CARBON PRICING, THE GREEN TRANSITION, AND INVESTMENT IN INDIA

A Policy and Financial Markets Analysis

RESEARCH PAPER

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Abstract

This paper examines the economic and financial implications of carbon pricing and the green energy transition for India. India's Carbon Credit Trading Scheme is evaluated against the EU ETS, China's national carbon market, and South Korea's K-ETS, with attention to the structural constraints that complicate direct model transfer from developed economies. The paper analyses how carbon risk transmits through commodity futures markets, drawing on evidence of rising carbon pricing risk premia and heterogeneous repricing across energy-intensive industries, and examines the distributional consequences of carbon taxation for Indian households, which remain regressive without revenue recycling. The empirical analysis uses daily log returns for ten NSE-listed stocks from January 2015 to December 2025, comprising 2,725 observations across five green and five non-green stocks. Applying Markowitz mean-variance optimisation and Sharpe-optimal portfolio construction, the study finds that the green portfolio delivered an annualised return of 12.77% against 7.20% for the non-green portfolio, with a Sharpe Ratio of 0.2313 against 0.0138. The Sharpe-optimal portfolio allocates 57% to green stocks, supporting the case for green allocation in the Indian equity context. A geopolitical case study of the 2026 West Asian conflict is used to support the investment case for renewables by illustrating how energy supply disruptions create asymmetric cost pressures. The findings support a proactively designed carbon pricing framework for India that balances climate accountability with developmental equity.

Keywords: Carbon pricing, emissions trading, green transition, commodity risk premium, carbon risk premium, green equity portfolios, portfolio optimisation, distributional effects

JEL Classification: Q54, Q58, G11, H23, G12

1. Introduction

The rapid rise of the energy transition around the world has led to fundamental shifts in climate governance that require both developed and developing nations to adopt economic policies capable of driving deep emissions reductions. Carbon pricing is a central component in modern climate strategy and refers to the mechanism used to address the externalities created by emissions through the use of market forces. Nonetheless, the development and implications of carbon pricing have become a point of contention in academia and policymaking because of the varied costs and benefits of such policies across economies, industries, and commodity markets. This paper seeks to contribute to this discussion through a multi-method examination of carbon pricing and the green transition, spanning comparative policy analysis, commodity risk pricing, and an original empirical study of green and non-green equity portfolios on the NSE from 2015 to 2025.

The paper also examines the distributional consequences of carbon pricing for Indian households, critically evaluates dissenting perspectives on ESG investing and carbon taxation, and considers the implications of geopolitical shocks, specifically the West Asian conflict, for India's energy markets and investment landscape. There are inherent contradictions between the country's aspirations of growth and its obligation to address climate change. With low per capita emissions of just 2.2 tons per year, India's emission profile raises critical concerns about equity and accountability regarding the pricing regime for carbon emissions.

The carbon financialisation process, reflected in the pricing of carbon allowances in energy futures, and the inclusion of transition risks in stock valuation, signals a radical transformation in the market understanding and valuation of environmental externalities. Studies based on the European Union's Emission Trading System (EU ETS) have found that carbon risk pricing is an increasingly significant driver of the pricing of commodities futures (Wang, 2024). Meanwhile, empirical evidence on green vs. brown commodity options highlights that climate policy uncertainty leads to risk premia during asset valuation (Gao et al., 2025).

Carbon pricing policies are currently in force in 53 countries and account for more than 28% of the world's GHG emissions, contributing more than USD 100 billion per year (World Economic Forum, 2025). Despite the increase in scope, there is an inequity in the efficacy of current systems. Fewer than 1% of global emissions are subject to carbon pricing at levels consistent with limiting warming to 2°C. At the same time, energy transition finance is concentrated mainly in developed countries and China. The intersection of climate policy and international trade represents one of the defining geopolitical and economic challenges of the current decade.

