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“The Effects of EU Green Deal Regulations on India’s Renewable Energy Exports to Europe (2012-2021)”

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ABSTRACT

The study investigates India's Renewable energy exports to the European Union (EU) in the period from 2012 to 2021 and is based on the policy framework of the European Green Deal through three main sectors - solar, wind and electric vehicles (EVs). It evaluates how the changing EU environmental regulations, trade policies, and sustainability mechanisms have resulted in the ups and downs of India's renewable exports. The regression results show that the export growth in these sectors is mainly driven by the policy changes rather than by market forces. On the other hand, solar exports indicate an alertness to global energy prices and EU renewable consumption, while wind exports are swayed by tariff systems, certification conformities, and technology access. Compared to other sectors, the EV sector shows the greatest policy dependency. Its competitiveness is directly linked to EU-level adoption mandates, certification standards, and moreover, India's domestic initiatives such as FAME-II and PLI schemes. The research highlights that the export paths are set by the strategic synchrony of India's renewable production policies and the EU's sustainability frameworks. Ultimately, it affirms that the EU Green Deal serves not only as an environmental strategy but also as an economic governance tool that determines trade between India and the EU in the field of renewable energy and cooperation.

Keywords: European Union (EU), Green Deal, Renewable Energy exports , Solar Sector, Wind Energy, Electric vehicles (EVs), Sustainability

INTRODUCTION

The accelerating pace of climate change has pushed countries to treat trade not merely as an exchange of goods but as a shared responsibility toward achieving a carbon-neutral future. Today, solar panels, wind turbines, and green technologies are not just commodities; they have become the new currency of diplomacy, shaping how nations negotiate both markets and climate goals.

Amid the evolving Global economics and environmental Dynamics, India seeks to cooperate with multiple nations to reduce its dependency on one and foster its idea of 'Self-Resilience'. Over the past decade, it has signed a significant number of agreements and has partnered with various trade blocs to nurture its industrial and renewable sectors. Among these, cooperation with the European Union (EU) stands out for its alignment of economic and sustainability objectives.

This research focuses on India's engagement with the EU under the framework of the European Green Deal and associated green trade policies. This paper examines the evolution of India-EU cooperation in green trade, identifies the policy and economic rationale for the research, and presents the analytical and diplomatic dimensions that make the topic relevant in contemporary trade discourse.

From the EU's standpoint, the EU Green Deal is a crucial determinant of its foreign relations with the world. The ambition to achieve carbon neutrality by 2050 has redefined the EU's external trade relations, including with key partners like India. For India, a rapidly growing renewable energy hub, this has opened new opportunities and challenges in aligning its solar, wind, and EV-related export sectors with evolving European sustainability standards. This research quantitatively analyzes India's renewable energy exports to the EU from 2019 to 2024, examining trends across the solar, wind, and EV component sectors to identify which has shown the greatest growth. By linking these patterns with policy developments under the EU Green Deal, the study explores how environmental diplomacy translates into trade flows, market access, and regulatory convergence. It further investigates the drivers and barriers, such as green standards, financing, certification, and technology access, that shape India's renewable exports to the EU.

Ultimately, the paper evaluates how the EU Green Deal functions not just as an environmental strategy but as a diplomatic and economic instrument influencing India-EU trade relations and policy cooperation, and suggests ways to enhance this partnership through evidence-based findings.

LITERATURE REVIEW

Since establishing diplomatic relations with the European Economic Community (EEC) in 1963, India and the European Union (EU) have progressively deepened their engagement evolving from developmental cooperation to contemporary collaborations in trade, green technology, and sustainability.This evolution has been underpinned by policy convergence in the renewable energy domain, with both parties pursuing low-carbon pathways aligned with their respective climate commitments under the Paris Agreement. The EU is India's second-largest trading partner, accounting for trade in goods worth €120 billion in 2024, or 11.5% of India's total trade. India is the EU's 9th largest trading partner, accounting for 2.4% of the EU's total trade in goods in 2024, laying the groundwork for a renewed strategic engagement.(EU Trade Relations with India, 2025).

Trade and investment policy serve as foundational pillars for any economy, yet their environmental dimension is increasingly significant. . India's renewable energy framework has evolved through initiatives such as the Jawaharlal Nehru National Solar Mission (2010), 100% FDI in renewables (2014), the National Wind-Solar Hybrid Policy (2018), and the Production-Linked Incentive (PLI) Scheme for Solar Manufacturing (2020) (Homepage | MINISTRY OF NEW AND RENEWABLE ENERGY | MINISTRY OF NEW AND RENEWABLE ENERGY | India, n.d.). These measures signify a gradual shift toward export-oriented clean energy growth {Updating}. In parallel, EU policy instruments like the European Green Deal (2019) and the Carbon Border Adjustment Mechanism (2023) have integrated sustainability into trade governance, shaping the evolving India-EU policy dynamic.

Introduced in 2019, the European Green Deal (EGD) is not a singular bilateral accord with India but a comprehensive policy framework integrating sustainability into EU trade and industrial strategy. It emphasises reducing carbon footprints and embedding environmental compliance within trade mechanisms, thereby indirectly influencing India's renewable energy export dynamics.

India's electric vehicle (EV) market is entering a crucial growth phase, with sales nearly tripling in 2022 and reaching almost 1.5% of total vehicle sales (IEA,2023; Lema et al., 2024). The domestic EV sector has developed with homegrown brands and a reasonably advanced supply network, reinforced by Local Content Requirement regulations. Despite these advances, high-tech components are still predominantly imported, highlighting persistent gaps in India's manufacturing capacity (UNCTAD, 2014; Deringer et al., 2018; Singh, 2023). These dynamics reflect how domestic policy initiatives such as India's FAME II scheme and LCR requirements intersect with EU sustainability standards, influencing competitiveness within the global EV supply chain.

Solar energy manufacturing forms a central pillar of India's green industrial policy, alongside EVs, batteries, and hydrogen electrolyzers. The country ranks fourth globally in wind and fifth in solar installed capacity, reflecting its growing influence in the global renewable energy landscape and its accelerated move away from fossil fuels (IFRI, 2024, pp.30-32). Bilateral initiatives, such as the EU-India Clean Energy and Climate Partnership, have supported technology dissemination, research, and innovation, contributing to widespread solar deployment across India. Consequently, solar energy forms a critical node in India-EU green cooperation, with trade flows increasingly governed by mutual standards of technology, certification, and carbon compliance.

