yamamoto [11] approach, showed the evidence of bidirectional Granger Granger-causality between commercial and residential non-renewable energy consumption and real GDP, respectively. Further, their results indicated significant evidence of unidirectional Granger-causality running from residential renewable energy consumption and industrial non-renewable energy consumption to real GDP. Payne [14] with the application of Toda–Yamamoto [11] approach for the period 1949–2007 found evidence of unidirectional Granger-causality running from biomass energy consumption to real GDP and hence provided support of the growth hypothesis. By the application of the Toda–Yamamoto [11] approach, for the period 1949–2006, Payne [15] found evidence for the absence of Granger-causality between coal consumption and real GDP, positive unidirectional Granger-causality running from real GDP to natural gas consumption, and positive unidirectional Granger-causality running from petroleum consumption to real GDP. Aslan and Çam [16] examine the Granger-causal relationship between nuclear energy consumption, economic growth, capital and labor for Israel, over the period of 1985–2009 using a bootstrap-corrected Granger-causality. They found that there exists unidirectional Granger-causality, which is running from nuclear energy consumption to GDP.

Pao and Tsai [17] examine the dynamic causal relationships between pollutant emissions, energy consumption and output of a panel of BRIC (i.e., Brazil, Russia, India and China) countries over the period 1971–2005, except for Russia (1990–2005). They found that in the long-run equilibrium energy consumption has a positive and statistically significant impact on emissions, while real output exhibits the inverted U-shape pattern associated with the Environmental Kuznets Curve (EKC) hypothesis with the threshold income of 5.393 (in logarithms). Further, in the short term, changes in emissions are driven mostly by the error correction term and short term energy consumption shocks, as opposed to short term output shocks for each country. The panel Granger-causality results indicate there is energy consumption–emissions bidirectional strong Granger-causality and energy consumption–output bidirectional long-run Granger-causality, along with unidirectional both strong and short-run causalities, from emissions and energy consumption, respectively, to output. Yildirim et al. [18] investigated the Granger-causal relationships among industrial production index, coal consumption and employment in the industrial sector for the period of 1973:1–2011:10 in the USA. After noticing that there are breaks in the regression model, the Hatemi-J test for cointegration was employed in the cases that take into account two possible regime shifts. They found that there is a long run relationship between industrial production and industrial coal consumption with the breaks at 1983:4 and 1998:4. Further, a negative relationship between coal consumption and industrial production for the period of 1973:1–1983:4 and positive relationship for 1983:5–1998:4 period was also found, however, for the last period that covers 1983:5–2011:10, the cointegration relationship turned to negative and the causal relationship between coal consumption and industrial production changes over time.

Yildirim et al. [19] using real GDP, employment, investment and kinds of renewable energy consumption in their empirical model for the USA found evidence of only one Granger-causal relationship which was running from biomass-waste-derived energy consumption to real GDP. No Granger-causal relationship was found between real GDP and all of the other renewable energy kinds such as total renewable energy consumption, geothermal energy consumption, hydroelectric energy consumption, biomass energy consumption and biomass-wood-derived energy consumption. That is using of energy from waste cause not only solving the dumping problems, but also it contributes to real GDP. Yildirim and Aslan [20] examine the relationship between energy consumption, economic growth, employment and gross fixed capital formation for 17 highly developed OECD countries by employing both the Toda–Yamamoto procedure which based on asymptotic critical values and the bootstrap-corrected Granger-causality test, since non-normality of the error term harms the validity of the Toda–Yamamoto procedure. They found that there exists unidirectional Granger-causality running from energy consumption to real GDP for Japan and bi-directional Granger-causality for Italy, New Zealand, Norway and Spain. Further, they found that there exists uni-directional Granger-causality from GDP to energy for Australia, Canada and Ireland whereas there is no Granger-causal nexus for all of other nine countries. Tugcu et al. [21] investigate the long-run and Granger-causal relationships between renewable and non-renewable energy consumption and economic growth by using classical and augmented production functions, and making a comparison between renewable and non-renewable energy sources in order to determine which type of energy consumption is more important for economic growth in the G7 countries for 1980–2009 period. Autoregressive Distributed Lag approach to cointegration was employed for this purpose. Also, they investigated Granger-causality among energy consumption and economic growth by employing a recently developed Granger-causality test by Hatemi-J [22]. They found that in the long-run either renewable or non-renewable energy consumption matters for economic growth and augmented production function is more effective in explaining the considered relationship. Further, they found the evidence of bidirectional Granger-causality for all countries in case of classical production function and mixed results for each country when the production function is augmented.

[1] This might be due to either the expansion of business and new employment opportunities brought by renewable energy industries that result in economic growth or through the import substitution of energy, which has direct and indirect effects on the increase of an economy's GDP and/or trade balance.

[2] For details, please refer to the original study by Payne [7,8] and Ozturk [9]. Besides Payne [7,8] and and Ozturk [9], Shahbaz et al. [36] and Tiwari [37,38] also have provided a comprehensive review of the literature and one may refer to those too.