This paper discusses such issues by adopting a systematic, multi-faceted approach to the subject. Firstly, the paper explores the carbon pricing system in the context of the country's development goals and greenhouse gas emissions profile. The design aspects of the CCTS, as well as its implications for policymaking, are compared to those of previous mechanisms. Then, the current global carbon pricing trends are analysed, drawing on comparative insights from the carbon pricing systems of the European Union, the UK, China, South Korea, and Japan being discussed in relation to their applicability for the Indian case.

Further, the financial aspect of carbon pricing is investigated by assessing how the cost of carbon affects the commodity risk premium, alters portfolio construction, and impacts the future markets through which transition risks can be managed. An independent part of the study contains an empirical examination of the green and non-green equity portfolios listed on the National Stock Exchange of India between 2015 and 2025, using the Markowitz mean-variance optimisation and maximising the Sharpe Ratio approaches.

The other issue explored by the paper is the spillover impact on other businesses, followed by a discussion on the dissenting viewpoints, which include criticism of carbon taxation for its regressive distributional impacts and ESG investing's political economy.

2. Literature Review

The intersection of carbon pricing, financial markets, and sustainable development has emerged as a key area of economic research, evolving from early theoretical work on Pigouvian taxes to recent empirical studies on policy design and real-world outcomes across regions like the EU, China, and emerging markets. In India, this debate has gained urgency with the introduction of the 2023 Carbon Credit Trading Scheme (CCTS), highlighting the challenge of balancing emissions reduction with growth, equity, and energy security. At the same time, a separate body of literature on ESG investing in Indian equity markets has developed, though it remains largely disconnected from carbon policy despite growing links through transition risk and financial repricing. This review bridges these strands, drawing on recent studies (2019–2025) to position the paper's contribution.

The **World Bank's State and Trends of Carbon Pricing (2024)** documents that carbon pricing revenues globally crossed the USD 100 billion threshold for the first time in 2023, as governments increasingly explored coverage of non-traditional sectors and pursued multiple instruments in parallel. Importantly, the report notes that countries including India, Indonesia, Morocco, and

Turkey have implemented or adjusted carbon pricing policies, in part in response to the EU's Carbon Border Adjustment Mechanism, contextualising India's CCTS as a strategic response to evolving international trade architecture rather than purely a domestic climate decision.

The OECD's Effective Carbon Rates 2025 report documents that at COP29 in Baku in 2024, parties adopted key decisions enabling market-based cooperation under Articles 6.2 and 6.4 of the Paris Agreement, formally operationalising internationally transferred mitigation outcomes, a framework that will shape how India's CCTS credits are recognised in cross-border carbon trade.

Sen and Sahoo, writing in **World Development Perspectives (2024)**, trace the history of India's market-based climate instruments, showing that a clean energy cess on coal introduced in 2010 rose to USD 4 per tonne by 2016 before being subsumed into the GST, demonstrating that the CCTS is an institutional deepening rather than a new departure.

A policy report from the **Columbia Centre on Global Energy Policy (2024)** argues that carbon markets can be a valuable tool for meeting climate goals more cost-effectively in emerging economies such as India, where access to finance for the energy transition is a challenge. The report traces the lineage from the PAT scheme through to the CCTS, noting that the PAT scheme set energy efficiency targets for industrial units across 13 energy-intensive sectors, leaving the CCTS to inherit both the lessons and credibility deficits of its predecessors.

Bua et al., published in the E**uropean Journal of Finance (2024)**, developed text-based daily climate risk indices using news analytics to analyse European asset prices. Their research shows that economically significant transition and physical risk premia emerged in European asset prices post-2015, with investors increasingly relying on firm-level ESG ratings rather than broad sectoral classifications to proxy transition risk exposure. As India’s CCTS matures, this dynamic could signal the fact that equity markets may reprice carbon exposure.

