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Trade Dynamics in the Face of Climate Regulations: A Study of India's Emission-Intensive Exports to Developed Countries

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This paper examines the long-term effects of developed countries' regulatory policies on emission-intensive (EI) exports from India. The study also checks for the occurrence of structural breaks in the proposed relationship. The results indicate that regulations on domestic industries by developed countries increase EI imports from India. Conversely, trade policy measures such as the imposition of import tariffs reduce imports of EI goods.

I. Introduction

The objective of this study is to empirically examine the association between trade flows and environmental regulations. In an open economy, domestic regulations and pollution taxation aimed at controlling energy consumption may be ineffective due to the replacement of dirty production with dirty imports (Copeland & Taylor, 2004). This impedes progress towards green innovation and sustainable growth. Given this context, the European Union (EU) has recently implemented the Carbon Border Adjustment Mechanism (CBAM) to impose tariffs on imported goods equivalent to carbon prices under the EU Emissions Trading System (Zhong & Pei, 2023). Other developed countries, such as the United Kingdom, the United States, and Japan, are also considering the implementation of "carbon border taxes". The introduction of trade restrictions, including tariffs and non-tariff trade barriers, may potentially reduce the mutual benefits derived from trade (Bhagwati, 1993). Developing countries that rely heavily on non-renewable energy sources and depend significantly on trade are likely to be most affected by these regulations (Kadekodi et al., 2007).

Based on the preceding discussion, our hypothesis posits that stringent environmental regulations induce carbon leakage and that trade regulations disrupt "dirty" trade flows. India provides a compelling context for exploring this relationship. The imposition of additional tariffs on carbon-embodied products by developed countries will directly impact Emission-Intensive (EI) export flows from developing countries like India, where dependence on fossil fuels as the primary energy source is substantial. Moreover, given that the EU ranks as India's second-largest export

destination, the introduction of CBAM is expected to exert a detrimental effect on India's exports, particularly in metal sectors such as iron, steel, and aluminum. Notably, these sectors constitute a significant proportion of India's exports to the EU.

Against this background, the research hypotheses have been identified, and an analytical framework has been developed. This study proposes to contribute to the existing literature in two significant ways. Firstly, it examines both dimensions of trade, considering exports from India to selected developed countries and Emissions Embodied Imports (EEI) in those countries as dependent variables. Secondly, the study tests for structural breaks in the proposed relationship, recognizing the implausibility of assuming that the relationship remains constant over time. While most existing literature explores the relationship through the Gravity model, which analyzes bilateral trade flows between countries, this study focuses specifically on India's export flow under certain regulatory measures in host countries. The findings indicate that regulations on domestic industries stimulate EI imports and support the effectiveness of tariffs as a tool for curbing the flow of emission-intensive goods.

The remaining part of the paper is structured as follows: Section II pertains to data and methodology. Section III elaborates on the empirical findings, and Section IV concludes the paper.

II. Data and Methodology

A. Data

This study utilised a balanced panel of 24 developed countries (namely Australia, Austria, Belgium, Czech Re-

Table 1. Variable description and data sources

Variables	Description	Data Source
$Export_{EI}$	Net export flows in EI goods from India (Trade value in 1000 US \$)	UN Comtrade
EEI	Emissions embodied in imports (Millions of metric tons)	OECD
GDP_{PC}	Per capita GDP at constant 2017 prices (Million US \$)	Pen World Table
EPS	Environmental Policy Stringency Index	OECD
ETR	Revenue collected from environmental taxes (in Million US\$)	OECD
$Tariff$	Applied rate, weighted mean, manufactured products (in percent)	World Bank
PEC	Primary energy consumption (TWh)	World Bank

Note: This table presents a detailed description of the variables utilized in the study and the respective data sources.

public, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, United Kingdom, the United States), which have either implemented or intend to implement a carbon border tax. The focus is on India's export flows in energy-intensive industries to these selected countries during the period from 1995 to 2018. The selection of industries is based on the research conducted by Low and Yeats (1992) and Sawhney and Rastogi (2015) and is also consistent with the list of 17 highly polluting industries identified by India's Central Pollution Control Board.

In accordance with the methodologies of Doğan et al. (2022) and Martínez-Zarzoso et al. (2019), the study employs various indicators as proxies for environmental regulations, such as the Environmental Policy Stringency Index (EPS) and Environmental Tax Revenue (ETR). Additionally, the applied weighted tariff rate on manufactured products has been included to account for trade policy measures. [Table 1](#) provides a description of the variables and data sources.

B. Methodology

The study aims to investigate the association between India's export in EI industries and host countries' regulatory policies. The linear form of models specification is as follows:

$$Export_{EI_{it}} = \alpha_i + \beta_1 GDP_{PC_{it}} + \beta_2 EPS_{it} + \beta_3 ETR_{it} + \beta_4 Tariff_{it} + \beta_5 PEC_{it} + \varepsilon_{it} \quad (1)$$

$$EEI_{it} = \alpha_i + \beta_1 GDP_{PC_{it}} + \beta_2 EPS_{it} + \beta_3 ETR_{it} + \beta_4 Tariff_{it} + \beta_5 PEC_{it} + \varepsilon_{it} \quad (2)$$

Where $Export_{EI}$ represents net exports from EI industries from India, and EEI represents emission embodied imports of selected countries as dependent variable.