India's collaboration with the EU also provides opportunities to develop expertise in offshore wind generation, identified as a priority under the Clean Energy and Climate Partnership (KAS, 2024, p.6). The European Green Deal creates a market opening for Indian industry as Europe seeks to reduce dependency on China, which supplied 89% of its solar panels and 64% of wind turbines in 2021 ((Statistical Reports - Eurostat, n.d.); Oertel et al., 2020). This shift could increase demand for Indian renewable technologies, though the implications of India's stance on CBAM remain to be seen.
While India, as a major exporter of renewable energy products including solar panels, wind turbines, and related components faces both opportunities and challenges under the EGD. Empirical analyses by Sarkar (2021) and Eva & Milek (2021) underscore that compliance with EU environmental standards remains a primary determinant of Indian export competitiveness in renewable components. Complementary findings by García-Herrero (2023) and Malik & Rao (2022) indicate that technology transfer and certification costs create structural barriers for Indian SMEs entering EU markets. These studies collectively highlight that regulatory harmonisation, rather than tariff reduction alone, defines the current trajectory of India-EU green trade.

The EU Global Gateway (2021) and the EU-India Connectivity Partnership have expanded the framework for sustainable infrastructure cooperation. While these initiatives primarily target transport and digital networks, they also indirectly support renewable energy integration through green finance and climate technology partnerships (EU Delegation to India, 2023). Scholars such as Borrell (2023) argue that this infrastructural diplomacy represents the EU's strategic repositioning as a "normative power" promoting green trade governance.
However, despite growing policy alignment, limited empirical evidence connects EU environmental regulations to India's renewable export performance. The reviewed literature reveals three gaps: (1) insufficient quantification of policy impact on export competitiveness; (2) limited exploration of trade-climate diplomacy mechanisms; and (3) underrepresentation of Global South perspectives in EU-centric policy analyses. This study addresses these gaps by empirically assessing India's renewable energy exports to the EU and interpreting the findings within a trade-environment nexus framework.

METHODOLOGY

The study employs a multiple linear regression model to examine the impact of selected economic and policy variables on India's sectoral exports to the European Union (EU). The model is designed to assess how variations in renewable energy consumption, applied tariffs, carbon allowance prices, currency exchange rates, and global oil price shocks influence export performance within the renewable energy sectors namely, solar, wind, and electric vehicles (EVs).
The econometric model applied for the analysis:

$$Yit = \beta 0 + \beta 1x1it + \beta 2x2it + \beta 3x3it + \beta 4x4it + \beta 5D1it + \varepsilon it \qquad \ldots(\text{eq } 1)$$

In equation 1, i represents the sector i.e. Solar energy, Wind energy, or EV & Related components, while the t represents the time period spanning from 2012 to 2021. Y stands for Standardised value of total exports for the specific sector in a particular year between the specified range. X1 denotes standardised total energy consumption of the (i) sector in the (t) time period. X2 on the other hand denotes the applied tariffs(in %) by the EU nation for the i sector in the t period. X3 stands for values of Emission Trading System (ETS) prices of EU imposed on the (i) sector in the (t) time period and X4 denotes the Currency exchange (Rupee per Euro).

$\beta 0$ represents the value of total i-th sector exports when all independent variables are held at zero.
$\beta 1$ is the standardized coefficient (β) measures the expected change in total sectoral exports (in standard deviation units) resulting from a one standard deviation change in renewable energy consumption of the i-th sector, ceteris paribus.
β_2 measures the change in total i-th sector exports corresponding to a one percent change in applied tariffs imposed by EU nations on Indian exports, holding other variables constant.
β_3 measures the change in total i-th sector exports due to a one-rupee change in the EU ETS (carbon allowance) price, keeping other factors constant.
β_4 measures the change in total i-th sector exports resulting from a one-rupee change in the currency exchange rate, ceteris paribus.
β_5 measures the change in total i-th sector exports associated with a one-thousand-rupee change in global oil prices, holding other variables constant.

The tariff variable ($_1$) was omitted because under the Trade and Tariff Data, WTO, solar photovoltaic (PV) modules and components face zero import duties . Likewise, the wind energy components were not subjected to any tariffs by the EU nations and hence the applied tariff variable has been dropped to get away with redundant information. This confirms that the absence of tariff barriers created a neutral playing field for Indian Solar and Wind exporters, leaving regulatory instruments and carbon pricing mechanisms under the EU Green Deal as the real determinants of competitiveness.

1.1. Assessments and Measures

i.Variable Standardization:
Each independent variable was standardized to eliminate unit disparities and allow interpretation of coefficients in standard deviation terms. This enabled identification of the relative contribution of each predictor to export performance.
ii. Model Estimation:
A multiple linear regression model was run for each sector (solar, wind, EV) using the least squares estimation technique. The dependent variable total exports of the respective sector was regressed on the selected independent variables.
iii. Significance Testing:
The t-statistics and corresponding p-values were examined to test the individual significance of each explanatory variable at the 5% level of significance. The F-statistic was evaluated to assess overall model fitness.
iv. Multicollinearity Diagnostics:
To detect the presence of multicollinearity among explanatory variables, Tolerance and Variance Inflation Factor (VIF) were calculated. Tolerance values between 0.22 and 0.41 and VIF values below 5 indicated that the explanatory variables were not excessively correlated, ensuring model stability.
v. Model Validation:
The adjusted R-square value was used to measure the explanatory power of the model after accounting for the number of predictors. The standard error of the estimate was checked to confirm the precision of the regression predictions.

2.Sector Analysis

2.1. Solar Sector (2012-2021)

Between 2012 and 2021, India's solar product exports to the European Union (EU) recorded a consistent upward trajectory, validating the study's hypothesis that the EU Green Deal (EGD) positively influenced India's renewable export performance.
According to the data, solar exports increased from ₹6.22 million in 2012 to ₹18.57 million in 2021, showing a steady, year-on-year rise. The decade-long trend reflects both a policy-led structural shift in EU demand and the growing export capacity of India's solar industry. This has further been analysed by conducting a linear regression and evaluation of existing reports over the course of this study.

2.1.i. Solar Export Momentum under the EU Green Deal
The data clearly show that India's solar exports gained the strongest momentum after 2016, coinciding with the rollout of the EU Green Deal and the reform of the Emissions Trading System (ETS). The Green Deal acted as a regulatory filter, deterring high-carbon imports, and as a market signal, promoting cleaner technologies and environmentally sustainable trading relationships.

