Energy Policy 57 (2013) 14–20

Contents lists available at SciVerse ScienceDirect

Energy Policy

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

Inflection point of environmental Kuznets curve in Mainland China

Ma-Lin Song [a], Wei Zhang [b,*], Shu-Hong Wang [c]

[a] School of Statistics and Applied Mathematics, Anhui University of Finance & Economics, Anhui Bengbu, China
[b] School of Economics, University of Jinan, Shandong Jinan, China
[c] School of Economics, NanKai University, Tianjin, China

ARTICLE INFO

Article history:
Received 15 December 2011
Accepted 19 April 2012
Available online 6 May 2012

Keywords:
Environmental Kuznets curve
Inflection point
Exhaust emissions

ABSTRACT

As environmental problems in Mainland China are receiving global increasing attentions, environmental Kuznets curve (EKC) is adopted here to validate time route of improvement for its various areas. The results indicate that some areas, such as Shanghai, Tibet, Guizhou, Jilin and Beijing have overstepped their inflection points; Liaoning, Anhui, Fujian, Hainan and Qinghai have no inflection points, and meanwhile it is about seven years for the others areas take to reach their inflection points. Therefore, it is essential to lay down some policies to change or advance the process of reaching inflection point for each area respectively.

1. Introduction

Recently, global advocating of green economy puts forward the idea that the increase of pollutant emissions should not become the cost for economic growth. Though the government in Mainland China is active in taking relevant measures to solve environmental problems, it is believed that problems, such as greenhouse gas emission, pollution of water resources are worsening and the accelerated trend has not been effectively held back either. The terrible environment problem not only affects people's health negatively, but also seriously threatens sustainable development. As the largest developing country, China is now facing the international restriction of reducing greenhouse gas emission, however, it is predicted that carbon emissions in Mainland China are probably increasing rigidly in the long future. Does this means that the persisting growth of China economic is inevitably related with more energy consumption and more greenhouse gas emission? Therefore, in-depth study for this problem seems very necessary and meaningful, especially at the current time China has promised to reduce its carbon emissions by 40–50% in 2020.

The environmental Kuznets curve (EKC) hypothesis, proposed by Grossman and Krueger (1991, 1993), postulates an inverted-U-shaped relationship between pollutants and per capita income (Dinda, 2004). With the average income increases, people begin to pay more attention to the inflection point of EKC and expect the U-shaped curve existing in China which means an automatic reduction in carbon emissions will occur when economic achieve to a certain level. Some scholars suggested that pollution havens play a significant role in shaping the EKC (Kearsley and Riddel, 2010), implying that these following problems deserve more attention: whether enterprises should pay more attention to environmental protection than to their own development when economy is developing and income is increasing rapidly; whether there exists inflection point in EKC of each province; when the inflection point appears if it exists; and whether provincial governments should interfere with the process by drawing up a series of policies.

The rest of the paper is organized as follows. In Section 2, we review precedent literature around the world, from which analyses and conclusions of relationship between greenhouse gas emission and economic growth conducted by various researchers are introduced and commented. Section 3 defines a new statistics δ to measure the changes in ingredients of exhaust emissions. In Section 4, we present empirical verification, creatively making the conclusion that EKC only exists for some areas and verifying it by data of 1993–2010. Finally, the policy implications of empirical results are proposed in Section 5.

2. Literature review

Experience of many developed countries indicates that natural environment was greatly destroyed and became deteriorated at the beginning of industrialization. Interestingly, once the economic development reached certain level, environmental conditions would see lots of improvement. This kind of phenomenon can be addressed by referring to EKC, a method which is often used to study the relationship between carbon emissions and economic growth. As economic growth helps promote the increase in income, some scholars analyzed the income flexibility

* Corresponding author. Tel.: +86 13589093950.
E-mail address: cfy0510@gmail.com (W. Zhang).

0301-4215/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.enpol.2012.04.036

of carbon emissions. Panayotou et al. (2000) collected experiential data of 124 years for 17 countries in OECD to carry out empirical analysis, finding that income flexibility of carbon dioxide emission was in the range of 2-0.4 with a downtrend. Later, some scholars (De Groot et al., 2004) studied the existence of an EKC for China by using 30 regions data which covered the period 1982–1997. This relationship occurred between economic growth and pollutant emissions in Tunisia (Fodha and Zaghdoud, 2010). Nasir and Rehman (2011) concluded that there was a quadratic long-run relationship between carbon emissions and income, by which the existence of EKC for Pakistan was confirmed. The results of the empirical investigation by Orubu and Omotor (2011) suggested the existence of an environmental Kuznets curve for suspended particulate matter. In the meantime, the empirical results conducted by Esmaeili and Abdollahzadeh (2009) fully supported the existence of an EKC for oil exploitation. Estimating the EKC in France by considering nuclear energy in electricity production, Iwata et al. (2010) provided the evidence to support the EKC hypothesis.

