Energy 74 (2014) 439–446

Contents lists available at ScienceDirect

Energy

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

Fossil & renewable energy consumption, GHGs (greenhouse gases) and economic growth: Evidence from a panel of EU (European Union) countries

Gülden Bölük [a, *], Mehmet Mert [b]

[a] Akdeniz University, Department of Economics, Antalya, Turkey
[b] Akdeniz University, Department of Econometrics, Antalya, Turkey

ARTICLE INFO

Article history:
Received 13 March 2014
Received in revised form
2 July 2014
Accepted 3 July 2014
Available online 28 July 2014

Keywords:
Environmental Kuznets Curve
Carbon dioxide emissions
Renewable energy

ABSTRACT

Recently a great number of empirical research studies have been conducted on the relationship between certain indicators of environmental degradation and income. The EKC (Environmental Kuznets Curve) hypothesis has been tested for various types of environmental degradation. The EKC hypothesis states that the relationship between environmental degradation and income per capita takes the form of an inverted U shape. In this paper the EKC hypothesis was investigated with regards to the relationship between carbon emissions, income and energy consumption in 16 EU (European Union) countries. We conducted panel data analysis for the period of 1990–2008 by fixing the multicollinearity problem between the explanatory variables using their centered values. The main contribution of this paper is that the EKC hypothesis has been investigated by separating final energy consumption into renewable and fossil fuel energy consumption. Unfortunately, the inverted U-shape relationship (EKC) does not hold for carbon emissions in the 16 EU countries. The other important finding is that renewable energy consumption contributes around 1/2 less per unit of energy consumed than fossil energy consumption in terms of GHG (greenhouse gas) emissions in EU countries. This implies that a shift in energy consumption mix towards alternative renewable energy technologies might decrease the GHG emissions.

1. Introduction

The increasing threat of global warming and climate change has been a major on-going concern since the 1990s. Because GHG (greenhouse gas) emissions result primarily from the combustion of fossil fuels, energy consumption and production are at the centre of climate change debates. According to the latest report of the EU-JRC (Joint Research Centre), (see Ref. [54], fossil fuel combustion accounts for about 90% of total global CO_2 emissions. The relationship between energy consumption and economic development, as well as economic development and environmental pollution has been studied intensively for the last three decades [27,39,41].

There are three main research branches discussed in the literature that consider economic growth, energy consumption and environmental pollution [79]. The first branch focuses on the relationship environmental pollution and economic growth, testing the validity of the so-called EKC (Environmental Kuznets Curve) hypothesis. Within the first branch of studies, the EKC was interpreted as reflecting the relative strength of scale versus technique effect [16]: 1768). However, as suggested by Panayotou in Ref. [57]; the shape of the EKC reflects some mixture of scale, composition and technique effect. When a country at the early phase of industrialization, due to the setting up rudimentary, inefficient industries, scale effect takes place and pollution emerges. Generally, however, as per capita income increases, both the output mix and production techniques change. This composition effect states that the movement from an agrarian to an industrial and finally to a service economy shifts gradually the economic growth to sectors that pollute less [40]. Technique effect allows for the possibility that as countries grow, “cleaner” technologies substitute for “dirtier” ones in the production process [15].

In many empirical studies a U-shaped relationship appears as follows: at a relatively low level of income per capita, growth leads to greater environmental damage, until it levels off at an intermediate level of income after which further growth leads to

* Corresponding author. Department of Economics, Akdeniz University, Dumlupinar Bulvari, Kampus, 07058 Antalya, Turkey. Tel.: +90 2423106407.
E-mail addresses: guldenboluk@akdeniz.edu.tr (G. Bölük), mmert@akdeniz.edu.tr (M. Mert).

http://dx.doi.org/10.1016/j.energy.2014.07.008
0360-5442/

improvements in the environment [24]. This relationship (EKC) has been explored for a variety of pollutants such as nitrous oxide, sulphur dioxide, suspended particulate matter, carbon monoxide, lead, deforestation, biological oxygen demand, etc. [25]. If EKC were true, this hypothesis would suggest that countries do not need to struggle to reduce the CO_2 emissions envisaged by the Kyoto Protocol, since economic development would eventually lead to environmental improvement [80].

The EKC hypothesis assumes emissions to be a function of income which indicates unidirectional causality running from income to GHG emissions [1]. The EKC hypothesis argues that the pollution level increases as a country develops but begins to decrease as rising income passes beyond a turning point. In other words, environmental quality will get worse first and then improve with economic growth [14] (See Fig. 1). Therefore, the EKC hypothesis states that the initial phases of economic development are associated with greater production of garbage and pollution emissions, though at some given income level (and/or per capita income) there is a turning point where greater GDP growth implies lesser environmental degradation [28]; p.9). The results of early EKC studies showed that some important indicators of environmental quality (for example, sulphur dioxide and particulates in the air) improved as income and consumption increased [75]; p. 1).