Regression Statistics	
Multiple R	0.96086
R Square	0.92326
Adjusted R Square	0.86187
Standard Error	0.37166
Observations	10

Fig. 2.1.a

The econometric diagnostics support this shift. The value of R square being 0.92 indicates a strong linear relationship between India's solar exports and the EU's regulatory variables, underscoring how carbon pricing and sustainability frameworks have consistently influenced export growth. Together, the European regulatory demand push and India's policy-based supply expansion explain why the solar sector has emerged as the most stable and policy-responsive segment of India's renewable exports to Europe between 2012 and 2021.
The Multiple R value of 0.96 further reflects a high degree of correlation between the observed and predicted values. However, upon examining the VIF of all independent variables, there was no significant value but one very close to the determining level of 0.2, which is EU_ETS_Price level with a tolerance of 0.21.

Variable	R Square	Tolerance	VIF
Total Solar Consumption stan	0.49992	0.500081	1.999675744
EU_ETS_Price_Rupee	0.78247	0.217532	4.597017673
Currency Exchange(Rupee/Eu	0.71524	0.284764	3.511681613
Global Oil Price shock	0.27	0.73	1.369863014

Fig.2.1.b

The model exhibits signs of multicollinearity among macroeconomic variables such as global oil prices and solar energy consumption. This is a common feature in energy trade regressions where variables follow similar global trends. However, since the study's objective is to examine directional effects rather than precise parameter estimates, the results remain robust and theoretically consistent. Future studies with larger datasets or sectoral disaggregation could further isolate these effects.

Following the EU-India Clean Energy and Climate Partnership signed in 2016, the partnership between the two regions has risen in the fields of technology transfer, investment in renewables, and harmonization of trade. Indian solar producers, taking cues, started to bring production and certification procedures in sync with EU sustainable standards, improving their exportability to the European market.

2.1.ii. Carbon Pricing, ETS, and Market Substitution Effects

Among all the explanatory variables, the role of the EU ETS (Emissions Trading System) proved particularly significant. Under this mechanism, European industries must purchase emission allowances for each tonne of CO_2 released, which increases their production costs. As these costs rose, particularly after 2017, imports from low-emission producers such as India became more competitive. This pattern reflects a broader market substitution effect, where European buyers replaced high-carbon domestic products with cleaner imports from emerging renewable economies.

Between 2017 and 2021, when ETS allowance prices nearly doubled, India's solar export values also surged from ₹9.55 million in 2015 to ₹18.57 million in 2021. The correlation between rising ETS prices and India's solar exports demonstrates how carbon-market tightening within Europe created new demand channels for clean-tech goods. As Mercom India (2025) observes, "higher ETS prices can make imports from India especially renewable or energy-efficient products - relatively cheaper and more attractive to EU buyers."

This relationship became deeper following the signing of the EU Green Deal framework and subsequent trade negotiations with India, which focused on sustainable development and the exchange of clean technologies. Policies like the Carbon Border Adjustment Mechanism (CBAM) followed this trend, bestowing favor on exporters that were able to show compliance with low-carbon and traceability standards. The combined impact of zero tariffs and increasing ETS prices thus considerably increased India's solar exports, making the EU one of India's most vibrant renewable energy markets.

2.1.iii. Domestic Policy Support: The Role of the PLI Scheme

India's domestic industrial policies have played an equally important role in complementing the external demand generated by the EU Green Deal. A key milestone was the introduction of the Production-Linked Incentive (PLI) Scheme for High-Efficiency Solar PV Modules by the Ministry of New and Renewable Energy (MNRE) in 2021. The program aims to boost India's end-to-end manufacturing - from polysilicon to module assembly - by linking financial incentives to output, efficiency, and sustainability standards.

In the regression analysis, the variable representing domestic solar output (x_4) showed a positive but slightly lagged impact, suggesting that industrial capacity expansions translated into higher exports after a short delay. The PLI scheme not only strengthened India's manufacturing base but also aligned its production standards with the EU's lifecycle and carbon-footprint requirements. The rollout of this program coincided with the single largest annual increase in solar exports (2021), highlighting how domestic initiatives amplified the export gains catalyzed by European demand.

Overall, the synergy between India's industrial policy incentives and Europe's climate-driven trade mechanisms created a mutually reinforcing framework that significantly boosted India's solar export performance in the late 2010s and early 2020s.

2.1.iv. Green Trade Substitution Effect

The expansion of the Green Deal and the tightening of the EU ETS have accelerated a global green trade substitution effect, where industries across Europe are progressively replacing carbon-intensive imports with low-emission alternatives. India's solar sector, supported by initiatives such as the National Solar Mission and the PLI Scheme, is set to gain from this shift.

As carbon costs rise, EU companies are more likely to import renewable components, cells, and solar modules from India to satisfy in-house emission targets and achieve long-run supply stability. This change is evidence of a structural repositioning of global supply chains in the direction of nations with lower production emissions and transparent environmental disclosure.

By regularly satisfying EU sustainability criteria such as lifecycle emissions, traceability, and efficiency - Indian exporters have attained a comparative edge.

2.1.v. Policy Levers to Deepen Export Gains

In order to sustain this upward momentum, India and the European Union must intensify their cooperation through concerted trade and policy instruments. Enhanced bilateral arrangements would solidify India's position as a champion exporter of renewable energy technology while allowing Europe to achieve its target of decarbonization through secure imports.

One key action is the addition of certification and traceability assistance for Indian exporters, including small and medium businesses. EU-compliant sustainability certification and digital traceability technologies would enable them to comply with lifecycle reporting obligations in the Green Deal. Simplifying these procedures through grants supported by government funds could diminish the cost burden on smaller exporters, effectively widening the number of compliant companies.

In the same manner, mutual recognition of standards between Indian and European accrediting bodies may reduce customs formalities and eradicate duplicative testing. This cooperation would not only lower transaction costs but also increase confidence in India's renewable exports because it is based on the highest international quality and sustainability standards.

In addition, collaborative research and development of low-carbon materials and low-carbon manufacturing technologies would enhance India's ability to retain a competitive position within the changing carbon-regulated European market. Such collaborations would also assist India in countering possible exposure to tools such as the CBAM by lowering embedded emissions in manufacturing.

All these steps are part of the overall goals of the EU-India Clean Energy and Climate Partnership and the EU-India Roadmap 2025, with the principal focus on technology sharing, sustainable development, and climate-based trade cooperation.

The overall trend from 2012 to 2021 makes one point clear: India's solar sector has been the most consistent and policy-responsive part of its renewable energy exports to Europe. The combination of EU carbon pricing, zero-tariff access, and India's own industrial incentives under the PLI scheme explains most of this growth. With the model explaining 86% of the variance in export values, the findings strongly support the hypothesis - the EU Green Deal has indeed had a positive and measurable impact on India's solar export performance.

