



# The moderating role of energy consumption in the carbon emissions-income nexus in middle-income countries<sup>☆</sup>

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## HIGHLIGHTS

- Moderating role of energy consumption in carbon emissions-income nexus was examined.
- We conducted both panel and country-specific analysis in 64 middle-income countries.
- Marginal effect of income on carbon emissions varies with level of energy consumption.
- Energy consumption moderates carbon emissions-income nexus in one-third of sample.
- Appropriate interaction of energy consumption and income can abate carbon emissions.

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## ABSTRACT

We examine the role of energy consumption in moderating the carbon dioxide emissions-income nexus in 64 middle income countries and compute the marginal effects of real GDP per capita on carbon dioxide emissions at various levels of energy consumption. To do so, we employ multiplicative interaction models because the traditional quadratic Environmental Kuznets Curve model cannot capture the marginal effects. We also use empirical techniques that can account for cross-sectional dependence, such as the Westerlund cointegration test and the Augmented Mean Group estimator. While the marginal effects of GDP on carbon dioxide emissions at the minimum, mean and maximum levels of energy consumption are 9.996, 9.210 and 8.452, respectively, we find no significant evidence that energy consumption moderates the relationship between income and carbon emissions in the panel. However, when we focus on specific countries, we find that energy consumption moderates the nexus between carbon emissions and income in roughly one-third of our sample and that the moderating effect is negative in about one fifth of the sample. We conclude with a discussion on why the moderating effect of energy consumption on the carbon emissions-income nexus differs between countries and offer some policy recommendations that are grounded in the main findings.

## 1. Introduction

Carbon dioxide (CO<sub>2</sub>) emissions, and other greenhouse gases in the atmosphere, constitute a serious global environmental threat. CO<sub>2</sub> emissions are the biggest contributor to the greenhouse effect, which harms the environment and adversely affect human lives [1]. The Environmental Kuznets Curve (EKC) hypothesis states that many indicators of environmental degradation, including CO<sub>2</sub> emissions, tend to get worse until average income reaches a turning point, then environmental quality begins to improve. A conventional EKC exhibits an

inverted U-shaped relationship between environmental quality and economic development, suggesting that environmental pollution increases up to a certain level as the economy grows, after which it decreases. Hence, the pollution level changes with different levels of economic development. In the early stages of economic development, environmental quality deteriorates, but subsequently improves at later stages, once the turning point is reached. One possible explanation for the EKC is that as a country develops, it moves from a clean agrarian economy to a polluting industrial economy and, thereafter, to a clean service economy. Environmental quality is also regarded as a superior

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