Journal of Cleaner Production 162 (2017) 1031–1047

Contents lists available at ScienceDirect

Journal of Cleaner Production

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

The turning points of carbon Kuznets curve: Evidences from panel and time-series data of 164 countries

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ARTICLE INFO

Article history:
Received 27 December 2016
Received in revised form
10 April 2017
Accepted 7 June 2017

Handling Editor: Yutao Wang

Keywords:
Global warming
Carbon emission reduction
Turning points (TPs)
CKC hypothesis
Panel data
Time-series data

ABSTRACT

With the dramatic economic development, global warming caused by carbon emission has become increasingly serious, and carbon emission reduction therefore comes to be the principle in most countries. Turning point (TP), which represents carbon emission turns from increasing to decreasing tendency with the economic growth, has become a major focus of political and academic concern. However, previous studies on TP were contextualized only in individual countries or regions but barely from a global perspective, which are insufficient for solving the carbon emission as a global issue. Therefore, this study aims to provide a global picture of the carbon emissions by identifying the TPs of 164 countries and five panel groups (i.e. global, high-income, upper-middle-income, lower-middle-income and low-income levels) in the world and the patterns of them. The results show that 123 individual countries and all the five panel groups accept the carbon Kuznets curve (CKC) hypothesis. Then, the TPs of them are identified. In particular, three close correlations are identified throughout the study: (1) the proportion of the CKC hypothesis and income level, i.e., the higher income level, the larger proportion of countries meeting the CKC hypothesis; (2) the TPs and income level, i.e., the higher income level, the higher TP; and (3) the turning years and income level, i.e., the higher income level, the shorter turning years. The identified TPs in this study provide valuable references for not only individual countries but also countries at different income levels to tailor their strategies and policies to finally achieve global carbon emission reduction.

1. Introduction

Over the last decades, the world has witnessed the unparalleled economic globalization development. The statistics are clear to support this. The GDP has increased from 1,423.6 billion US dollars in 1961 to 76,124 billion US dollars in 2013, accounting for nearly 53.4 times with an annual average rate of 8.1% (World Bank, 2013). However, the dramatic economic development has also triggered a number of environmental problems in particular the global warming (Chatzizacharia et al., 2016; Ji et al., 2016; Tan et al., 2017; Shen et al., 2017b; Pan and Li, 2016; Shen et al., 2016, 2017a). Global warming has aroused worldwide concerns, which can be evidenced from the signature of United Nations Framework Convention on Climate Change (UNFCCC) in 1992 and effectiveness of the Kyoto Protocol (2005) to the opening of the United Nations Climate Change Conference in 2009 in Copenhagen, and the 2015 Climate Change Meet in Paris. Therefore, it is urgent to take measures to deal with global warming.

The major increase in Greenhouse Gas (GHG) is attributed largely to carbon dioxide emissions (CO_2) as the principal gas leading to global warming and climate change. According to the fifth report of the IPCC (2014), the carbon emission has increased from 9,434.4 million tons in 1961 to 34,649.4 million tons in 2011, accounting for almost 3.7 times with an average annual growth rate of 2.7%. The report further suggests that the value may double or even triple by the middle of this century if the growth of the emission cannot be effectively controlled. Stern (2007) warned that, if no action is taken to reduce emissions, the overall costs and

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http://dx.doi.org/10.1016/j.jclepro.2017.06.049
0959-6526/

risks of climate change will be equivalent to at least a 5% of global GDP loss each year. It is therefore considered important to maintain the coordinative development between economic development and carbon emission at the global level.

Conventionally, environmental Kuznets curve (EKC) presents a hypothesis that describes the relationship between economic development and environmental quality. It posits the existence of an inverted U-shaped relationship between per capita income and the environment quality, suggesting that while levels of environmental damage increase first with rising per capita GDP, then subsequently decline (Grossman and Krueger, 1991; Shafik and Bandyopadhyay, 1992). Ever since, the EKC hypothesis has become an independent research issue, provoking a large body of theoretical and empirical literature (Al-Mulali et al., 2015a; Bo, 2011; Jebli et al., 2016; Tutulmaz, 2015). However, when the dependent variable is carbon emission per capita, these studies are sometimes referred to as carbon Kuznets curve (CKC) hypothesis (Liddle, 2015). If the hypothesis of CKC is correct, a TP in the relationship between income per capita and carbon emission per capita should exist which would be attractive to policy makers (Tao et al., 2008). A TP implies that economic growth can improve both living standards and environmental quality to some extent (Richmond and Kaufmann, 2006). Therefore, a 'belated' TP may hinder the sustainable development of environment and economic. Reaching TP of CKC as soon as possible should be the target of each country. Thus, it is necessary to recognize the TP for each country as countries have experienced and will trend different economic and environmental development. Furthermore, CKC as the hypothesis of internal rules of development, that different countries have different characteristics, such as population scale, energy structure and technology level which are the factors affecting the carbon emission (Shahbaz et al., 2013; Yin et al., 2015), will lead to the different TPs of countries. Due to the different TPs, different countries will make different carbon emission reduction targets and adopt different strategies specifically. Galeotti et al. (2006) emphasized that the TP would allow the government to precisely know where his/her country is located along the curve, which will be helpful when making reduction targets and adopting relevant strategies. Therefore, this paper aims to identify the TPs of CKC of different countries.

