Science of the Total Environment 646 (2019) 862–871

Contents lists available at ScienceDirect

Science of the Total Environment

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

Effect of foreign direct investments, economic development and energy consumption on greenhouse gas emissions in developing countries

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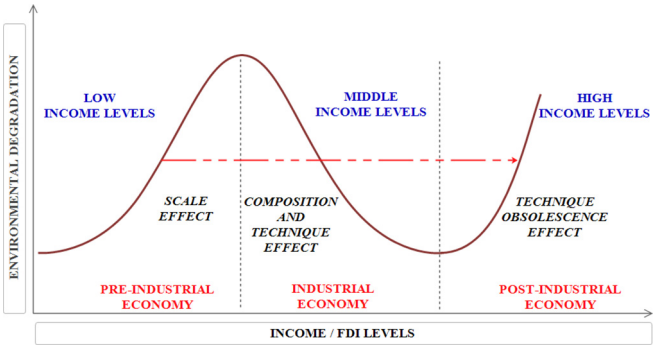
HIGHLIGHTS

- The environmental Kuznets curve hypothesis is valid for China and Indonesia.
- The pollution haven hypothesis is valid for China, India, Indonesia, Iran and South Africa.
- The study found a strong positive effect of energy consumption on CO_2 emissions.
- Foreign direct investment increases the level of CO_2 emissions in Indonesia.
- Clean and modern energy technologies will improve industrial-based pollution levels.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 25 June 2018
Received in revised form 26 July 2018
Accepted 26 July 2018
Available online 27 July 2018

Editor: D. Barcelo

Keywords:
Pollution haven hypothesis
EKC hypothesis
Panel quantile regression
Environmental pollution
China
South Africa

ABSTRACT

In accordance with the Sustainable Development Goal 17 of improving global partnership for sustainable development, this study examined the effect of foreign direct investment inflows, economic development, and energy consumption on greenhouse gas emissions from 1982 to 2016 for the top five emitters of greenhouse gas emissions from fuel combustion in the developing countries, namely; China, India, Iran, Indonesia and South Africa. The study employed a panel data regression with Driscoll-Kraay standard errors, *U* test estimation approach and panel quantile regression with non-additive fixed-effects. The study found a strong positive effect of energy consumption on greenhouse gas emissions and confirmed the validity of the pollution haven hypothesis. The environmental Kuznets curve hypothesis is valid for China and Indonesia at a turning point of US$ 6014 and US$ 2999; second, a U-shape relationship is valid for India and South Africa at a turning point of US$ 1476 and US$ 7573. Foreign direct investment inflows with clean technological transfer and improvement in labour and environmental management practices will help developing countries to achieve the sustainable development goals. Mitigation of greenhouse gas emissions depends on enhanced energy efficiency, adoption of clean and modern energy technologies, such as renewable energy, nuclear, and the utilization of carbon capture and storage for fossil fuel and biomass energy generation processes.

1. Introduction

The pollution haven hypothesis postulates that dirty industries migrate from high-income countries to low and middle-income countries through the trading of goods and foreign direct investment. Foreign direct investment (FDI) inflows remain one of the main sources of

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https://doi.org/10.1016/j.scitotenv.2018.07.365
0048-9697/

external funding for developing countries, yet, the relocation of carbon-intensive and energy-intensive industries from jurisdictions with more stringent environmental regulation to weak locales results in pollution haven. The transfer, dissemination, and diffusion of FDI inflows with polluting technologies, goods, and services to developing countries become the most important part of the challenge to achieve the sustainable development goals (SDGs). On the contrary, the environmental Kuznets curve (EKC) hypothesis postulates that the initial growth of a country's economic development leads to gradual deterioration of environmental quality and improves environmental conditions after reaching a threshold in economic development (Grossman and Krueger, 1991). Thus, both the pollution haven hypothesis and the EKC hypothesis are important policy derivatives for developing countries. Considering the importance of climate change mitigation and its impacts, as accentuated in SDG 13, the effect of FDI inflows, economic development, and energy consumption on greenhouse gas emissions in developing countries needs further attention to be able to alleviate the impacts.

Studies on pollution haven hypothesis (Zakarya et al. (2015) Behera and Dash, 2017; Solarin et al. (2017) Sun et al. (2017), support the validity of this hypothesis. Solarin et al. (2017) validated the pollution haven hypothesis for Ghana using the autoregressive distributed lag (ARDL) bounds testing approach. Sun et al. (2017) examined the impact of FDI inflows, economic growth, energy use, economic freedom, urbanization, financial development, and trade openness on CO_2 emissions using the autoregressive distributed lag model. The study confirmed the validity of the pollution haven hypothesis in China and that the positive effect of FDI inflows stems from the large contribution of manufacturing, mining and electricity shifted from the developed countries. Using the fully modified ordinary least squares (FMOLS) and dynamic ordinary least squares regression, Behera and Dash (2017) found a positive impact of FDI inflows and energy consumption on CO_2 emissions in 17 south and southeast Asian countries, thus, confirming the pollution haven hypothesis. Zakarya et al. (2015) found a long-run effect of FDI inflows and energy consumption on CO_2 emissions in Brazil, Russia, India, and China, thus, validating the pollution haven hypothesis via panel causality and FMOLS regression. On the contrary, studies like Zhu et al. (2016) and Zhang and Zhou (2016), rejected the pollution haven hypothesis. Zhu et al. (2016) employed panel quantile regression to examine the heterogeneous effect of FDI inflows, economic growth, and energy consumption on CO_2 emissions in Indonesia, Malaysia, Philippines, Singapore, and Thailand from 1981 to 2011. The study found insufficient support for the pollution haven hypothesis but rather found the halo effect hypothesis in high emission countries. Zhang and Zhou (2016) argue that FDI inflows of modern technologies contribute to CO_2 emissions reduction in China rather than environmental deterioration. Dasgupta et al. (1999, 2001) and Dean et al. (2004) revealed that developing countries depend on sophisticated technology transfer through FDI inflows from developed countries as their primary source of acquiring technology. Hence, clean and upgrading from vintage to modern technologies help in the reduction of emission levels.