2.2. Wind Export

WIND SECTOR ANALYSIS

Regression Statistics	
Multiple R	0.9696
R Square	0.94012
Adjusted R Square	0.89222
Standard Error	0.3283
Observations	10

The regression shows strong and strengthening relationships between EU-ETS prices and India's wind sector to EU. The positive ETS-export link suggests that India's policy efforts to align with EU certification are beneficial. This indicates the increasing role of carbon market dynamics and policy framework under the EU Green Deal, aiming to increase renewable adoption through emission-based incentives (European Commission, 2023). The major forces shaping India's wind sector export trends are basically driven by the regulatory mechanism of Green Deal rather than market demand and price fluctuations. Moreover, India's success in EU markets depends not only on European wind power consumption but also on India's wind sector exports following the EU carbon standards. As European buyers prefer suppliers compliance with green and traceable manufacturing.
This regulatory convergence enhances India's sectoral competitiveness in the EU renewable market.

Variable	R Square	Tolerance	VIF
Total Wind Consum	0.546937203	0.453063	2.207199548
ETS_Price	0.653383057	0.346617	2.885029192
Currency Exchange(	0.630853889	0.369146	2.708954446
Global Oil Price shoc	0.283707841	0.716292	1.396078384

The regression reveals that EU's Wind Energy Consumption (P=0.64) has no statistically impacted on India's wind exports. The variable Applied Tariff was excluded from the wind-sector regression as its value remained constant (zero) across all observations. Since the variable exhibited no variation, it could not contribute to explaining changes in the dependent variable that is annual wind sector exports, leading to numerical errors (#NUM!) in the regression output.
In the wind sector regression, the dummy variable representing global oil price shocks exhibited the lowest tolerance value, indicating potential multicollinearity with other energy-related predictors, particularly global oil prices and ETS values. To test model robustness, the regression was re-estimated after excluding this dummy. The Adjusted R^2 and significance levels of the remaining variables showed minimal change, confirming that the model remains stable and robust even without the inclusion of the oil shock dummy. Therefore, given its limited statistical contribution and high correlation, the variable was excluded from the final specification.

Green Tech Certifications: India's Offshore Wind Policy, Competitiveness, and Regulatory Impact

Policy measures like India's Offshore Wind Energy Lease Rules (2023) have been proven a crucial point for the wind sector exports. Under these rules, there is formalised site leasing, viability gap funding and environmental clearance processes which offer the investors long term stability. India's purpose is to develop a strong and powerful offshore market (MNRE 2023). Hence, by integrating certification, sustainability assessment, and transparent lease mechanisms, India has aligned its framework with EU green compliance standards.

The policy's visible effects on the wind sector exports under green deal includes the increased confidence among the investors while doing trade and a consistent shift towards EU standardized certifications. However, EU-India trade conversation on CBAM adjustments have helped to reduce the uncertainty for exporters, as India's domestic carbon pricing efforts are now recognised in EU calculations (Mercom India, 2025; Carbon Copy, 2025). These developments highlight a connecting policy path where environmental accountability has become the foundation of competitiveness. As India continues to synchronize its regulatory environment with EU standards, its wind sector stands positioned not only as an exporter of wind energy sector components but also as a trustworthy partner in Europe's long-term green energy transition.

The data shows the major rise in the year 2021 as there were various reasons for the sudden jump in India's wind exports. The EU has a positive trade balance in wind related goods to countries outside the EU. However, during the covid pandemic in 2019, China's restrictive wind market policy (import tariffs and VAT exemption to domestic manufacturers). Moreover, India's Offshore wind policy led the development of wind exports following the EU Green Tech Certification as it mainly focused on the development of Infrastructure near the shore of the oceans to generate more wind power using wind turbines and advanced technology.EU showed a positive balance of wind energy related components export from India about EUR 277 million in 2021. This was an important shift of major wind turbine manufacturers from China to the possibility of using Indian resources as these were low cost export hubs of wind sector components and the EU was facing increasing costs from China's policy. This leads to the rise in wind sector export trends of India under EU Green Deal.

Policy-Led Growth in India's Wind Energy Exports

India's wind energy exports to the European Union have been shaped less by demand and more by the policies that define the EU Green Deal. Rather than competing on price or volume, Indian exporters are now competing on sustainability. The EU Green Deal basically links trade access with countries on the basis of environmental performance, then rewarding countries while doing trade if they follow the EU standards and companies that can meet its strict climate and carbon standards. All these are steps taken by the EU that show that it is significantly policy driven instead of demand driven.

The EU Emissions Trading System has been a major influence on India's renewable energy and related components exports. So, when carbon prices increase in Europe, the demand for renewable technologies and low- emission components grows on the other hand. This creates a bunch of opportunities for the Indian manufacturers (European Commission, 2023). Moreover, the EU Taxonomy for Sustainable Activities and Green Technology Standards have set transparent measures for what qualifies under the EU Green Deal standards. Hence, the Indian firms that provide utmost clarity in carbon accounting, resource use, and supply-chain traceability are the ones to gain the European contracts.

India has acknowledged its own forward-looking policies like FAME-2 and PLI Scheme. The Offshore Wind Energy Lease Rules (2023) established the structured leasing, environmental clearances, and certification standards that align diligently with EU Green Deal requirements (Ministry of New and Renewable Energy [MNRE], 2023). These measures help the investors to gain confidence and also help Indian exporters to meet the EU standards.

The recent discussion on Carbon Border Adjustment Mechanism (CBAM) also helps in bridging the regulatory gaps (Mercom India, 2025; Carbon Copy, 2025). Therefore, these efforts by the Indian Government shows how the policy alignment drives India’s wind energy export growth, not just by market demands or money fluctuations. By embracing global climate standards, India’s wind sector is emerging as a trusted partner in Europe’s clean energy transition. Whereas, the implementation of the EU’s Carbon Border Adjustment Mechanism (CBAM) has imposed cost pressures on Indian exporters. As CBAM charges carbon emissions fixed in exported goods, industries dependent on coal-based manufacturing such as steel and turbine components face higher tariffs while doing trade in the EU market. This reduces India’s cost advantage as a low-cost manufacturing hub. Small and medium enterprises find it difficult to meet EU carbon standards and certification requirements, which reduces the competitiveness and market access rather than India’s policy focus on wind exports.

