# The impact of financial development, income, energy and trade on carbon emissions: Evidence from the Indian economy

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### ABSTRACT

This paper examines the long-run equilibrium and the existence and direction of a causal relationship between carbon emissions, financial development, economic growth, energy consumption and trade openness for India. Our main contribution to the literature on Indian studies lies in the investigation of the causes of carbon emissions by taking into account the role of financial development and using single country data. The results suggest that there is evidence on the long-run and causal relationships between carbon emissions, financial development, income, energy use and trade openness. Financial development has a long-run positive impact on carbon emissions, implying that financial development improves environmental degradation. Moreover, Granger causality test indicates a long-run unidirectional causality running from financial development to carbon emissions and energy use. The evidence suggests that financial system should take into account the environment aspect in their current operations. The results of this study may be of great importance for policy and decision-makers in order to develop energy policies for India that contribute to the curbing of carbon emissions while preserving economic growth.

## 1. Introduction

Climate change and global warming are the greatest and most controversial environmental issues of our times. There is broad consensus among scientists that accumulated carbon dioxide emitted from the burning of fossil fuels, along with contributions from other human-induced greenhouse gas emissions, are warming the atmosphere and oceans of the earth (IPCC, 2007). The global effects of climate change are already apparent in increasing the frequency of extreme weather events, altering precipitation patterns, heightening storm intensity, reversing ocean currents and a rising sea level. These changes, in turn, can have significant impacts on the functioning of ecosystems, the viability of wildlife, and the well-being of humans.

With the world's second largest population and over 1.1 billion people, India is one of the lowest greenhouse gas emitters in the world on a per-capita basis. Its emission of 1.18 tonnes of carbon equivalent per capita in 2008 was nearly one-fourth of the corresponding global average of 4.38 tonnes. However, India is highly vulnerable to climate change, as a large population are dependent on agriculture

and forestry for livelihood. The Indian economy is also dependent on natural resources and any adverse impact on these and related sectors will negate government's efforts to eradicate poverty and ensure sustainable livelihood for the population.

India accords high priority to its development. The economy has been growing, on average, at 7.7% per year between 2000 and 2007, and fossil-fuel carbon emissions have increased by 125% between 1950 and 2008, becoming the world's third largest fossil-fuel $CO_2$-emitting country. As outlined in India's 12th Five Year Plan (2012–2017), the government of India has provisionally set a 9% GDP growth target, which will require energy supply to grow at 6.5% per year. Being aware of achieving its growth trajectory in an environmentally sustainable manner, India has announced in December 2009 that it would aim to reduce the emissions intensity of its GDP by 20–25% from 2005 levels by 2020. Therefore, India is faced with the challenge of identifying the common ground between climate change policy and economic growth and pursuing measures that achieve both.

However, to control the greenhouse gas emissions and to ensure the sustainability of the economic development, it is important to better understand the inter-temporal links in the environment–energy–income nexus. In the literature, there have been few researches to explore the relationship between these variables in the case of India.

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Ghosh (2010) investigated the causal relationship between carbon emissions and economic growth using ARDL bounds testing approach complemented by Johansen–Juselius maximum likelihood procedure in a multivariate framework by incorporating energy supply, investment and employment. The result revealed the absence of a long-run causality between carbon emissions and economic growth; however a bi-directional short-run causality between the two is found. Alam et al. (2011) applied the Toda and Yamamoto causality test to examine the dynamic relationship between carbon emissions, economic growth, energy consumption, labour forces and gross fixed capital formation. They found a bi-directional Granger causality between energy consumption and carbon emissions in the long run but neither carbon emissions nor energy consumption causes movements in economic growth. Jayanthakumaran et al. (2012) analyzed the long-run relationship between carbon emissions and other variables such as growth, energy, trade and endogenously determined structural breaks. They found evidence for the existence of an EKC hypothesis for India. However, they failed to derive a clear picture regarding the association of structural change and carbon emissions. Kanjilal and Ghosh (2013) examine the EKC hypothesis using threshold cointegration with endogenously determined structural breaks. The study advocates that the existence of structural breaks in the period of the study can produce misleading results if they are not incorporated in the cointegration testing models.

This paper extends the above-mentioned multivariate framework further by including the impacts of financial development into the nexus. To the best of our knowledge, there has never been an attempt to investigate the causes of carbon emissions for India by taking into account the role of financial development and using single country data. This study tries to fulfil this gap. In this respect, we argue that the analysis of the relationship between carbon emissions and financial development may reduce the problems of omitted variable bias in econometric estimation. This attempt may also be of great importance for policy and decision-makers to better apprehend the determinants of carbon emissions in order to develop effective energy policies that will palliate the impacts of human activities, and thereby contribute to the curbing of carbon emissions while preserving economic growth.