The empirical study begins with testing for cross-sectional dependence among states. The study employed the Pesaran (2004) Cross-Sectional Dependence (CSD) test, which measures the correlation among cross-sections. To test for stationarity in the presence of CSD, the Pesaran (2007) second-generation unit root test was conducted. The baseline regression model is based on the assumption that coefficients do not change over time, although this is unlikely to hold true. We follow Ditzen et al. (2021) to detect

multiple structural breaks in panel data in the presence of CSD. After estimating the break dates, we can estimate the model for each regime. The test uses a sequential testing approach to determine the number of structural breaks and provides F-statistics and corresponding critical values at each step. The F-statistics in the model are robust to heteroscedasticity and autocorrelation. Rejection of the null hypothesis implies that the number of breaks may increase by one at each step until the null is accepted.

Consider the following model with N units and T periods and s structural breaks in vector form:

$$y_{i,t} = x'_{i,t}\beta + w'_{i,t}\delta_j + e_{i,t} \quad (3)$$

Where $t = T_{j-1}, \dots, T_j$ and $j = 1, \dots, s+1$ with $T_0 = 0$ and $T_{s+1} = T$. There are s breaks, or $(s+1)$ regimes j covering the observations $T_{j-1}, \dots, T_j$.

Given that our variables are integrated of different orders, it is appropriate to employ the Autoregressive Distributed Lag (ARDL) model based on the Pooled Mean Group (PMG) methodology as proposed by Pesaran et al. (1999). The PMG approach allows for homogeneous long-term coefficients while accommodating country-specific intercepts, short-term coefficients, and adjustment parameters. Equation 1 can thus be reformulated into the ARDL (p, q) model as follows:

$$LnExport_{EI_{it}} = \alpha_i + \sum_{j=0}^p \gamma_{ij} LnExport_{EI_{it-j}} + \sum_{j=0}^q \beta_{ij} LnX_{it-j} + \varepsilon_{it} \quad (4)$$

The reparametrized form of Equation (4) into the error correction form is as follows:

$$\Delta LnExport_{EI_{it}} = \phi_i ECT_{it} + \sum_{j=0}^{p-1} \gamma_{ij} \Delta LnExport_{EI_{it-j}} + \sum_{j=0}^{q-1} \beta_{ij} LnX_{it-j} + \varepsilon_{it} \quad (5)$$

$$ECT_{it} = LnExport_{EI_{it}} - \theta X_{it} \quad (6)$$

In the above equations, X_{it} is the vector of independent variables and Ln represents the natural logarithm form of the respective variables. Δ represents the difference operator; ECT_{it} is the error correction term; and ϕ_i represents the error correcting adjustment parameter. The coefficient of interest is θ which represents long-run relationship between the variables.

Table 2. Cross-sectional dependence and second-generation panel unit root test

Variable	Pesaran (2007) Unit Root test (CIPS)		Pesaran (2004) CSD test	
	At level	First difference	CD-test statistic	p-value
	Zt-bar	Zt-bar		
$LnExport_{EI}$	-4.735***	-17.082***	67.870	0.000
$LnEEI$	-1.982**	-10.468***	59.75	0.000
$LnGDP_{pc}$	0.832	-5.864***	68.480	0.000
$LnEPS$	-5.397***	-15.651***	72.790	0.000
$LnETR$	-2.665**	-11.969***	67.240	0.000
$Tariff$	1.511	-19.391***	71.120	0.000
$LnPEC$	-5.149***	-16.046***	22.200	0.000

Note: This table reports results obtained from the cross-sectional dependence and second-generation panel unit root tests. ***, **, and * indicate statistical significance at 1%, 5%, and 10% levels, respectively.

III. Empirical Findings

The empirical analysis tested for CSD among states and found its presence. Hence, the study used a second-generation unit root test, confirming that variables are integrated of orders $I(0)$ and $I(1)$. This makes the ARDL procedure feasible. Results are reported in [Table 2](#).

The study proceeds by testing for structural breaks in the proposed relationships. The variables of interest, EPS and $Tariff$, are utilized as proxies for environmental stringency and trade restrictions, respectively. The test results are reported in [Table 3](#) and indicate the presence of three structural breaks in the relationship between $Export_{EI}$ and $Tariff$, with estimated break dates in 1998, 2004, and 2012. Similarly, in the analysis of the relationship between $Export_{EI}$ and EPS , the estimated break dates are 1998 and 2004. Subsequently, new variables for each regime are generated for both $Tariff$ and EPS , which are then used for further analysis. The results are presented in two panels: Panel A, where the dependent variable is $Export_{EI}$, and Panel B, where the dependent variable is EEI .

