Spatial Statistics 21 (2017) 377–389

Contents lists available at ScienceDirect

Spatial Statistics

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

Re-examining environmental Kuznets curve for China's city-level carbon dioxide (CO_2) emissions

Zheye Wang, Xinyue Ye *

Department of Geography, Kent State University, Kent, OH, 44242, USA

ARTICLE INFO

Article history:
Received 9 April 2016
Accepted 27 September 2016
Available online 7 October 2016

Keywords:
CO_2 emissions
EKC
Areal interpolation
DMSP/OLS night lights
Urban China

ABSTRACT

Chinese central government promised to reduce its CO_2 emissions intensity by 40%–45% by 2020 compared to the level of 2005. However, with limited knowledge on local CO_2 emissions, the government could hardly decompose its mitigation plan to local administrative divisions. In this paper, we first interpolate the provincial CO_2 emissions to prefectural cities with a combination of areal interpolation method and DMSP/OLS nighttime light data. Then, we test the EKC hypothesis with this city-level data and spatial econometric modeling. This research reveals an uneven landscape of CO_2 emissions at both provincial and city scales, suggesting a differentiated decomposition of the mitigation target in China. The city-level monotonic increasing relationship between GDP per capita and CO_2 emissions per capita confirmed by our EKC test indicates that CO_2 emissions would not decrease automatically as income increases. To that end, actions such as improving the energy efficiency and implementing carbon taxes should be taken to reduce CO_2 emissions.

1. Introduction

Climate change has become a challenging problem across the world during the past several decades (Nicholson-Cole, 2005; Ballantyne et al., 2016). Carbon dioxide (CO_2) as the primary greenhouse gas

* Corresponding author.
E-mail address: xye5@kent.edu (X. Ye).

http://dx.doi.org/10.1016/j.spasta.2016.09.005
2211-6753/

has been proved to be a major cause of this global environmental issue (Karl and Trenberth, 2003). Rapid urbanization and industrialization since 1978 have dramatically increased the carbon dioxide emissions in China (Cole et al., 2011; Ge et al., 2011; Stern and Zha, 2016). At the same time, the country has been receiving accumulated pressures from multiple foreign nations in climate change negotiations (Lewis, 2008). In this context, to meet Copenhagen climate agreement, the Chinese government pledged to reduce CO_2 emissions intensity by 40%–45% by 2020 compared to the level of 2005.

In order to achieve its mitigation goal, Chinese central government needs to decompose it to local administrative units (such as provinces, prefecture-level cities, etc.), which requires a good understanding on the CO_2 emissions in various administrative divisions. Many researches were conducted to study the characteristics of CO_2 emissions at national and/or provincial scales (Hu and Huang, 2008; Zhang and Cheng, 2009; Zhang et al., 2009, 2010, 2011; Guan et al., 2009). Most of them were based on the energy consumption data issued by the National Bureau of Statistics, where only national and provincial data are available. Due to the data availability problem at finer scales, there are only a few studies trying to analyze the city-level CO_2 emissions (Huang and Meng, 2013; Su et al., 2014; Meng et al., 2014). Since policy implementation in China is a hierarchical diffusion process (Schreifels et al., 2012), it is important to develop a reliable city-level CO_2 emissions data warehouse to support the top-down decomposition of mitigation targets.

Operational Line-scan System (OLS) night-time light (NTL) data from the Defense Meteorological Satellite Program (DMSP), which contain the lights from cities, towns, and other sites with persistent lightning, have been recognized to be capable of reflecting human socioeconomic activities (Elvidge et al., 1997; Sutton and Costanza, 2002; Ebener et al., 2005; Doll et al., 2006; Sutton et al., 2007; Ghosh et al., 2010b; Henderson et al., 2012). Many researches have revealed the potential use of nightlight observations to facilitate the estimation of CO_2 emissions at fine scales (e.g., Doll et al., 2000; Ghosh et al., 2010a). In particular, Meng et al. (2014), Shi et al. (2016), and Su et al. (2014) have proved the existence of a positive relationship between aggregated sums of nighttime lights and CO_2 emissions and shown the feasibility of estimating emissions at finer scales (e.g., prefectural cities, urbanized areas, and grids with 1 km resolution) from available China's provincial emissions with linear regression models. Albeit not mentioned in these articles, the top-down estimation is actually a process to overcome the modifiable areal unit problem (MAUP) arising from the variability of attribute values (here, CO_2 emissions) when shifting geographical units (here, provinces to prefectural cities). Areal interpolation is a solution to minimize the MAUP impact (Kar and Hodgson, 2012). The areal interpolation methods could be divided to be either simple or intelligent (Lin and Cromley, 2015; Thomas-Agnan and Vanhems, 2015). Intelligent areal interpolation methods use ancillary information to improve estimation accuracy, whereas its simple counterpart just transfers data from one zonal system to another without using ancillary information. The linear regression models adopted by the aforementioned studies i.e., Meng et al. (2014), Shi et al. (2016), and Su et al. (2014) to disaggregate China's provincial CO_2 emissions to prefecture-level cities could be classified into intelligent areal interpolation since they use nighttime lights as ancillary variable. However, linear regression-based areal interpolation is not the only option we have to achieve the same goal. In our paper, we propose another intelligent approach which is to apply the proportional relationship between CO_2 emissions and nighttime light levels achieved from provincial data to prefecture-level cities. Since it could avoid the parameter estimation procedure, this method is believed to be simpler and more easily implemented than linear regressions.

In addition to facilitating the decomposition of the mitigation target, city-level CO_2 emissions data could also be useful for examining the relationship between economic growth and CO_2 emissions in urban China (He et al., 2014). Hypothesizing an inverted-U-shaped relationship between environmental pollutants and income per capita (i.e., economic growth first increases and then decreases environmental degradation), the Environmental Kuznets Curve (EKC) has been tested in a large body of literature, yet resulting in various conclusions (see Dinda, 2004 for a survey). On the one hand, air pollutants with direct human health effects, such as SO_2, CO, and suspended particulate wastes, are more likely to show the evidence of EKC (Dinda, 2004), while the results in the case of CO_2 are mixed (Galeotti et al., 2009). Aside from the inverted-U shaped relationship between economic growth and CO_2 emissions, other relationships such as U-shaped, N-shaped, and monotonic have