The remainder of the paper is organized as follows. Section 2 presents a brief literature review related to financial development and carbon emissions. Section 3 describes the data and methodology. Empirical results are given in Section 4 while the summary and the concluding remarks are outlined in Section 5.

## 2. A brief literature review

The impact of financial development on environmental conditions has gained increasing attention in the recent literature. Yuxiang and Chen (2011) used provincial data of Chinese economy to examine the impact of financial development on industrial pollutants and found improvements in environment due to financial development. They claimed that financial development improves environmental quality by increasing income and capitalization, exploiting new technology and implementing regulations regarding environment. Jalil and Feridun (2011) investigated the impact of financial development, economic growth and energy consumption on $CO_2$ emissions in the case of China from 1953 to 2006. The results of the analysis revealed a negative sign for the coefficient of financial development, suggesting that financial development in China has not taken place at the expense of environmental pollution. On the contrary, it is found that financial development saves the environment from degradation. Moreover, the results confirm the existence of a long-run relationship between carbon emissions, income, energy consumption and trade openness while supporting the presence of EKC hypothesis. Similarly, Zhang (2011) explored the effect of financial development on carbon emissions.

Results indicated that, first, China's financial development constitutes an important driver for carbon emissions increase, which should be taken into account when carbon emissions demand is projected. Second, the influence of financial intermediation scale on carbon emissions outweighs that of other financial development indicators but its efficiency's influence appears by far weaker although it may cause the change of carbon emissions statistically. Third, China's stock market scale has a relatively larger influence on carbon emissions but the influence of its efficiency is very limited. Finally, among financial development indicators, China's FDI exerts the least influence on the change of carbon emissions, due to its relatively smaller volume compared with income. Ozturk and Acaravci (2013) examined the causal relationship between financial development, openness, economic growth, energy consumption and carbon emissions in Turkey for the period 1960–2007. Empirical results yielded evidence of a long-run relationship between carbon emissions, energy consumption, income, openness ratio and financial development. The results also supported the validity of EKC hypothesis in Turkish economy. However, financial development has no significant effect on carbon emissions in the long-run.

For cross-country case studies, Talukdar and Meisner (2001) examined the impact of private sector involvement on carbon emissions using data from 44 developing countries over nine years (1987–95). They found that both foreign direct investments and domestic financial capital markets in an economy are likely to have positive impacts on the environment. Claessens and Feijen (2007) analyzed the role of governance in reducing $CO_2$ emissions and reported that with the help of more advanced governance firms can lower the growth of carbon emissions. They suggested that financial development might stimulate the performance of firms due to the adoption of energy efficient technologies, which reduce carbon emissions. Tamazian et al. (2009) investigated the linkage between financial development, economic development and environmental quality for BRIC countries using panel data over the period 1992–2004. Their results revealed that higher degree of economic and financial development decreases the environmental degradation. Tamazian and Bhaskara Rao (2010) tested the role of economic, financial and institutional developments on environmental degradation with a sample of 24 transition countries for the period from 1993 to 2004. Their findings showed that financial liberalization may be harmful for environmental quality if it is not accomplished in a strong institutional framework. In addition, the findings confirm the existence of an EKC.

India is included in some of the above-mentioned panel data studies. However, it is widely recognized that any potential inference drawn from these cross-country studies provides only a general understanding of the linkage between the variables, and thus are unable to offer much guidance on policy implications for each country (Ang, 2008; Lindmark, 2002; Stern et al., 1996). Hence, the aim of this research is to investigate the impact of financial development on carbon emissions in the case of India.

## 3. Methodology and data

Following the empirical literature in energy economics, it is plausible to form the long-run relationship between carbon emissions, financial development, economic growth, energy consumption, and foreign trade in linear logarithmic quadratic form, with a view of testing the long-run and causal relationships between these variables in India, as follows:

$$CO_{2t} = \beta_0 + \alpha_F F_t + \alpha_Y Y_t + \alpha_{Y2} Y_t^2 + \alpha_E E_t + \alpha_T T_t + \varepsilon_t \qquad (1)$$

where $t$ and $\varepsilon$ denote time and error, respectively. $CO_2$ is carbon emissions (measured in metric tonnes per capita), $F$ stands for