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The impact of renewable energy consumption to economic growth: A panel data application

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ABSTRACT

Internationally, the importance of renewable energy in the energy mix has been increasingly appreciated. The advantages of the renewable energy usage for the world's energy security and the environment are indisputable and much discussed in the literature. However, its effects on the economic welfare of the countries are yet to be examined fully and described quantitatively. The purpose of this paper is to estimate the impact of the renewable energy consumption to economic welfare by employing panel data techniques. The results show that the influence of renewable energy consumption or its share to the total energy mix to economic growth is positive and statistically significant. From a policy point of view, promoting renewable energies bears benefits not only for the environment but also for the economic conditions of the countries.

1. Introduction

It is without doubt that one of the most severe problems of the modern world is the climate change and its important negative consequences to the environment. Human activity, particularly the consumption of energy, has been considered among the main factors contributing to the changing of climate in the last decades (IPCC, 2007). To tackle the future changes of the environment, among other measures, a change in the current technologies of generating energy is imperative. Traditional generation techniques such as coal-burning have detrimental effects to the environment and hence, internationally, countries have turned towards more environmentally-friendly generation techniques from renewable sources such as solar and wind.

The Energy Information Administration (EIA) reports that the generation of energy through renewable sources has been the fastest growing source recently (EIA, 2009). Developed economies promote renewable sources in order to strengthen the energy security of supply and control their greenhouse gas emissions (GHG) (Moselle, 2011). For example, the European Commission aims to increase the share of renewable sources to 20% of the total by 2020 (EC, 2009). On the other hand, the developing economies see in the use of renewable energies, solutions to the challenges of rural electrification and lack of access to electricity (Munasinghe, 2010, Pereira et al., 2010). For example a large proportion of the African population has no access to electricity, even though the continent has a great abundance of alternative and renewable energy sources such as solar, thermal, photovoltaic, wood, biomass, wind and biogas. Kaygusuz et al. (2007) and Kaygusuz (2007) also mention that the choice to promote renewable energies will lead not only to further modernization of the energy sector but also to support the various countries' goals for economic development and sustainability.

The purpose of this paper is to determine quantitatively the impact of renewable energy consumption to the economic conditions in a panel data framework including all the OECD countries for the period from 1990 to 2010. The results of this analysis have important implications for the implementation of future policies on promoting renewable energies in combination with macroeconomic policies. The importance of this paper lies with the fact that it takes into account the importance of not only the volumes of renewable energies consumed but also their share in the total energy mix of each country; an indicator that shows the importance of renewable energies in a country's energy planning and future. Moreover, this paper uses a sound theoretical framework, assuming that the renewable energies are part of the production capacity of a country.

The paper is structured as follows. Section 2 discusses briefly international literature dealing with the nexus between renewable energies and economic growth. The following section discusses the methodology and the data used while next the empirical results are presented. Finally the last section concludes the analysis.

2. Brief literature review

Renewable energy is considered to be in synergy with many aspects of sustainable development (Stigllitz, 2002). That is the reason that sustainable development through renewable energies is at the center of policies all over the world. As Bugaje (2006) mentions, "in making renewable

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energy consumption sustainable and acceptable to other socioeconomic parameters of development, the following must be considered:

- Sustainability of the environment through appropriate resource management;
- Economic sustainability through infrastructure and service development that keeps affordability firmly to the front because of the disadvantaged rural populations;
- Social sustainability through ensuring that the poor benefit, and that women's incomes and concerns, legal rights for all, and children's rights are all appreciated and supported;
- Administrative sustainability through ensuring that there is administrative capacity for program implementation and this will be maintained or increased over time."

A number of studies have been conducted showing the importance of renewable energies globally with regard to their relationship to the countries' economic conditions. For instance, Sadorsky (2009) concluded that there is a positive relationship between real per capita income and per capita renewable energy consumption. This result is confirmed by Apergis and Payne (2010) who examined the same relationship for the OECD countries in a panel data context. Frondel et al. (2010) focused on the implications of the renewable energy usage to job creation and effective market operations in Germany. Sari and Soytas (2004) by carrying out a decomposition exercise concluded that waste, hydraulic power and wood consumption explain approximately 31.5% of the variation in real GDP for Turkey. More recently, Tugcu et al. (2012) examined the renewable and non-renewable energy linkages with economic growth in G7 countries. Their findings showed not only that renewable energy is a contributing factor to economic growth but also that a production function is effective in explaining the relationship. Also, Menegaki (2011) examining the same question for the European countries, found that in the long-run a 1% increase in the share of renewable energy to the total energy mix will increase GDP by 4.4%.