2.3. EV & Related components Exports

Regression Statistics	
Multiple R	0.95557
R Square	0.91311
Adjusted R Square	0.80451
Standard Error	0.44214
Observations	10

Fig.2.3.a

The regression indicates that India's EV exports to the EU are strongly policy-driven rather than purely market-driven. A high R^2 (0.91) reflects that variables such as EU ETS prices, applied tariffs, and currency conditions collectively explain export performance.

	R square	Tolerance	VIF
Total EV Consum	0.58781	0.41219	2.426042015
Applied Tariffs on	0.73513	0.26487	3.775386237
Currency Exchang	0.77973	0.22027	4.539971523
EU_ETS_PRICE_R	0.75121	0.24879	4.019416792
Global Oil Price sl	0.67	0.33	3.030326494

Fig.2.3.b

To detect the presence of multicollinearity among the explanatory variables, *Tolerance* and *Variance Inflation Factor (VIF)* values were computed. Tolerance values below 0.20 and VIF values above 5 generally indicate problematic levels of multicollinearity. In the present model, tolerance values range between 0.22 and 0.41, and corresponding VIF values remain below 5, suggesting that while some degree of interdependence exists particularly between currency exchange rates and ETS prices it does not reach a level severe enough to distort the regression estimates. Hence, multicollinearity is within an acceptable range.

Results from regression analysis for the period 2018-2019 indicate that applied tariffs were at 0%, a time when the tariffs were neutral to clean-technology exchange. Exports kept increasing till 2021; however, after the implementation of CBAM, the cost of embodied carbon is likely to hold back the growth of exports. The future of the EV sector looks great as it is negotiable in the context of India-EU talks under the Trade and Technology Council (TTC) that highlight certification, technology as well as sustainability standards harmonization. These initiatives are indicative of a cooperative and proactive framework designed to secure India's position in the transition of Europe to green mobility.

2.3.i. Policy-Driven Dynamics of India’s EV Exports and Battery Sector Linkages

The growing demand for electric vehicles (EVs) in the European Union (EU) has had a significant impact on the Indian market for EVs. The data derived from regression analysis indicate that EU consumption is still the biggest factor in the export market growth especially because the European markets are rapidly moving towards completely non-polluting vehicles. The demand for EVs created under the EU’s renewable transition policy has opened up new avenues for Indian sellers, particularly in the areas of battery and components. These sectors have profited from the combined advantage of low cost and increase in technical collaboration, which in turn, has made India a viable supplier in the European changing supply chain.

(1) EU Consumption as the Main Force

EU EV consumption is the only statistically valid predictor, which indicates that when the EU-level adoption targets, purchase subsidies, and infrastructure expansion under the Green Deal and REPowerEU programmes become more intense, India's exports will also increase. The European pledge to reach 100 per cent zero-emission vehicle sales by 2035 has created a guaranteed demand base that has a positive impact on India's export flow. The regression model indicates that the increase in European consumption has a direct effect on the Indian supply of batteries, power electronics and other components that are competitively priced.

This is an indication that the Indian EV ecosystem is becoming integrated with the EU renewable transition supply chain catalyzed by the rising European demand.

2) Impact of the EU–India Green Deal

Legitimation of the EU–India Clean Energy and Climate Partnership (2016) and its complimentary policies 2020 Resource Efficiency and Circular Economy Partnership and 2022 Trade and Technology Council (TTC) have been the main factors in converting climate collaboration into trade performance.

These collaborations have ensured that Indian exports have met even the highest European sustainability requirements by providing the means of standards recognition, certification mechanisms, and circular-value-chain research. The working group of the TTC on battery materials and recycling has had a particularly prominent role in facilitating technological exchange which allowed the adoption of low-carbon manufacturing practices aligned with EU Battery Directives (2006, 2021). Thus, the growth of India's exports, which was reflected in the regression, results from deep regulatory linkages instead of merely market expansion.

(3) Domestic Policy Drivers and Institutional Anchors

At the national level, India’s EV export performance not only reflects the government’s insistence on industrial policy but also the collaboration in environmental policy. The National Automotive Testing and R & D Infrastructure Project (NATRiP) set up the global standards for testing and certification facilities that eventually got India’s auto sector connected with the “world” in terms of quality. The National Electric Mobility Mission Plan (NEMMP 2020) declared a long-term vision of non-polluting and affordable transport. The FAME India scheme, mainly its Phase II prolongation, encouraged the use of renewables through tax exemptions for vehicles, charging infrastructure and technology development. The Performance Linked Incentive (PLI) scheme was the main highlight which Union Cabinet gave a green signal to in 2021 with an allocation of ₹ 25,938 crore for the period of 2022-2027, which in turn boosted the domestic production of Advanced Automotive Technology (AAT) products including zero-emission and hydrogen-fuel-cell vehicles. The PLI for Advanced Chemistry Cell (ACC) batteries and FAME-II incentives (₹ 11,500 crore) worked as the complement in the whole scenario as together they cut down on the country’s battery imports while at the same time supporting the making of high-quality batteries in India. These measures dovetailed with the EU's climate policy and hence the result where India's export performance was not influenced by short-term price elasticity or exchange rate volatility but rather anchored in coordinated policy making was observed in the regression analysis. From now on, the incentive allocation for the years 2023-24 to 2027-28 is done in a phased manner, which indicates a long-term strategy to enhance the competitiveness of the sector.

2.3.ii. Policy Leverages to Deepen EV Export Gains

The zero percent tariffs between 2018 and 2019 which happened at the same time as the liberalization of the EU market and the beginning of the Indian electric vehicle (EV) exports show the influence of policies rather than that of market-driven competition. According to regression diagnostics, this time frame is a structural window through which the EU has been able to rapidly phase out of the carbon sector by technological access rather than by facing off against it. The elimination of taxes on imports allowed Indian electric two- and four-wheeler manufacturers and other related parts to conduct their testing in Europe under very favorable conditions. But the situation has changed after 2021 with the rollout of the Carbon Border Adjustment Mechanism (CBAM) where the carbon cost burden of exported goods takes priority over tariff rates. The insignificant tariff coefficient in the regression shows that it is not just compliance and certification but also the overcoming of tariff barriers that will influence the future viability of trade.

Thus, the strategic task has to be to align the domestic production to the EU lifecycle and recycling standards that would then reduce any risk related to the CBAM. The policy continuum from FAME-II, through PLI-Auto, and finally to ACC-battery incentives directly responds to this requirement by offering support through energy-efficient manufacturing, traceability, and localized battery assembly. The Resource Efficiency Partnership and TTC collaboration are facilitating a transition towards circular material flows overcoming raw-material constraints in lithium, cobalt, and rare-earth elements, and giving support to end-of-life recycling through a structured framework.

