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An integrated specification for the nexus of water pollution and economic growth in China: Panel cointegration, long-run causality and environmental Kuznets curve

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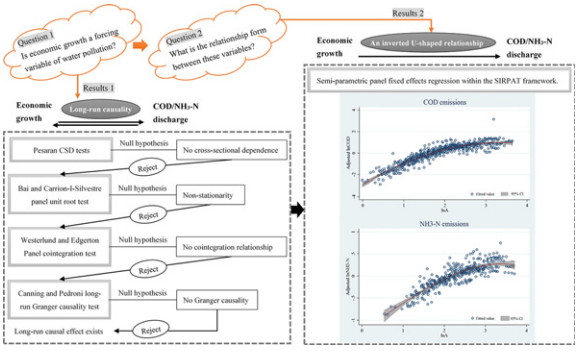
HIGHLIGHTS

- An integrated methodology is proposed to elucidate the income-water pollution nexus.
- Panel causality between income and COD/NH_3-N discharge is performed for China.
- The existence of income EKC hypothesis for COD/NH_3-N discharge is tested for China.
- Long-run causality from income to COD/NH_3-N discharge is present.
- The income EKC hypothesis is confirmed for COD/NH_3-N discharge.

GRAPHICAL ABSTRACT



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ABSTRACT

This paper concentrates on a Chinese context and makes efforts to develop an integrated process to explicitly elucidate the relationship between economic growth and water pollution discharge—chemical oxygen demand (COD) discharge and ammonia nitrogen (NH_3-N), using two unbalanced panel data sets covering the period separately from 1990 to 2014, and 2001 to 2014. In our present study, the panel unit root tests, cointegration tests, and Granger causality tests allowing for cross-sectional dependence, nonstationary, and heterogeneity are conducted to examine the causal effects of economic growth on COD/NH_3-N discharge. Further, we simultaneously apply semi-parametric fixed effects estimation and parametric fixed effects estimation to investigate environmental Kuznets curve relationship for COD/NH_3-N discharge. Our empirical results show a long-term bidirectional causality between economic growth and COD/NH_3-N discharge in China. Within the Stochastic Impacts by Regression on Population, Affluence and Technology framework, we find evidence in support of an inverted U-shaped curved link between economic growth and COD/NH_3-N discharge. To the best of our knowledge, there have not been any efforts made in investigating the nexus of economic growth and water pollution in such an integrated manner. Therefore, this study takes a fresh look on this topic.

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1. Introduction

Economic development today is global. China's extraordinary economic growth has captured the world's attention as the global scope of its effect become gradually significant. China's GDP has gone up more than tenfold since 1978 while GDP per capita has increased at an average annual rate of more than 9% over the last three decades (China NBoSo, 2015b). In contrast, China's water pollution reduction fell short of the targets for a number of pollutants in absolute terms. In recent year, water quality continues to be worse in China (Bu et al., 2011; Ongley et al., 2010). In light of this, the Chinese government put forward a target in the 11th Five-Year Plan (2006–2010) to reduce chemical oxygen demand (COD) discharge, and then added a proposal in the 12th Five-Year Plan (2011–2015) to reduce ammonia nitrogen (NH_3-N) discharge. The Plans stipulated binding targets to reduce COD discharge and NH_3-N discharge by 10% every five-year period, respectively. In fact, by the end of 2014, COD discharge and NH_3-N discharge decreased by 8% from its 2011 level (China NBoSo, 2015a). Although substantial reductions in the discharge of some pollutants into water have realized with greater efforts made to cure water pollution, the current run up of pollution discharge in China remains to be massive. Deterioration in China's water quality primarily caused by anthropogenic pollutant discharge becomes more acute over time, accompanying economic growth. In 2014, groundwater supplies in more than 60% of Chinese cities were categorized as “bad to very bad”, while more than a quarter of China's major rivers were considered to be “unfit for human contact” (Albert and Xu, 2016). Thereupon, of particular research interest to these issues inevitably triggers mounting immense concern on the dynamic impact of economic growth on water pollution.

There are a host of studies relating the nexus of economic development and environment, which have investigated the underlying hypothesis by applying different data sets and various estimation procedures. The most common argument in these studies is environmental Kuznets curve (EKC) hypothesis, wherein the levels of pollution first increase with economic growth and decline subsequently relative to economic growth in higher levels. Heated debates in various environmental pollution have been made on the EKC hypothesis and sizable empirical studies support the inverted-U-shaped relationship between economic growth and pollution indicators, such as carbon dioxide emission (Al-Mulali et al., 2015; Kang et al., 2016; Yin et al., 2015), sulfur dioxide emission (Stern, 2006; Wang et al., 2016b), nitrous emission (Cho et al., 2014; Zhang et al., 2015), waste water (Diao et al., 2009; Li et al., 2016), total suspended particulate (Day and Quentin, 2003) and biological oxygen demand (Lee et al., 2010). However, little research has all tried to detect the existence of the EKC relationship for COD/NH_3-N discharge related to economic growth, which are significant indicators of water quality.