Panel A of [Table 4](#) indicates that EPS in the host country has a significant and positive impact on $Export_{EI}$ across all three regimes in the long-run. In the short run, however, EPS exhibits a negative but statistically insignificant impact in the first two regimes (1995-2004). From 2005 onwards, EPS shows a positive and significant impact on $Export_{EI}$. This study adds to existing literature on the pollution haven hypothesis (PHH), which argues that stringent regulations in developed countries drive the transfer of EI industries to developing countries, thereby increasing the concentration of EI goods in their import baskets. The findings suggest that developed countries import emission-embodied goods to meet their consumption demand. The higher consumption demand of selected countries is also reflected in their higher per-capita income, as evidenced by the coefficient of GDP_{PC} , which is 1.427 percent. Additionally, the coefficient of ETR demonstrates a positive and significant impact on $Export_{EI}$ in both the short-run and the long-run. Furthermore, to examine the efficacy of "carbon border taxes" in limiting the flow of emission-intensive goods, the study includes tariffs imposed on im-

ported goods as explanatory variables. $Tariff$ has a negative impact on $Export_{EI}$ in all four regimes, supporting fundamental trade theories that identify tariffs as a policy aimed at reducing imports. PEC has a significant and positive impact in the short-run but show a negative impact in the long-run. These results support the hypothesis that stringent regulations cause carbon leakage and tariffs affect EI trade flows.

We also used Emissions Embodied Imports (EEI) as a dependent variable to confirm our results. Panel B of [Table 4](#) shows that EEI aligns with the findings in Panel A. Both EPS and ETR positively impact the inflow of emission-embodied products into developed countries. This implies that developed countries replace their production-based emissions with dirty imports to meet climate goals. Higher tariff rates, however, negatively affect emissions-embodied imports.

IV. Conclusion

The study analyzed the empirical relationship between regulatory policies of developed countries and exports in emission-intensive (EI) sectors from India. The study found a positive relationship between environmental regulations in host nations and imports in EI sectors. Additionally, the study supports the effectiveness of tariffs as a tool for reducing the flow of emission-intensive goods. As developed countries take actions to mitigate emissions within their territories, these efforts could influence trade patterns and production activities in partner countries. The findings provide insights into the resilience of these sectors to economic shocks associated with emission-reducing policies in developed countries. Further research is needed to determine whether products from developing countries might lose their comparative advantage due to additional carbon taxes or remain competitive compared to goods produced in developed nations.

Table 3. Ditzen et al. (2021) sequential test for multiple structural breaks

Detection of Structural break test for Export_{EI} and Tariff		
Bai & Perron Critical Values		
	F-Test Statistic	Breakpoints
F(1 0)	7.73***	1998
F(2 1)	114.45***	2004
F(3 2)	28.39***	2012
F(4 3)	11.70	
Detection of Structural break test for Export_{EI} and EPS		
Bai & Perron Critical Values		
	F-Test Statistic	Breakpoints
F(1 0)	19.01***	1998
F(2 1)	24.93***	2004
F(3 2)	6.45	

Note: This table displays the outcomes of the structural break test, estimating the number of breakpoints within the proposed relationship. The null hypothesis posits that there is no structural break in the relationship. The identified breakpoints indicate the number of breaks for which the null hypothesis is rejected. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4. PMG-ARDL based estimated results

Panel A: Dependent variable: LnExport_{EI} - EI export flows from India to selected countries		
Variables	ARDL-PMG results	
	Short-run	Long-run
ECT	-0.372 (0.063)***	
LnGDP _{pc}	1.986 (1.725)	1.427 (0.240)***
LnEPS (1995 – 1998)	-1.115 (0.762)	0.521 (0.164)***
LnEPS (1999 – 2004)	-0.102 (0.194)	0.887 (0.166)***
LnEPS(2005 – 2018)	0.715 (0.358)**	0.599 (0.182)***
LnETR	0.533 (0.253)**	0.881 (0.166)***
Tariff (1995 – 1998)	0.033 (0.042)	-0.419 (0.075)***
Tariff (1999 – 2004)	0.169 (0.109)	-0.454 (0.084)***
Tariff (2005 – 2012)	-0.227 (0.087)***	-0.222 (0.088)**
Tariff (2013 – 2018)	0.115 (0.264)	-0.184 (0.090)**
LnPEC	2.050 (1.067)**	-1.464 (0.490)***
Intercept	-0.643 (0.234)***	
Panel B: Dependent variable: LnEEI - emissions embodied in imports of selected countries		
Variables	ARDL-PMG results	
	Short-run	Long-run
ECT	-0.255(0.037)***	
LnGDP _{pc}	2.365(0.199)***	0.228(0.115)**
LnEPS	0.001(0.033)	0.150(0.038)***
LnETR	0.201(0.040)***	0.331(0.040)***
Tariff	0.011(0.006)*	-0.046(0.017)***
LnPEC	-0.092(0.118)	2.586(0.017)***
Intercept	-4.736(0.760)***	

Note: This table presents the short-run and long-run estimates of ARDL-PMG regression. In Panel A, *LnExport_{EI}* is the dependent variable, while in Panel B, *LnEEI* is the dependent variable. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively. Standard errors are reported in parentheses.

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