Renewable and Sustainable Energy Reviews 57 (2016) 362–366

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

The causal relationship between biomass energy use and economic growth in the United States

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ARTICLE INFO

Article history:
Received 10 January 2015
Received in revised form
16 December 2015
Accepted 17 December 2015

Keywords:
Biomass
GDP
Renewable energy

ABSTRACT

This paper examines the causality relations among economic growth, biomass energy consumption, employment and capital in the U.S between 1961 and 2011. Using the ARDL bounds testing approach to cointegration, long and short run relationships among the variables are estimated. Long run and short run coefficients indicate that biomass energy consumption has positive impacts on economic growth for the U.S. In addition, the Granger causality results illustrate that unidirectional causality from biomass energy consumption to real GDP supportive of the growth hypothesis.

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1. Introduction

Energy is regarded as a key factor in the generation of assets and also an important part of economic growth. This makes energy resources particularly significant for "every country in the world. Environmental issues especially carbon dioxide emissions are encouraging countries to use renewable sources instead of fossil fuels. Since 1980s, with global warming and a sharp decline in environmental quality, people have reached a consensus of environmental protection and sustainable development [1,2].

Theoretically, fossil fuels are considered to be able to renew themselves for a very long period of time, but they are in danger of complete extinction in the near future [3]. Therefore, renewable energy has been the strongest growing source of electricity generation [4].

Biomass energy sources are among the most promising, most hyped and most heavily subsidized renewable energy sources as seen in Fig. 1. Biomass resources, which have been historically significant energy supplies, offer a near-term renewable alternative to fossil fuels. Biomass resources include wood wastes and residues from the production of paper and forest products, agricultural residues, long-rotation woody plantings, thinning, logging residues and specialized wood and herbaceous crops developed specifically for energy production [5].

Biomass energy use increased by 60% from 2002 to 2013 in the United States. This growth is entirely due to increased consumption of biomass to produce biofuels, mostly ethanol but also a smaller amount of biodiesel and other biomass-based diesel fuels. In 2013, biomass accounted for about half of all renewable energy consumed and 5% of total U.S. energy consumed [6]. Biomass resources are distributed widely across the United States, ensuring that communities across America can benefit both financially and environmentally from increased biomass production.

A variety of studies have dealt with the relationship between energy consumption and GDP linkage. These studies have been performed in different countries and with various modeling

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http://dx.doi.org/10.1016/j.rser.2015.12.109
1364-0321/

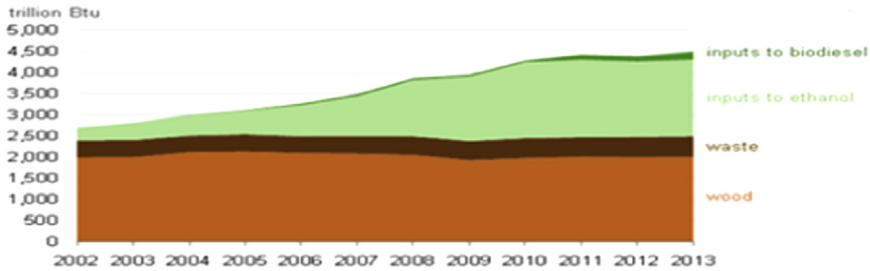

Fig. 1. Biomass energy consumed, by type (2002–2013),
source: EIA, monthly energy review, short-term energy outlook, and EIA estimates.

methods, approaches and findings.[1] However, only a few studies have examined the relationship between biomass energy consumption and economic growth.

Directions of the causal relationship between energy consumption (EC) and economic growth (EG) should be classified into four hypotheses, each of which has essential implications for energy policy [7]. The growth hypothesis proposes that unidirectional causality runs from EC to EG. It means that increases in EC have an impact on EG. As a result, EC has a fundamental role in EG. If there is a unidirectional causality from EG to EC, it is called conservation hypothesis. This hypothesis supports that the reduction in EC will have little/no effect on EG. Also, it is supported that an increase in real GDP causes an increase in EC. The feedback hypothesis argues bidirectional causality between EC and EG. This relationship involves that there is a joint effect between EC and EG. In other words, energy conservation has negative effect on EG, and decreases in GDP have negative impact on EC. No causality between EC and EG is referred to as neutrality hypothesis. Under the neutrality hypothesis, EC is not correlated with GDP, which means that the increase or decrease in EC has no effect on EG and vice versa [3].