Negotiation Trajectory and Future Prospects

The ongoing EU–India negotiations under the TTC and Clean Energy Partnership are progressively converging around the issues of sustainable mobility, critical-mineral security, and carbon-neutral certification systems.

The regression findings suggest that keeping policy convergence and limiting regulatory friction will be the key factors in determining India's continued access to the EU markets. The trajectory here is such that once the EU demand for low-carbon vehicles becomes the main factor and India gets stronger in the area of resource-efficient production, then the integration of India's EV sector into the European transport decarbonization architecture is going to be a long-term process. If high levels of in-house production based on the 2021 PLI framework are maintained, the EV sector will not only cover import dependence but also become a major export growth engine in the transition of the global industrial sector to the eco-friendly one.

CONCLUSION

The research study focused on analyzing the effects of the EU Green Deal on India's renewable energy exports to the EU in the areas of solar, wind, and electric vehicles for the period from 2012 to 2021. The results indicate that the export of goods from India to the EU was generally increasing, but the impact of policies differed between sectors and only partially supported the hypothesis. In the solar sector, the applied tariff variable was the only factor with a significant statistical impact; in the wind sector, exports were significantly influenced by the EU ETS price variable; and in the EV sector, EU EV consumption was recognized as the only significant predictor. The relatively high R^2 values found in all models (from 0.86 to 0.92) are a confirmation of good explanatory power. The diagnostic tests revealed that the tolerance levels were acceptable, with VIF values being below 10, which indicates that the models were stable. While the energy-related variables exhibited some degree of multicollinearity, especially between global oil prices and consumption, it did not affect the interpretive validity. To sum up, the findings suggest that the EU-India renewable exports are affected more by the specific market and regulatory mechanisms rather than the broad alignment of the policy under the Green Deal framework.

The results bring to the forefront the disparate impact of the EU Green Deal on renewable sectors, revealing that India's export path has been moulded by both the market-driven and regulatory factors. Tariff structures were the main factors that affected solar exports while carbon pricing that of wind. On the other hand, EV-related exports were mainly affected by the EU's consumer demand and the policy alignment under REPowerEU and zero-emission mandates. This indicates that more than generic trade openness, India's export competitiveness relies on targeted policy synchronisation through the PLI and FAME-II schemes. The validation of the study's strong model and sensitivity testing made it more believable, revealing the close connection between India's renewable trade potential and the changes in EU mechanisms such as CBAM and carbon compliance. The larger implication is that India can make use of its low-carbon manufacturing base to maintain trade resilience as the EU raises its sustainability standards.

Because of the brief period under study (2012-2021), the investigation reveals merely the initial stage of the EU Green Deal's influence. It is suggested that the following inquiries would be better off with a longer time frame and that ongoing developments, like the implementation of CBAM and India-EU FTA negotiations, should be considered. Unpacking the dataset through finer sectoral disaggregation and better policy variable measurement could make it possible to pinpoint specific connections between domestic incentives and EU import demand. Similarly, future research might advance the testing of structural models with certification overlaps, recycling standards, and emissions criteria being considered as factors in compliance-led competitiveness. Moreover, by performing a similar analysis on other emerging markets, it would be possible to find out whether India is an exception or part of a larger trend in the region. The aforementioned improvements would lead to a more clear-cut understanding of the long-term sustainability of India's renewable export growth under the Green Deal regime.

This research lays the groundwork for revealing the interactions between policy, market, and institutional changes in India-EU renewable energy trade. Even though the results are still exploratory, they give support to the view of India as an emerging player in the EU's decarbonizing market, with the prospect to benefit from global transitions to green energy. The study highlights the fact that it will be policy consistency, not specific economic factors, that will shape the future of export growth. With EU regulations becoming more stringent, India's through sustainable production, certification, and bilateral dialog will be the factor deciding whether this growth or stagnation continues in the next ten years.

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DATA SOURCES

1. **Sector-specific data for EU-India exports with EU27 from 2012-2019 and EU28 from 2019-21.**

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Sector-specific data for EU-India exports with EU27 from 2012-2019 and EU28 from 2019-21.

2. Applied tariffs

https://ttd.wto.org/en/data/idb/applied-duties?member=U918&product=85414090&year=2021

3. **Renewable energy Consumption**

https://data.un.org/Data.aspx?d=EDATA&f=cmID%3aEC%3btrID%3a13361

4. **EU ETS prices**

https://icapcarbonaction.com/en/ets-prices

5. **Currency exchange rates**

https://data360.worldbank.org/en/indicator/IMF_IFS_ENE_XDC_EUR?view=datatable&country=IND&compBreak1=IMF_ER_A&recentYear=false&minYear=2012&maxYear=2021

Due to data limitations, sectoral applied tariffs were averaged across HS codes to obtain a representative yearly rate.

3.Appendix

3.1. Solar sector Regression

3.1.i. Model 1

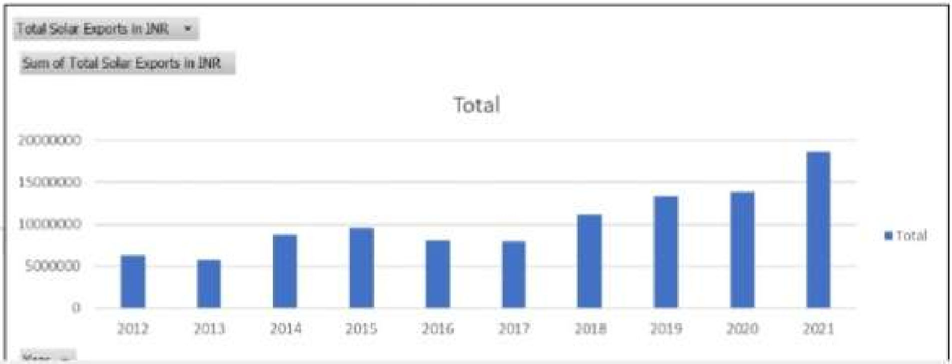
			MODEL 1		
Year	Standardised Solar exports	Total Sol	EU_ETS_Pr	Currency Exchange(R	Global Oil Price shock
2012	-1.031519906	2.1867	497.1433	68.7	0
2013	-1.152983871	-0.64989	340.2263	77.8	0
2014	-0.392713664	-1.06644	479.4894	81.1	1
2015	-0.191332453	-0.75632	542.4711	71.2	1
2016	-0.576404114	-0.59735	390.4169	74.4	0
2017	-0.596269822	-0.59362	423.7383	73.6	0
2018	0.22170389	-0.1962	1250.549	80.8	0
2019	0.751008733	0.18271	1948.182	78.8	0
2020	0.888945927	0.43304	2060.449	84.6	1
2021	2.079565279	1.05737	4715.74	87.4	1