Although the EKC hypothesis has become a key notion to represent the relationship between a measured level of environmental pollution and economic growth, but the theoretical and methodological agreement related to the EKC hypothesis remains elusive (Esteve and Tamarit, 2012). There is an ongoing discussion on appropriate specification and estimation strategies. More recently, most studies on the EKC hypothesis focus on cross-sectional economic, social and environmental dimensions by using panel data. In doing so, individual units in panel-data estimation are possible to be interdependent, inherently arisen with potential implications on parameter estimation and inference. To a certain extent, non-stationary are possible to present in explanatory variables, which could lead to spurious regression estimation results. In addition, one important critique for previous empirical EKC studies is that these studies are based on a single polynomial specification where there is no test for causal effects and or feedback effects between pollution and economic growth, based on the assumption that there is no simultaneous relationship between the two variables. In fact, a continuous or higher economic growth does not necessarily warrant greater efforts to contain water pollution discharge. Therefore, this study motivates to develop an integrated process to explain the conceptual and analytic problems that plague the large part of the empirical EKC literatures.

In this present study, we firstly test for cross-sectional dependence (CSD) by the correlation-coefficients between the time-series for each panel, conduct panel unit-root test to examine the stationary properties of the underlying variables, and estimate cointegration relationship between the variables. Once the panel cointegration is present, secondly, we proceed to perform Granger causality test to infer the causality of economic growth and COD/NH_3-N discharge and its impact direction as well. Further, we augment and improve the Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) model (York et al., 2003), in which we incorporate several control variables to tackle with possible endogeneity and omitted variable bias (Qin and Wu, 2015; Rafiq et al., 2016; Wang et al., 2015), and validate its utility for comprehensive empirical examination of the EKC hypothesis for COD/NH_3-N discharge. Within the STIRPAT framework, we conduct the newly proposed semi-parametric panel fixed effects regression (Baltagi and Li, 2002) supplemented with traditional parametric estimation method to attain more reliable results.

In summary, this paper aims at making efforts to take a more comprehensive and precise look at the nexus that can help in understanding dynamic interrelations between economic growth and COD/NH_3-N discharge with more recent province-level panel data. To the best of our knowledge, there has never taken efforts in investigation of the economy-pollution nexus in an integrated manner, let alone discusses in water pollution. We believe that our present study could open a way forward in achieving a holistic framework for future study on development and pollution relationship.

The remainder of the paper is organized as follows. Section 2 gives a brief overview of the literature relevant to this study around the EKC hypothesis. In Section 3, we briefly describe the data and specify theoretical and analytic methods. Section 4 discusses how we test for the signs and present main empirical findings on the nexus of economic growth and COD/NH_3-N discharge. The summary of our findings and some concluding remarks are proposed in Section 5.

2. Literature review and this research contributions

Environmental degradation is influenced by economic processes through compositional and technology effects (Grossman, 1995). The Kuznets curve has been a theoretical tool widely performed for examining the relationship between environmental and economic variables since Grossman and Krueger (1991) put forward the EKC hypothesis, which claims that environmental quality deteriorates with economic development at low income levels and turns to improve at high levels (Grosman and Krueger, 1994; Hettige and Wheeler, 1992; Koop, 1998; Panayotou, 1993; Panayotou, 2000; Selden and Song, 1994; Shafik and Bandyopadhyay, 1992). In subsequent research, particular conclusions have further expanded the previous work by considering more comprehensive measures to confirm the EKC relationship between economic growth and environmental degradation, commonly referring by analogy to the inverted U-shaped relationship (Ang, 2007; Copeland and Taylor, 2004; Kijima et al., 2010; Soytas and Sari, 2009; Soytas et al., 2007; Stern, 2004).

More recently, many similar debates in EKC studies have affirmed environmental quality improvements once GDP per capita reaches a higher level, both in developed and developing economies, including Europe, Americas, East, South and Central Asia, Middle East and North Africa (Brizga et al., 2013; Jaunky, 2011; Kasman and Duman, 2015; Pao and Tsai, 2011; Shafiei and Salim, 2014). According to the recent survey, 70% of the surveyed studies tend to examine the existence of the EKC hypothesis (Al-Mulali et al., 2015), especially in emerging and developed countries. With the fast economic growth, Kuznets approaches become of key policy interests in designing environmental management strategies in developing nations (Chowdhury and