On the other hand, some scholars did not believe that the EKC always exists. Taking the case of Spain from 1972 to 1997 as an example, Roca and Alcantara (2001) concluded that there was no evidence supporting this hypothesis of EKC in either the weak or the strong sense. The studies of Huang et al. (2008) demonstrated that statistical data of many countries did not possess evidence supporting the EKC hypothesis for greenhouse gas emissions. By the using time series and panel data analyses, Akbostanci et al. (2009) still did not found that there existed an inverted U-shaped relationship between environmental degradation and income in Turkey.

Some other scholars became interested in comparative study between developed and developing countries, concluding that EKC did exist for developed ones, but there was no EKC for developing ones, such as Mainland China. For instance, with a simultaneous estimation, Shen (2006) thought that environmental improvement does not mainly depend on income growth and some provinces in China should take some active measures to improve their environment before they become wealthy. From another perspective, the study of Yaguchi et al. (2007) proposed that neither per capita income nor past energy consumption significantly affects the carbon dioxide emission and energy consumption in both China and Japan, which implies that reducing carbon dioxide emission is not the responsibility of an individual country. Also, to estimate the relationship of health benefits of tunneling through the EKC in China, Brajer et al. (2008) economically valued the health benefits realizable to cities in China from successful efforts to "tunnel" under the EKC over the next generation. Other researches about EKC had been related with economic prosperity, biodiversity conservation (Mills and Waite, 2009), oil shock of the 1970s (He and Richard, 2010) and degree of corruption (Leitao, 2010). Moreover, some results showed the evidence of the EKC existence in America and Europe, but not in Africa and Asia and Oceania (Lee et al., 2010).

Although some evidences suggest that increased economic activity does not always ensure environmental protection (Halkos and Tzeremes, 2009), it is easy to verify the existence of EKC for certain environment index of single country or region. Meanwhile, the results of panel data from some countries and regions and that of individual countries and regions vary widely (Dijkgraaf and Vollebergh, 1998; Stern and Common, 2001). With increasingly more attention on environmental problems of Mainland China, the importance of verifying the existence of EKC for various areas becomes prominent. Liu et al. (2008) concluded that the scale of farmland conversion in China will expand when the economic growth is at the beginning; after reaching its peak value, it will turn to decrease accompanying further economic growth, in which the peak values vary with different region and time. Our paper holds the idea that political, economic and cultural features are quite different for various regions in this vast country, as a result, economic principles could be better revealed with more subdivisions. In the frequently-used linearity regression model, logarithm of environmental pollution is chosen as the variable to be explained with logarithm of national income as the explaining variable. First, different indexes for environmental pollution and national income will lead to different results. Besides, EKC is not a linearity structure, so making linearity regression may result in self- regression and calculating results imprecise.

To solve the above difficulties, panel data over 1985–2005 in China is included, and waste gas, waste water and solid wastes are chosen as environmental indexes with GDP as an economic index. Then Song et al. (2008) suggest that a long-run cointegrating relationship between the per capita emission of three pollutants and the per capita GDP will exist. With field research in 2001, 2004, and 2006 for eight Chinese provinces, Liu (2008) obtained some conclusions contrary to the EKC, that communities can achieve environmental improvement along with economic growth friendlily at early stages of development. Different studies estimating an EKC conducted by Brajer et al. (2011) proved that different choices of pollutants and measuring methods lead to completely different results.

The above-mentioned conclusions are useful for the analysis of China's problems. However, many of these conclusions are made on the assumption that EKC does exist for various regions or Mainland China. If there does not exist EKC, there conclusions immediately become incredible. Thus, the priority of this article is placed on verifying the existence of EKC; then time of reaching EKC peak and its relevant route can be further calculated for various provinces.

3. Data analysis for individual province

Waste gases are emitted directly to the atmosphere, affecting the environment; while it is quite hard to quantitatively measure the effects of waste water and solid waste because their mobility and diffusibility are poor and environmental self-purifying weakens their effects. In addition, waste gases are the by-product for many industries with much more emission volume than waste water and solid waste and the data can be easily collected. Therefore, industrial waste gas emission is chosen as the environmental pollution index. Since the reform and opening-up in 1978, especially after the remark made by Deng Xiaoping in his South Tour, China's economy is developing rapidly and resident income is also increasing year by year. Meanwhile, environmental pollution is worsening as well. According to the China Statistical Yearbooks, in 1993, volume of industrial waste gas emission was 8524.9 billion cubic meters; in 2010 the volume has reached 52916.8 billion cubic meters, increasing by nearly 6 times. Volumes of industrial waste gas emission for individual province in period of 1993–2010 are shown respectively in Fig. 1.

Comparing the situation of 1993 with that of 2010, it is noticed that the share of each province has greatly changed, with more emission transferring from the west and the central to the east. Statistic value δ is calculated to measure these changes as follows:

$$\delta = \frac{x_{it}}{\sum_N x_{it}} - \frac{x_{i0}}{\sum_N x_{i0}} \quad (1)$$

x_{it} denotes the volume of waste gas emission of region i in the year t. If $\delta > 0$, it indicates that environmental pollution becomes more severe. According to formula (1), changes in pollution for