3.1.ii. Model 2 (EU_ETS_Price dropped)

Year	Standardised	Total Solar Consumption	Currency Exchange(Rupee/Euro) (	Global Oil Price shock
2012	-1.03151991	2.186704179	68.7	0
2013	-1.15298387	-0.649894232	77.8	0
2014	-0.39271366	-1.066442077	81.1	1
2015	-0.19133245	-0.756321995	71.2	1
2016	-0.57640411	-0.597348107	74.4	0
2017	-0.59626982	-0.593622879	73.6	0
2018	0.22170389	-0.196197512	80.8	0
2019	0.751008733	0.182713532	78.8	0
2020	0.888945927	0.433042369	84.6	1
2021	2.079565279	1.057366721	87.4	1

Total Solar Consumption and total Solar Sector Exports has been standardised from thousands of rupees

3.1.iii.



3.1.iv

Years	Sum of Total Solar Exports in INR
2012	6222540
2013	5740358.4
2014	8758441.2
2015	9557874.3
2016	8029236
2017	7950374.1
2018	11197525.4
2019	13298733.4
2020	13846309.6
2021	18572771
Grand Total	**103174163.4**

3.1.v. Model 1 coefficients and test statistics

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-1.03574209	2.85738127	-0.36248	0.731811	-8.38087	6.30939	-8.38087	6.30939
Total Solar Consumption standardised	-0.14978214	0.17518907	-0.85497	0.431615	-0.60012	0.300556	-0.60012	0.300556
EU_ETS_Price_Rupee	0.00070415	0.00019291	3.650176	0.014746	0.000208	0.0012	0.000208	0.0012
Currency Exchange(Rupee/Euro) (control variable)	0.00102286	0.03925169	0.026059	0.980218	-0.09988	0.101923	-0.09988	0.101923
Global Oil Price shock	0.16372616	0.28109718	0.582454	0.585537	-0.55886	0.886309	-0.55886	0.886309

3.1.vi. Model 2 coefficients and test statistics

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-9.1263799	3.151295774	-2.89607	0.027475	-16.8373	-1.41544	-16.8373	-1.41544
Total Sola	0.3011567	0.217072961	1.387353	0.214669	-0.23	0.832315	-0.23	0.832315
Currency E	0.115115	0.04149191	2.774396	0.032235	0.013588	0.216642	0.013588	0.216642
Global Oil	0.41457	0.476327967	0.870346	0.417568	-0.75096	1.580102	-0.75096	1.580102

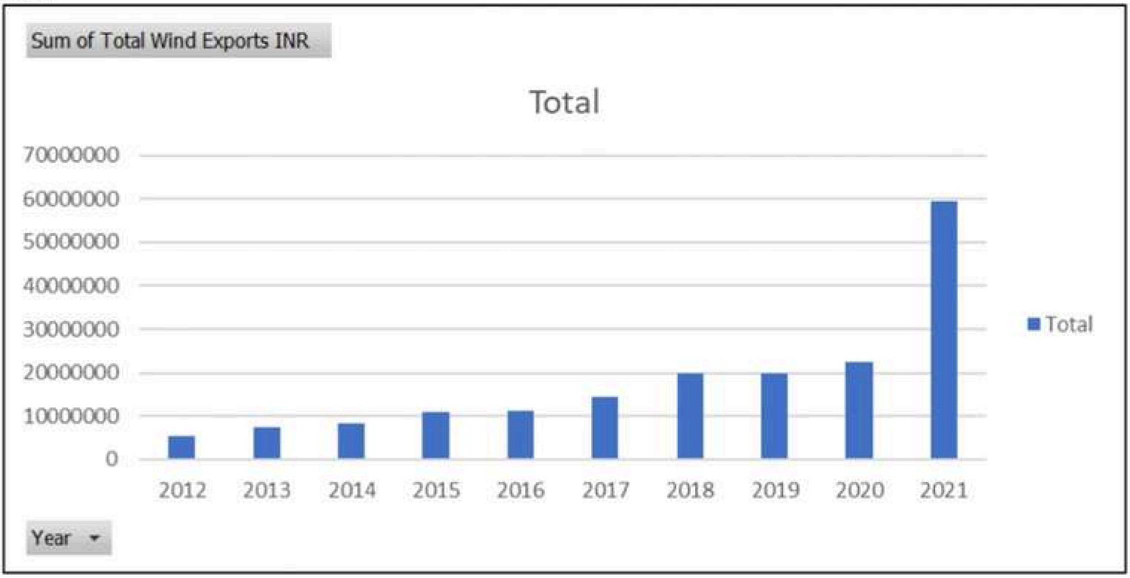
3.2. Wind sector

3.2.i. Model 1

		MODEL 1			
Year	Total Wind Exports	Total Wind Consumpti	ETS_Price	Currency Exchange	Global Oil Price shock
2012	-0.662100607	-1.631852676	497.143	68.7	0
2013	-0.610383648	-1.125252706	340.226	77.8	0
2014	-0.576765038	-0.883476144	479.489	81.1	1
2015	-0.466912675	-0.326718215	542.471	71.2	1
2016	-0.446662447	-0.152092692	390.417	74.4	0
2017	-0.252239663	0.138831149	423.738	73.6	0
2018	0.066130901	0.661712367	1250.55	80.8	0
2019	0.011720988	1.245885454	1948.18	78.8	0
2020	0.232252861	1.001130313	2060.45	84.6	1
2021	2.70495933	1.07183315	4715.74	87.4	1

Total Solar Consumption and total Solar Sector Exports has been standardised from thousands of rupees.

3.2.i.