Chien and Hu [8] analyzed the effects of renewable energy consumption of 45 countries for the period of 2001–2002. They concluded that increasing the use of renewable energy improves an economy's technical efficiency and leading economic growth. For the case of G7 countries, Sadorsky [14] examined the relationship among renewable energy consumption, income, oil prices and CO2 emissions by vector auto regression for the period of 1980-2005. He found that increases in real GDP per capita and carbon dioxide emissions per capita are found to be major drivers behind increases in G7 renewable energy consumption per capita. For the case of 18 developing countries, Sadorsky [15] employed causality techniques to examine the relationship between renewable energy consumption and economic growth over the period 1994–2003. No short-term causality is found between GDP and renewable energy consumption.

On the other hand, Apergis and Payne [16] investigated the relationship between renewable energy consumption and economic growth for the case of 20 OECD countries. They concluded that there is bidirectional causality between renewable energy consumption and economic growth in both the short-run and the long-run.

The same linkage is examined by Apergis and Payne [17] for the case of 13 Eurasia countries over the period 1992–2007. They found that feedback hypothesizes valid relationship between renewable energy consumption and output. For the case of U.S., Menyah and Wolde-Rufael [18] concluded that there is unidirectional causality from growth to renewable energy for the period 1960–2007. For a panel of six Central American countries, Apergis and Payne [19] illustrated that there is bidirectional causality between renewable energy consumption and economic growth in both the short- and long-run by using panel error correction model.

Menegaki [20] investigated the causal relationship between economic growth and renewable energy for 27 European countries in a multivariate panel framework over the period 1997–2007 using a random effect model. Empirical results do not confirm causality. Tugcu et al. [21] examined the causal relationships between renewable and non-renewable energy consumption and economic growth in G7 countries for 1980–2009 periods. Although bidirectional causality is found for all countries in case of classical production function, mixed results are found for each country when the production function is augmented. Bildirici [22] examined the short-run and long-run causality analysis between biomass energy consumption and economic growth in the 10 developing and emerging countries by using the Autoregressive Distributed Lag bounds testing (ARDL) approach for the period 1980–2009 and concluded that there is weak evidence of causal relationships between variables. Bildirici and Ozaksoy [23] examined the causality analysis between biomass energy consumption and economic growth in the selected 10 countries by using ARDL and vector error-correction models for the period from 1960 to 2010. They concluded that there is unidirectional causality from GDP to biomass energy consumption for Austria and Turkey, and there is unidirectional causality from biomass energy consumption to GDP for Hungary and Poland. For Spain, Sweden, and France, it was found as bidirectional causality.

Al-Mulali et al. [24] investigated the long run relationship between renewable energy consumption and GDP growth in high income, upper middle income, lower middle income, and high income countries. The results showed that 79% of the countries have a positive bi-directional long run relationship between renewable energy consumption and GDP growth. This characterizes the feedback hypothesis. In contrast, 19% of the countries illustrated no long run relationship between the variables. This represents the neutrality hypothesis. Moreover, 2% of the countries showed a one way long run relationship from GDP growth to renewable energy consumption, verifying the conservation hypothesis, and from renewable energy consumption and GDP growth representing the growth hypothesis.

Apergis and Payne [25] investigated the determinants of renewable energy consumption per capita for a panel of seven Central American countries over the period 1980 to 2010. They found that a long-run cointegrated relationship exists between renewable energy consumption per capita, real GDP per capita, carbon emissions per capita, real coal prices, and real oil prices with the respective coefficients positive and statistically significant.

Yıldırım et al. [26] investigated causal relations between various renewable energy consumption and GDP linkage. They concluded that there is only one causal relationship was found from biomass-waste-derived energy consumption to real GDP. No causal relationship was found between real GDP and all of the other

[1] Azam et al. [9] for ASEAN-5 countries; Tampakis et al [10], Zafeiriou [11] and Tsantopoulos et al. [12] for Greece; Zafeiriou et al. [13] for EU.