The innovation and contribution of this paper with other references mainly lies in the following three aspects. First, this is the first study providing detailed country-by-country analyses by calculating the TPs of CKC in 164 individual countries. These findings reveal the gaps between carbon emission status and theoretical TP, which is helpful for effective and specific policy-making, and contributes particularly for global carbon emission reduction. Secondly, this study provides the benchmark for the each income level, which is useful for guiding carbon emission reduction at income level. Thirdly, this research innovatively combines the time-series and panel data analysis to identify the TPs in different countries and different income levels. By doing so, the results can be enriched, and the results from time-series data can ensure the results from panel data more reliable.

The reminder of this paper is organized as follows. Section 2 reviews the existing literatures examining the CKC hypothesis at different countries and regions. The method and data are introduced in Section 3. Section 4 displays the steps for testing the CKC hypothesis. Section 5 presents the empirical analysis of panel and time-series data. Section 6 demonstrates the discussion on the results from the empirical analysis results. Section 7 concludes this study.

2. Literature review

In order to identify the TP, the key step is to examine the hypothesis of CKC. If the CKC hypothesis for a country is accepted, the econometric model can be established, thus the TP can be identified. Currently, various researches have focused on examining the existence of CKC in individual counties. For example, Nasir and Rehman (2011) employed the Johansen method of cointegration to investigate the CKC hypothesis in Pakistan for the period 1972–2008, and confirmed the existence of CKC. Esteve and Tamarit (2012) tested the non-linearity relationship between carbon emission capita and GDP per capita in Spanish economy over the period 1857–2007, which demonstrates the existence of CKC for the Spanish case. The results of Lau et al. (2014) study indicated that the inverted-U shaped relationship does exist between economic growth and CO_2 emission in both the short- and long-run for Malaysia after controlling for two additional explanatory variables including foreign direct investment (FDI) and trade. Shahbaz et al. (2013) applied autoregressive distributed lag (ARDL) bounds testing approach to investigate the long-run cointegration between CO_2 emissions per capita and GDP per capita. The empirical evidence reveals that CKC exists both in long and short runs in Romania over the period 1980–2010. Further, Shahbaz et al. (2013) recognized that energy consumption is the major contributor to energy pollutants, and suggested declining CO_2 emissions through effective implementation of economic incentives and financial development. Yin et al. (2015) opined that the CKC hypothesis was accepted in China context, and identified the key factors affecting low-carbon economic development in China: energy efficiency, energy structure and industrial structure. Lindmark (2002) tested the hypothesis by examining the inverted-U shaped between carbon emission and economic growth in Sweden from 1870 to 1997 utilizing the structural time-series. The research by Aldy (2005) stated that the CKC hypothesis was also accepted in the US using the state-level data. Boutabba (2014) employed the Granger causality test to examine the long-run equilibrium and the existence and direction of a causal relationship between carbon emission and economic development in India, and hypothesis was accepted. In testing the CKC hypothesis in Nepal, Bastola and Sapkota (2015) combined the Johansen cointegration and ARDL bounds tests to confirm the inverted-U shaped relationship between economic development and carbon emission. Mohammed Albiman et al. (2015) validated the CKC using the time-series data of Tanzania during the period 1975–2013 combined with Toda and Yamamoto non-Causality test.

A few researchers also examined the CKC hypothesis at regional level. For example, Chang (2015) tested the CKC hypothesis of BRICS and G7 countries by applying the cointegration estimation with data envelop analysis. Cho et al. (2014) adopted panel unit root and cointegration tests as well as the fully-modified ordinary least squares (FMOLS) approach to examine the CKC hypothesis in Organization for Economic Cooperation and Development (OECD) countries over the 1971–2000 period. The research by Al-Mulali et al. (2015b) built a CO_2 panel data model and the results of Kao cointegration test and FMOLS indicated an inverted U-shape relationship between CO_2 and GDP, confirming CKC hypothesis in Latin America and Caribbean countries. Atici (2009) validated the CKC hypothesis in Central and Eastern European region by applying panel data from 1980 to 2002.

The above discussions suggest that various researches have focused on testing the CKC hypothesis from individual country or regional level. Nevertheless, carbon emission is a severe global problem, it is thus the responsibility of every country to mitigate the global warming by bringing down the dramatic growth of carbon emission, a few researches have been conducted to test the CKC hypothesis at the global level. As Galeotti et al. (2006) emphasized that identifying TP could precisely indicate a country's status along the curve, which is helpful when the government makes reduction targets and adopts relevant strategies. Therefore, this paper aims to (1) test the CKC hypothesis in 164 countries and