Row Labels	Sum of Total Wind Exports INR
2012	5435831.2
2013	7551738.1
2014	8273563.2
2015	10790656.5
2016	11342944
2017	14277496.5
2018	19859356.4
2019	19874946.3
2020	22430004
2021	59492084.3
Grand Total	**179328620.5**

3.2.iii.Model 1 coefficients and test statistics

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	-0.756502	2.271551	-0.333033	0.752619957	-6.595710595	5.082707	-6.595711	5.082707
Total winf consumption std	-0.079959	0.162581	-0.491812	0.643681303	-0.497887015	0.337968	-0.497887	0.337968
ETS_Price	0.000756	0.000135	5.598722	0.002510733	0.000408774	0.001103	0.000409	0.001103
Currency Exchange(Euro/Rupee) (control variable)	-0.002399	0.030453	-0.078768	0.940272252	-0.080679402	0.075882	-0.080679	0.075882
Global Oil Price shock	-0.031819	0.250391	-0.127077	0.903831918	-0.675470651	0.611833	-0.675471	0.611833

3.3 EV & Related Components Sector

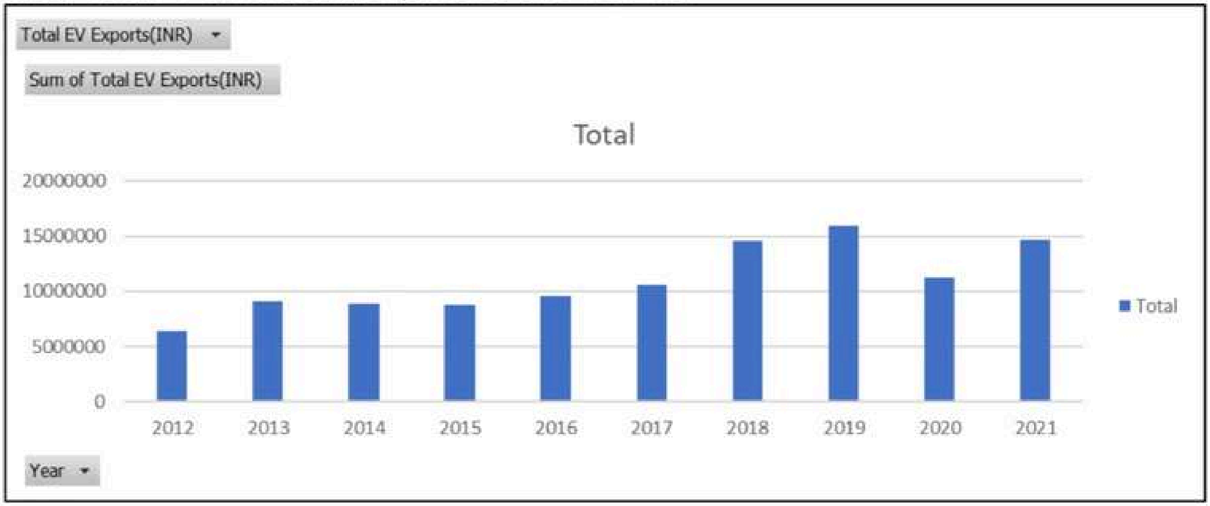
3.3.i.Model 1

			Model 1			
Year	Total EV &	Total EV C	Applied Tariff	Currency E	EU_ETS_PI	Global Oil Price shock
2012	-1.460953	-3.80712	0	68.7	497.1433	0
2013	-0.623352	-3.616005	1.39285714	77.8	340.2263	0
2014	-0.675675	-3.524794	5	81.1	479.4894	1
2015	-0.718594	-3.314757	1.42857143	71.2	542.4711	1
2016	-0.441163	-3.24888	1.42857143	74.4	390.4169	0
2017	-0.116293	-3.139129	2.14285714	73.6	423.7383	0
2018	1.149595	-2.941872	0	80.8	1250.549	0
2019	1.602593	-2.721492	0	78.8	1948.182	0
2020	0.102483	-2.813826	3	84.6	2060.449	1
2021	1.181359	-2.787153	2.5	87.4	4715.74	1

3.3.ii. Model 2

		Model 2			
Year	Total EV &	Total EV C	Applied Tariff	EU_ETS_PI	Global Oil Price shock
2012	-1.460953	-3.80712	0	497.1433	0
2013	-0.623352	-3.616005	1.39285714	340.2263	0
2014	-0.675675	-3.524794	5	479.4894	1
2015	-0.718594	-3.314757	1.42857143	542.4711	1
2016	-0.441163	-3.24888	1.42857143	390.4169	0
2017	-0.116293	-3.139129	2.14285714	423.7383	0
2018	1.149595	-2.941872	0	1250.549	0
2019	1.602593	-2.721492	0	1948.182	0
2020	0.102483	-2.813826	3	2060.449	1
2021	1.181359	-2.787153	2.5	4715.74	1

3.3.iii. Total EV & Related components over 2012-21



3.3.iv.

Row Labels	Sum of Total EV Exports(INR)
2012	6423272.4
2013	9037523.8
2014	8874216.9
2015	8740262.7
2016	9606156
2017	10620116.1
2018	14571099
2019	15984960.9
2020	11302941.3
2021	14670237.8
Grand Total	**109830786.9**

3.3.v. Model 1 coefficients and test statistics

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	0.647047787	5.029542149	0.12865	0.90384	-13.3172	14.6113	-13.3172	14.6113
Total EV Consumption Standardised	1.691054031	0.608502086	2.77904	0.04987	0.00158	3.38053	0.00158	3.38053
Applied Tariffs on EV & related Exports	-0.12862018	0.18181619	-0.70742	0.51834	-0.63342	0.37618	-0.63342	0.37618
Currency Exchange(Rupee/Euro)	0.06516178	0.053093649	1.2273	0.287	-0.08225	0.21257	-0.08225	0.21257
EU_ETS_PRICE_Rupees	4.31131E-05	0.000214589	0.20091	0.85057	-0.00055	0.00064	-0.00055	0.00064
Global Oil Price shock	-0.39873003	0.49682428	-0.80256	0.46721	-1.77814	0.98068	-1.77814	0.98068

3.3.vi. Model 2 coefficients and test statistics

	Coefficients	*andard Err*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*pper 95.0%*
Intercept	6.369232	1.979495	3.217605	0.023528	1.280778	11.45768	1.280778	11.45768
Total EV C	2.011595	0.576755	3.487782	0.017512	0.529	3.494191	0.529	3.494191
Applied Ta	0.01309	0.147384	0.088819	0.932674	-0.36577	0.391953	-0.36577	0.391953
EU_ETS_P	0.000207	0.000176	1.176084	0.292503	-0.00025	0.00066	-0.00025	0.00066
Global Oil	-0.58345	0.496872	-1.17424	0.293177	-1.86069	0.693803	-1.86069	0.693803

The dummy variable for global oil price shocks was assigned the value ‘1’ for the years 2014-2015 and 2020-2021, corresponding to major fluctuations in global energy prices, and ‘0’ otherwise.