Although the relationship has been discussed in the literature already but not extensively, this paper learns from others and combines their strong points in the analysis. The theoretical framework followed was derived by Fang (2011) and justified by Tugcu et al. (2012). A Cobb-Douglas (Cobb and Douglas, 1928) production function is used where the technological level of the countries is proxied by the total expenditures for Research and Development (R&D). Also, two different variables representing the countries' economic conditions are utilized for robustness purposes, as in Fang (2011): Gross Domestic Product (GDP) and GDP per capita. To ensure the robustness of the results and to answer some policy questions, two variables are used to represent renewable energy: the total renewable energy consumption and the share of renewable energy consumption to overall energy consumption of the countries, as in Fang (2011).

The panel cointegration technique proposed by Pedroni (1999, 2004) and employed in Apergis and Payne (2010) is also used here. With regard to the data, Apergis and Payne (2010) include only 20 OECD economies while this paper aims at using data of at least 30 of the OECD economies depending on data availability. The time period here spans from 1990 up to 2010, while Apergis and Payne (2010) include data only until 2005. The analysis blends the rational and methodology of Fang (2011) and Apergis and Payne (2010). Fang (2011) looked at the influence of renewable energy consumption and its share to various macroeconomic indicators such as Gross Domestic Product (GDP) and GDP per capita in China; while Apergis and Payne (2010) investigated the relationship for 20 OECD economies. This paper adopts the theoretical framework of Fang (2011) that examines the hypothesis within a Cobb–Douglas production function and the econometric methodology employed in Apergis and Payne (2010).

3. Methodology

3.1. Theoretical model

The theoretical basis of this focus area lies with the fundamental economics of production as it was used by Fang (2011) in his effort to evaluate the influence of renewable energy consumption to the Chinese economy. In his empirical work followed here, in order to represent a relationship between inputs and output, a Cobb–Douglas functional form is used. This general function has the form of Cobb-Douglas production function (Cobb and Douglas, 1928):

$$Q = AL^{\alpha}K^{\beta} \tag{1}$$

where Q is the monetary value of production; L is the labor input; K is the capital input, A is the total factor productivity and α and β are the elasticities of labor and capital respectively.

Although the labor and capital variables can be easily quantifiable as the number of employed people in the country and gross fixed capital formation respectively, the technological change can be represented by various variables. Following Fang (2011), in this exercise the R&D expenditure is used as a proxy to technological changes. Following Fang (2011), two variables will represent the possible influence of renewable energy consumption to economic growth: total consumption of renewable energy and share of renewable consumption to the energy mix. Thus, the final Cobb–Douglas function to be estimated will be as follows in its natural logarithm form (denoted by the small letters):

$$gdp(\text{or } gdppc) = \alpha_0 + \alpha_1\, trc(\text{or } src) + \alpha_2\, cap + \alpha_3\, empl + \alpha_4 r\_d + \mu \tag{2}$$

where gdp is the Gross Domestic Product and gdppc is the Gross Domestic Product per capita; trc is the total renewable energy consumption; src is the share of renewable energy consumption to total energy consumption; cap is the gross capital formation; empl is the number of employees; r_d is the R&D expenditure of each country and $\alpha_0 \ldots \alpha_4$ are the unknown parameters to be estimated while μ is an error term.

3.2. Econometric methodology

The above theoretical model will be estimated using panel data techniques. Firstly, unit root tests will be used to confirm formally whether the variables are stationary or not. A number of unit root tests were considered but most test for a common root among the series. The chosen test was the one proposed by Im et al. (2003) that tests for unit roots allowing heterogeneous autoregressive coefficients. The equation used to test for unit roots is:

$$y_{it} = \rho_i\, y_{i(t-1)} + \delta X_{it} + \varepsilon_{it} \tag{3}$$

where $i = 1,\ldots N$ for each country; $t = 1,\ldots T$ is the time period; X_{it} is the symbol for the combination of all the exogenous variables in the model (fixed effects or time trend also included); ρ_i represents the autoregressive coefficients and finally ε_{it} is the error term. As explained in detail in Apergis and Payne (2010), Im et al. (2003) allows for different orders of serial correlation and follows the typical augmented Dickey Fuller (ADF) in average:

$$\varepsilon_{it} = \sum_{j=1}^{p=1} \varphi_{ij}\varepsilon_{it-j} + u_{it}. \tag{4}$$

If Eq. (4) is substituted into Eq. (3):

$$y_{it} = \rho_i y_{it-1} + \sum_{j=1}^{p=1} \varphi_{ij}\varepsilon_{it-j} + \delta_i X_{it} + u_{it} \tag{5}$$

where ρi shows the number of lags in the ADF regression.