



Renewable and non-renewable energy-growth-emissions linkages: Review of emerging trends with policy implications



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ABSTRACT

This study is an extension of the previous studies which focused mainly on energy-growth nexus but fails to consider the carbon emission implication of this relationship. The methodology of the study permits a comprehensive and comparative analysis of existing studies on (renewable and non-renewable) energy-growth-emission nexus in order to draw some implications for policy and research. The survey revealed the extent of the spread of studies across issues, time and geographical space (countries and regions). It also disclosed the range of methodological approaches adopted to analyse the issues over time and the frequency of their use. It unravelled the varied findings across countries and regions given the diverse methods employed and specific features of the economies analysed. Arising from the literature survey, this study highlights the existing gaps in the literature and new direction for policy and research. The general policy implication of the findings of this study is that pollution effect of energy-growth nexus should be taken into consideration in policy formulation for sustainable development. Further, the design of regional and global policies should recognise the fact that energy-growth-emission linkages varied across countries even in the same region. Some new direction for research on renewable and non-renewable energy-growth-emission linkages pointed out in this survey includes the following. Future research on energy-growth nexus without considering the pollution impact may not contribute so much to the literature. Studies should investigate the substitution/complementary effects of the energy varieties on growth-emission nexus, while new methodological contributions are imperative.

1. Introduction

The literature sets on the links between energy and emission (energy-emission nexus); energy and growth (energy-growth nexus) and among energy, emission and growth (energy-emission-growth nexus- EEO) are quite extensive. Existing studies analysed different combinations of the three levels of relationships for different countries (specific or groups), time periods, and analytical/methodological approaches. Based on the foregoing, findings remain inconclusive, while policy prescriptions are diverse. Literature in this area suggested the existence of four causality hypotheses (growth, conservation, feedback, and neutrality hypotheses) which have been tested in all regions, with the results of such tests conflicting across regions and countries (Ozturk, [1]; and Omri, [2]). Some studies have also tested the Environmental Kuznets Curve (EKC) Hypothesis in the process of analysing the linkages.

The growth hypothesis states that a unidirectional causality runs from energy consumption to economic growth. This therefore implies that energy consumption plays a crucial role, directly or indirectly in

promoting economic growth given its important contribution to production process (Payne, [3] and Sharma, [4]). Similarly, the conservation hypothesis indicates that economic growth generates energy consumption. Thus, this hypothesis holds that there is unidirectional causality running from economic growth to energy consumption. A growing economy can increase real income per capita which in turns raises aggregate demand. This consequently stimulates increased production of goods and services, which requires high consumption of energy. It is also possible for economic growth to produce a negative impact on energy consumption if there is technological advancement which lessens energy use per output unit.

In the same vein, the feedback hypothesis shows that there is bidirectional causality between energy consumption and economic growth. It stresses the direct positive connection and complementary link between the two variables. The neutrality hypothesis suggests that there is no causal relationship between energy consumption and economic growth. It states that the effect of energy consumption on output growth is relatively small, hence negligible. Likewise, the EKC hypothesis describes the causal link between environmental pollution

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(carbon emissions) and economic growth. It states that environmental pollution tends to rise at low level of per capita income, but after a point, as per capita income rises, pollution tends to fall (Grossman and Krueger, [5]).

In recent years, especially during the last three decades, there is increased campaign for the reduction of greenhouse gas emissions, which has continued to be associated with the rising level of non-renewable energy consumption. Consequently, many countries have increased their investment in renewable energy production significantly, so as to meet up with the growing consumption of the renewable energy (Al-mulali et al., [6]). Following this development, there is a renewed interest of the various stakeholders including the policy makers, policy analysts, energy traders and consumers as well as the academics. Thus, in order to support policy analysis a number of studies have evolved over time investigating the causal relationship between non-renewable energy consumption and either economic growth or carbon emissions or both, while another set of studies have examined the link between renewable energy consumption and either economic growth or carbon emissions or both. Yet, another round of papers focused on the link between both types of energy and either economic growth or carbon emissions or both.

Despite the rising interest in renewable and non-renewable energy consumption and their relationships with economic growth and carbon emissions, there are a number of gaps yet to be identified and addressed in this area. Earlier attempts to identify some gaps led to three surveys of existing literature by Payne [7] and Ozturk [1] who reviewed electricity-growth and energy-growth nexus respectively, and Omri [2] who surveyed studies on the nexus between consumption of energy varieties (total energy consumption, electricity consumption, nuclear consumption and renewable energy consumption) and economic growth. Despite the significant contributions these studies made in unravelling the frontiers of knowledge in these areas and identifying gaps for further or future research, a number of gaps still exist for some reasons. These include passage of time (the periods covered by the previous studies end in 2012) and dynamics in the world economy; very recent interest in the renewable energy consumption and policy analysis; and the reawakened interest in sustainable development which led to the introduction of pollution into the energy-growth analysis. Against the above background, this current survey identifies the following gaps in which it contributes to the body of knowledge in the literature.