A study published in the **Journal of Chinese Governance (2023)** finds that China's national carbon market, despite being the world's largest by volume, underperforms because policy design conflicts, policy uncertainty, inexperienced market regulation, and excessive government intervention are its primary constraints. As separately reported, China's average carbon price in 2023 was approximately USD 8 per tonne, far below the EU ETS price near USD 85 per tonne, illustrating that market scale does not substitute for institutional depth. The **IEEFA's 2025 Asian ETS comparative analysis** notes that South Korea's ETS has the broadest coverage among Asian systems, regulating 79% of national emissions, while the OECD documents that South Korea's updated Basic Plan for the period 2026-2035 includes significant increases in auctioning in the electricity and other high-emitting sectors, offering India a medium-term design benchmark.

In a seminal contribution to climate finance, Bolton and Kacperczyk, writing in the **Journal of Financial Economics (2021)**, find that stocks of firms with higher total carbon dioxide emissions earn higher returns, with a one-standard-deviation increase in scope 1 emissions associated with a 1.8% annualised return premium. They further show that institutional investors systematically underweight high-emission-intensity firms, providing foundational evidence that markets price transition risk through ownership behaviour even absent a formal carbon price, directly motivating this paper's investigation of whether a comparable dynamic is observable on the NSE.

Hambel and van der Ploeg, publishing in the **Journal of Monetary Economics (2025)**, demonstrate theoretically that policy transition risk generates carbon premiums, higher expected returns on brown than on green assets, especially when the economy is carbon-intensive and close to a temperature cap. Their model shows that this premium is purely risk-driven and reflects the asymmetric impact of policy shocks, making it applicable to the Indian case, where carbon pricing remains nascent.

A 2024 working paper by **Bhaduri** from the **Madras School of Economics** examines the Nifty ESG100 and Nifty100 Enhanced indices from 2018 to 2022, finding that ESG characteristics emerged as essential factors for assessing sustainability and social impact of investment following COVID-19, and testing whether ESG strategies reduce downside risk sensitivity during crises, making it a direct methodological precursor to this paper's analysis of green portfolio resilience from 2015 to 2025.

A separate study in the **China Accounting and Finance Review (2025)** applies multi-factor models to Indian ESG indices from 2011 to 2023, concluding that green indices such as BSE Carbonex outperform traditional indices, while ESG investments exhibit higher systematic risk in emerging markets during both crises and calm periods, a structural difference that bears directly on how this paper's findings should be interpreted relative to Bolton and Kacperczyk's developed-market results. Reporting by the **International Financing Review on NSE's proposed**

Green Equity Pathway (2025) underlines the capital mobilisation context, noting that India needs approximately USD 167 billion per year from 2015 to 2030, with NSE's three-tier green equity classification designed to create visibility, trust, and comparability, directly expanding the green-versus-brown investment universe this paper draws from.

Dorband et al., published in **World Development (2019)**, establish a foundational regularity, finding that an inverse U-shaped relationship between energy expenditure shares and income explains why carbon pricing tends to be regressive in higher-income countries, while distributional effects tend to be progressive on average in lower-income countries. The authors argue that mitigating climate change, raising domestic revenue, and reducing inequality are not mutually exclusive even in low- and middle-income countries, though they signal that progressive outcomes must be actively designed rather than assumed. Steckel et al., writing in **Nature Sustainability (2021)**, deepen this analysis for developing Asia, finding that differences in distributional outcomes are generally more pronounced within income groups than across them, and that within-group heterogeneity is particularly important for India, where inequality intersects with geography, caste, and uneven access to clean energy.

A complex systems study in **Nature Communications (2025)** adds a dynamic dimension, finding that carbon pricing can induce critical tipping points, incentivising technological adoption, but at elevated price levels, a surge in corporate distress can undermine its redistributive advantages, making the sequencing of India's carbon price escalation a critical design question. On the political economy of sustainable finance, a study in **Frontiers in Political Science (2024)** traces how ESG has been framed by political critics as an illegitimate tool for imposing a decarbonising agenda through financial markets, while **Fortune (2024)** reports that a wave of discontent is sweeping Europe, with accusations of greenwashing making the ESG label itself a liability. Analysis from the **Harvard Law School Forum on Corporate Governance (2024)** documents that for the first time in Q1 2024, ESG fund closures outnumbered launches globally, while separately, investors withdrew significant capital from US ESG funds in 2024 yet poured USD 740 billion into the broader mutual fund universe suggesting the ESG retreat is largely a retail and political phenomenon while institutional capital continues integrating climate risks under alternative framings.