The EKC concept first emerged in 1991 with Grossman and Krueger's pioneering study of the potential impacts of the NAFTA (North American Free Trade Agreement). Within the first wave of EKC studies, basic EKC models were used and income growth and its environmental impacts were estimated in the model without any explanatory variables. Refs. [30,31,70,12,57,37,69,68,53,67,34] tested the economic growth and environmental pollution relationship and EKC hypothesis. Refs. [73,21,45,14] provided review surveys of empirical EKC studies.

The second branch of EKC studies concentrates on the energy consumption and economic growth relationship. The main argument of these studies is that economic growth and output are closely related to growth in energy consumption. Energy is the engine of economic growth, since all production and consumption activities need some form of energy as a basic input. These studies test the causal relationship between economic output and energy consumption and intensively use time series models such as causality (Granger, Toda Yamamoto, Dolado-Lütkepohl), the VECM (Vector Error Correction Model), the VAR (Vector Autoregressive Model) and the ARDL (Autoregressive Distributed Lag) bound test etc. A paper by Kraft and Kraft (1978) found unidirectional causality from GNP growth to energy consumption in the USA for the period from 1947 to 1974. A number of empirical studies tested the relationship between energy and economic development (See Refs. [2,77,23,78,51,38,71,76,42,74,26] etc.). Payne [59] provided an extensive review of the studies on the empirical results of the energy consumption and economic growth relationship.

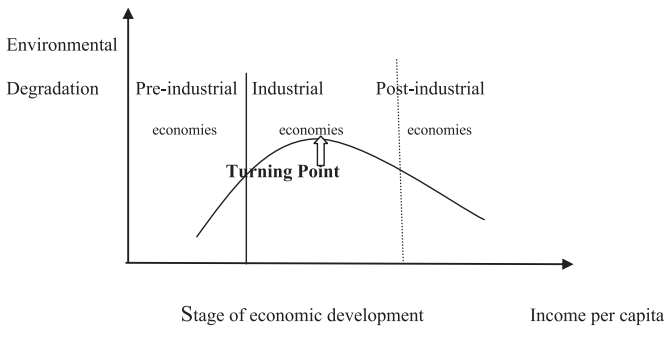

Fig. 1. The Environmental Kuznets Curve: a development–environment relationship. Source: Ref. [57]; p. 46.

Due to the omitted variables in previous studies, a third group of EKC studies has emerged. The third wave of EKC studies combines the two approaches used in previous research groups. Moreover, within the third group of EKC studies, the relationship between environmental pollution, economic growth, energy consumption and some other variables such as urbanization and trade openness has been investigated. Studies by Refs. [61,4,79,32,5,72,3,47,1,55,56,46,64] focused on the relationship between economic growth, energy consumption and pollution.

According to the [22]; renewables are the fastest growing source of world energy and the share of renewables in total energy use will increase from 10% in 2008 to 14% in 2035 [22]. In many countries, considerable attention has been focused on renewable energy because of concerns over the volatility of oil prices, dependency on foreign energy sources (the energy security problem) and the environmental consequences of GHG emissions. Renewable energy market is supported by various incentive mechanisms to ensure sufficient investments in renewable energy sector. More than 100 countries both defined specific goals and developed focused policies regarding renewable energy. To develop renewable energy all over the world, market-based and non-market based promotion mechanisms such as feed-in tariffs, premiums, quota based green certificates, bidding incentives, incentives for investment, tax exemptions and discounts have been put in place by the governments. Worldwide governmental support for renewable energy rose from 41 billion US dollars in 2007 to 88 billion US dollars by 2011. Worldwide support for renewable energy is expected to be around 115 thousand million US Dollars in 2015 [20]. Recently, a number of energy consumption-economic growth studies have focused on renewable energy consumption Refs. [17,18,65,66,6–8,48] examined the relationship between renewable energy consumption and economic growth.

The existing literature indicates that a large part of EKC studies focuses on the nexus of energy-output or pollution-output. Although recently a few studies have “combined” the approaches of these strands and investigated the inter-temporal linkage in the energy-environment-income nexus, in EKC studies generally other explanatory variables have been excluded. One important variable which is generally omitted in these relationships is the energy [50]. Including the fuels and/or energy and or splitting into energy types in EKC studies helps policy makers' understanding of the factors that may affect energy use and/or carbon emissions in the long term.

To the best of our knowledge, there has been no study so far that tests the EKC hypothesis including renewable energy consumption as a variable affecting the environment. In a research paper by Ref. [50]; however, panel data analysis was conducted for 24 EU countries and it was assumed that the impacts of energy consumption on emissions were dependent on the primary energy mix. Despite this, we directly used renewable energy consumption as an important variable having affects on GHG emissions, since it was expected that greater use of renewables in final energy consumption would eventually lower GHG emissions in the world.

In this study, we aim to examine the relationship between economic growth, GHG emissions and energy consumption taking into account renewable energy for EU countries using panel data analysis. Moreover, we also use centered values of explanatory variables to fix the multicollinerity problem which has been generally ignored in empirical EKC studies. The rest of the paper is organized as follows. In the second section, material and methods are presented. The third section discusses the empirical results. The fourth section discusses the results of the model. The final