



INTERNATIONAL CONFERENCE
ON
INDIGENOUS KNOWLEDGE SYSTEMS AND
SUSTAINABLE DEVELOPMENT
स्वदेशी ज्ञान परम्परा एवं धारणक्षम विकास



9-10 March, 2025

Vigyan Bhawan, Maulana Azad Road, Rajpath Area,
Central Secretariat, New Delhi - 110011

Organized by:

Shaikshik Foundation

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International Conference
on
Indigenous Knowledge Systems and
Sustainable Development
स्वदेशी ज्ञान परम्परा एवं धारणक्षम विकास
9-10 मार्च, 2025, विज्ञान भवन, नई दिल्ली



ईशावास्यमिदं सर्वं यत्किञ्च जगत्यां जगत् ।
तेन त्यक्तेन भुञ्जीथा मा गृधः कस्यस्त्विद्धनम् ॥
जड़-चेतन प्राणियों वाली यह सृष्टि सर्वत्र परमात्मा से व्याप्त है।
इसके पदार्थों का आवश्यकतानुसार भोग करें, किंतु
'यह सब मेरा नहीं है के भाव के साथ' पदार्थों का संग्रह न करें।

ISBN : 978-81-953575-6-7

प्रकाशन तिथि : 9 मार्च, 2025 फाल्गुन शुक्ल १०, विक्रम संवत् २०८१, युगाब्द ५१२५

अक्षर संयोजन : अजीत झा, सागर कम्प्यूटर, जयपुर

मुद्रक : पॉप्योराइट प्रिंट मीडिया प्रा. लिमिटेड, उदयपुर

प्रकाशित लेख में लेखकों के निजी विचार हैं, इससे संपादक-मण्डल का सहमत होना अनिवार्य नहीं है।



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Advancing to Sustainable Future through Exporting Clean Energy Products in China and India : A Poisson Pseudo Maximum Likelihood Estimation Approach

□ Arvind Goswamiⁱ, Rajesh Kumar Jangirⁱⁱ, Pullaiah Cheepiⁱⁱⁱ,
Harmanpreet Singh Kapoor^{iv}, Vinod Kumar^v

Abstract

The main aim of this study is to investigate the impact of variables that affect the international trade of clean energy products in India and China. For this, data were collected from UN Comtrade for exports of clean energy commodities based on HSN's six-digit level from 2000 to 2022. The data for other variables such as renewable energy consumption (REC), gross domestic product (GDP), free trade agreements (FTAs), population, border, and distance was collected from World Development Indicators, the CEPII database, and GPS. The analysis used the augmented Gravity Model and Poisson Pseudo Maximum Likelihood Estimator (PPMLE). The study results depict that GDP positively impacts the growth of clean energy product exports in both countries. In the case of border and FTA, both positively affect exports in China and India. As per the results, it is advisable that these countries should sign more FTA to improve exports of clean energy.

Keywords : India, China, PPMLE, Clean Energy, Sustainable Development, Trade

1. Introduction

Climate change is considered one of the world's most recent and major challenges. It is a facet of environmental degradation and the biggest threat to sustainable development (Goswami et al., 2024). In 2015, the United Nations introduced 17 sustainable development goals (SDGs), which focused on several areas, such as poverty, education, health, and climate. Of the 17 goals, SDG 7 focuses on "clean and affordable energy for all" (Ahmed et al., 2022). Energy has played a fundamental role in the evolution of human beings, but after industrialization, the sudden rise in energy demand was fulfilled by burning fossil fuels. These fossil fuels are the major source of GHG emissions (Goswami et al., 2023). The rise in energy demand led to the trade of fossil fuels from crude oil-rich countries to the rest of the world (Ahmad & Zhang, 2020). In the last three decades, emerging economies like China and India have become import hubs for fossil fuels.

This rise in the burning of fossil fuels to fulfill their energy needs led these economies to become one of the biggest emitters of greenhouse gases (GHGs) in the world, and the trend of GHG emissions is given below in Figure 1. The rising levels of GHG emissions can be reduced by producing clean energy technology (CET) and exporting it to achieve high economic growth.

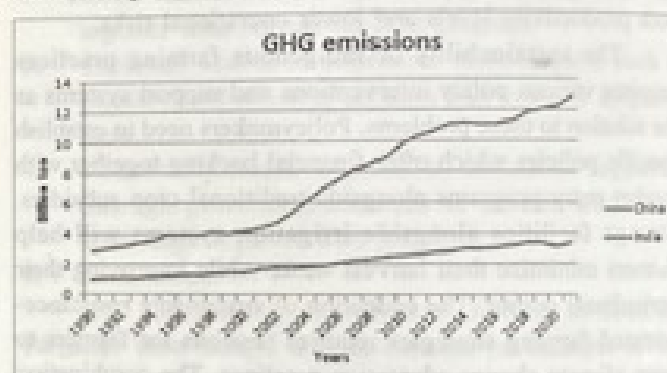


Figure 1 : Trend of GHG emissions

Source : World Development Indicators

Figure 1 shows that from 1990 to 2021, GHG emissions have depicted an increasing trend that shows the need to shift to clean energy from traditional fossil fuels. The main aim of this study is to assess the variables that impact the export of CETs in China and India. By focusing on these variables, the hurdles can be removed to achieve high exports for a sustainable future.