First, none of the previous authors incorporated studies related to carbon emissions in their surveys. Second, despite the specific studies on the role of each type of energy (**non-renewable** such as oil, coal, diesel, fossil fuel and natural gas, and **renewable** such as well as biomass) in economic growth and carbon emissions, past literature surveys appear not to have covered some of them, making literature survey an on-going exercise. Third, more studies on renewable energy consumption were published in very recent time (2014–2016), than those considered in the previous studies. Fourth, this survey seems to be the first comprehensive attempt to cover three level causal analyses of energy consumption, economic growth and carbon emissions. Thus, this survey covers energy-growth nexus; energy-emission nexus; and energy-growth-emission nexus. Besides, both renewable and non-renewable energy consumption and their varieties are considered. This study adopts descriptive approach (with presentation and discussion of tables and charts) which aids “snap shot” understanding of the issues discussed. This approach is suitable because it gives room for rigorous and transparent analysis, while it is superior to the methods used in most of the existing studies, which largely dwelled on qualitative method. The new insight gained by adopting this methodological approach is that it permits and enhances comparative analysis of issues, methods and findings across time, countries and regions.

The study is structured in eight sections such that, after this introduction section is section two which discusses the methodology

adopted in analysing the selected articles, while section three provides an overview of the identified studies on the subject matter. Reviews of studies on renewable energy consumption, economic growth and carbon emissions is presented in section four, while section five contains the overview of studies on non-renewable energy consumption, economic growth and carbon emissions. Section six reviews studies on a combination of renewable and non-renewable energy consumption, economic growth and carbon emissions, with section seven providing a discussion of findings of the survey. Summary and lessons for research and policy are presented in section eight.

2. Methodology

The search criteria for this study involve general Google and individual journal web searches in order to avoid introducing bias into the article selection process. It also involves selection of studies focusing on energy-growth nexus, energy-emission nexus, growth-emission nexus and energy-growth-emission nexus, all of which must be economics related. In order to draw implications not only for research but also for policy, empirical studies were reviewed, while theoretical and descriptive papers were not considered in this study. Moreover, only published articles which are largely sourced from major energy journals are utilised so as to ensure highly quality outcome from this study.

The outcome of the search is the spread of articles across the journal outlets presented in Fig. 1. A total of 107 studies were obtained and used for this survey, out of which about 80% were published in major energy journals. Also, over 20% (each) of the articles utilised were published in Renewable and Sustainable Energy Reviews, and Energy Policy respectively, while significant proportion of the articles were also published in Energy Economics, Applied Energy and Energy. Articles published in other journal outlets include those from Economic Modelling, Ecological Economics, Renewable Energy, Journal of Renewable and Sustainable Energy among others.¹ Moreover, the study utilised studies conducted between 2006 and 2016 following the rising interest in renewable versus non-renewable energy and environmental issues during this period. In addition, most energy-growth-emission related studies became dominant during this period. The paper employs descriptive method in analysing the selected articles to enhance its quantitative quality. This method allows “a bird-eye view” of the various issues analysed in the paper compared to the discussion method mostly used in existing related studies. Content analysis of each of the various articles was performed using percentages and frequency distribution tables, figures and charts to illustrate the dynamic nature of (time and geographical dimensions) issues, methods and findings.

3. Overview of studies on renewable and non-renewable energy-growth-emission nexus

Studies on renewable and non-renewable energy consumption have generated a lot of interest in the recent years, especially in terms of their causal relationship with economic growth and carbon emissions.

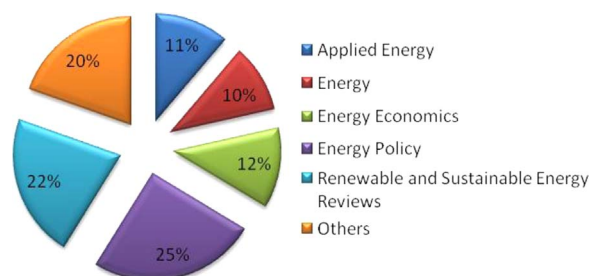


Fig. 1. Spread of articles across journals. Source: Authors Compilation.

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