The EKC hypothesis posits that the initial stages of economic development are characterized by high emission levels and environmental stress, however, as the economy grows and reaching a specific turning of income level, pollution levels decline (Grossman and Krueger, 1991). Panayotou (1993) argued that the initial stages of economic development increase the natural resource extraction leading to an increase in waste generation. However, at higher levels of economic development, the improvements in technology, stringent environmental regulations and a structural change in the economy from pollution-intensive industries to services and information declines environmental deterioration (Grossman and Krueger, 1991; Panayotou, 1993; Sarkodie, 2018). A number of recent studies on the EKC hypothesis (Lau et al. (2014); Al-Mulali and Ozturk (2016) Abdallh and Abugamos (2017) Sarkodie (2018) Sarkodie and Strezov (2018) support this hypothesis while Özokcu and Özdemir (2017) and Zoundi (2017) reject the validity of the EKC hypothesis. The opposing arguments on both the pollution haven and the EKC hypothesis due to the mixed outcomes in existing literature prompt on the need for further empirically tests of the validity of both hypotheses by examining the effect of FDI inflows, economic development, and energy consumption on GHG emissions.

The aim of this study is to investigate both pollution haven and EKC hypotheses to determine the effect of foreign direct investments, economic development, and energy consumption on greenhouse gas emissions in developing countries. The study selects the top five greenhouse gas emitting developing countries, namely China, India, Iran, Indonesia and South Africa. Contrary to existing literature, which adopts econometric methods that have challenges with cross-sectional dependence and issues when the time dimension becomes large, this study employs the Driscoll-Kraay covariance estimator that does not restrict the limiting behaviour of the panels and produces robust standard errors. As most of the results from previous studies neglect the distributional heterogeneity which may adversely impact the findings, this study considers distributional heterogeneity using panel quantile regression. The study employs Powell (2016) estimator with non-additive fixed-effects and non-separable disturbance term in the panel quantile estimation, which can correct the additive fixed-effects and separate disturbance terms when panel quantile regression is employed in the analysis. In order to produce robust estimations, the panel quantile regression is estimated using an adaptive Markov Chain Monte Carlo optimization based on 1000 draws. The study contributes to the global debate on greenhouse gas emissions from the top five emitters of carbon emissions from fuel combustion in developing countries by assessing the determinants of disaggregate greenhouse gas emissions throughout the quantiles.

2. Materials and methods

2.1. Data

To meet the outlined objectives, the study employs data from the World Development Indicators (World Bank, 2016) from 1982 to 2016 for the top five emitters of greenhouse gas emissions from fuel combustion in developing countries, namely; China, India, Iran, Indonesia and South Africa. The selection of the five countries stems from the Global Energy Statistical Yearbook 2018 ranking on CO_2 intensity by Enerdata (2017). Five study variables, Foreign direct investment net inflows (FDI), GDP per capita (GDPP), CO_2 emissions (CO_2E), total greenhouse gas emissions (GHG) and Energy use (ENE) are adopted in the study, as presented in Table 1. The World Bank defines FDI inflows as the inward direct investment to the indigenous economy made by foreigners (World Bank, 2016). GDP per capita is an indicator which measures the total economic output reflecting the changes in the production of goods and service excluding the cost of social and environmental production and consumption (Disano, 2002). CO_2 emissions measure anthropogenic emissions from fossil fuel energy combustion, industrial processes like cement manufacturing, and agricultural, forestry and land-use (World Bank, 2016). GHG emissions measure the six main GHG namely CO_2 emissions, methane, sulphur hexafluoride, nitrous oxide, hydrofluorocarbons, and perfluorocarbons. Thus, the data on non-CO_2 greenhouse gas emissions (NCO_2E) is extracted by deducting CO_2 emissions from the total greenhouse gas emissions to derive the data series. Energy use is an indicator which measures the primary energy consumption before end-use (World Bank, 2016). The selection of the data is based on the United Nations' Indicators of Sustainable Development: Guidelines and Methodology and the Sustainable Development Goals (SDGs) (United Nations, 2015). Due to the availability of data, missing data points are filled with Microsoft Excel interpolation method by aggregating duplicates using average at 99.99% confidence interval presented in Appendix A.