2. Data and Methodology

To analyze the impact of variables that affect the pattern of exports of CETs, Poisson Pseudo Maximum Likelihood Estimation (PPMLE) has been used. For this, 33 commodities have been selected, and export data for these commodities for the period 2000-2022 have been collected from UN Comtrade. Along with the exports of CETs, gross domestic product (GDP) (2015 constant US\$), total population, partner countries' GDP, free trade agreements (FTA), and border have been selected as independent variables. The PPMLE is an extended version of the augmented gravity model, where it

is not required to satisfy the ordinary least square (OLS) assumptions. The basic gravity model is given below in equation (1).

$$X_{ij} = \alpha \frac{Y_i \beta_1 Y_j \beta_2}{D_{ij} \beta_3} \quad \dots (1)$$

Here, X_{ij} is the total export of i th commodity from j th country. Y_i and Y_j are the sizes of the economies of exporting and importing countries, D_{ij} is the distance between countries, α is constant, β_1 , β_2 , and β_3 are the elasticity of Y_i , Y_j , and D_{ij} , respectively. This equation depicts that international trade is proportionally related to economies' size and inversely related to distance. The logarithmic transformation of equation 2 is given below:

$$\ln X_{ij} = \alpha + \beta_1 \ln Y_i + \beta_2 \ln Y_j + \beta_3 \ln D_{ij} + \varepsilon_{ij} \quad \dots (2)$$

After all the developments in the gravity model, dummy variables such as border and FTA, known as the augmented

gravity model, can also be included. Hence, equation 2 is transformed after including all these variables and given as follows:

$$\ln X_{ij} = \beta_0 + \beta_1 \ln Y_i + \beta_2 \ln Y_j + \beta_3 \ln D_{ij} + \beta_4 \ln FTA_{ij} + \beta_5 \ln B_{ij} + \beta_6 \ln P_j + u_{ij} \quad \dots (3)$$

Here,

i (exporting country), j (importing countries), t (time period) 2000-2022,

$\ln X_{ij}$: Export of i country to j country in natural log

$\ln Y_i$: GDP of country i for period 2000-2022 in natural log

$\ln Y_j$: GDP of country j for period 2000-2022 in natural log

$\ln D_{ij}$: Distance between country i and j in natural log

FTA_{ij} : Dummy variable for free trade agreements between countries i and j

B_{ij} : Dummy variable for common border between countries i and j

P_j : Population of country j for the period 2000-2022 in natural log

U_{ij} : Error term

3. Results and Discussions

In this section the results of the PPMLE have been discussed. The results of the PPMLE are given below in Table 1.

Country	$\ln(\text{Egdp})$	$\ln(\text{dist})$	$\ln(\text{lgdp})$	$\ln(\text{Pop})$	Border	Fta	Constant
China	0.0199***	0.138***	0.0188***	0.0521***	0.0112***	0.0238***	-2.590***
India	0.102***	0.177***	-0.0122**	0.0462***	0.0204***	0.138***	-2.934***

Sig. level: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table 1 offers a comparative analysis of factors influencing export potential in China and India through PPMLE. The results show that in most countries, their economic growth is a significant variable in determining exports of clean energy products. This confirms the rejection of the null hypothesis and concludes that economic growth is significant for exports of clean energy products. For example, China sees export gains from its GDP, population, and FTAs, suggesting benefits from further FTA expansion and improved cross-border trade. Similarly, India's exports are bolstered by GDP, population, and regional ties, indicating room for growth by strengthening trade agreements and targeting larger markets. Similarly, India is showing significant results for all variables. In the case of India, it was found that as India's importing partners' economy grows, it negatively impacts its CET exports. This can be due to a protectionist approach or a transition toward self-reliance.

Discussions

China and India are the largest emerging economies in the world, and they share borders, showing that cooperation between these two economies is necessary for regional

development. In 2023, these two economies were among the top three biggest polluters worldwide, which makes them vulnerable from a climate change perspective and shows the urgency for a rapid transition toward clean energy that requires enormous investment (Behera et al., 2024). In 2024, China invested 680 billion US\$, the highest in the world, and India stands fourth with 68 billion US\$ investment in renewable energy (IEA, 2024). This may seem high, but it is far below the required investment to achieve sustainable development goals by 2030. To achieve high exports in CETs, the government should consider these variables.

4. Conclusion and Policy Recommendations

The focus of this chapter was to investigate the significant variables that affect the trade of clean energy products in AEEs, which can be a significant step toward achieving sustainable development goals like SDG 7 and SGD 13. The PPMLE has been used to tackle the effect of heteroscedasticity and cross-sectional dependence. The results depict that in the case of China, economic growth, population, and FTAs positively impact the export of clean energy products. India is also witnessing the same kind of



relationship, in which exports are bolstered by economic growth, population, and regional ties, indicating room for growth by strengthening trade agreements and targeting larger markets. On the basis of these results, it is advisable that both countries sign more FTA as it positively impacts exports and enhances regional cooperation.

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