3. Methodology

The paper adopts a multi-method approach to examining the implications of carbon pricing and the green transition on India's economy, markets, and investment landscape. The paper combines qualitative analysis of policy frameworks and academic literature in both the Indian and the global context, by drawing on secondary sources, and also includes a quantitative examination of portfolio performances, spanning 2,725 data points per stock for 10 stocks from **January 2015 to December 2025.**

The first and second parts of the study are qualitative in nature and look at a contextual examination and policy analysis of carbon pricing mechanisms in India and around the world. The analysis of India uses emissions data and trajectory analysis from the Climate Scorecard mid-year report, the Niti Aayog's economy-wide GHG emissions dashboard, ICAP's notification on sectoral emission intensity targets, and academic sources, among others. The global contextual analysis covers the carbon pricing systems of the European Union (EU), the United Kingdom (UK), China, South Korea, Japan, and other emerging economies, and looks at assessing and comparing their designs, coverage, and effectiveness. This is done by drawing on published government sources, regulatory frameworks, academic sources, and reports by international organisations, including those of the World Economic Forum (WEF), the European Commission, the World Bank, the European Central Bank, etc.

The third component looks at examining the relationship between carbon pricing and commodity market risk premiums. This section uses empirical studies from peer-reviewed academic literature, including panel regression models on the effects of the EU ETS on the underlying risk premiums of the commodity market, event studies of key policy announcements, and factor model analyses of carbon risk as a systematic risk factor in equity and futures markets.

The fourth section analyses the spillover effects of commodity risk pricing on related industries by drawing on recent empirical literature that examines the interconnectedness across energy and non-commodity markets, including those such as agriculture, chemicals, and metals. Four spillover routes are briefly discussed in this section as well, namely, changes in information, changes in policy expectations, reallocation of funds based on climate news, and the combined effect of the aforementioned sources as a macro-behavioural factor.

The next part of the study is quantitative in nature and aims to examine and compare the risk-adjusted performance of green and non-green NSE-listed stocks in the Indian market over a ten-year period spanning 2015-2025. The analysis uses secondary data from *investing.com* in the form of closing prices sourced for five green (renewable and clean energy) stocks and five non-green (fossil fuel and carbon-intensive industries) stocks. The green stocks comprise **TATAPOWER, SUZLON, JSWENERGY, NHPC, and SJVN,** while the non-green stocks comprise **COALINDIA, ONGC, IOC, TATASTEEL,** and **NTPC.**

We compute daily log returns for each stock using the following formula:

$$Daily\ log\ returns\ =\ ln\,(\frac{P_t}{P_{t-1}})$$

where P_t represents the closing price on the current trading day and P_{t-1} represents the closing price on the preceding trading day. We use log returns instead of simple returns as they are time-additive and approximately normally distributed. As mentioned before, 2,725 observations per stock are used, totalling 27,250 observations.

Following this, four naive portfolios are constructed that use fixed and predetermined weights without employing any optimisation techniques. These are a pure green portfolio, a pure non-green portfolio, a 75-25 portfolio, aggressively leaning towards green stocks with a 75% allocation to them and 25% to the non-green stocks, and another less aggressive 50-50 portfolio with equal allocations to each category and to each stock. Descriptive statistics are calculated for each of the given categories. Measures included are mean return, standard deviation, skewness, kurtosis, and Sharpe Ratio, on a daily and on an annualised basis.

Subsequently, individual stock statistics and a 10x10 covariance matrix are constructed, and these serve as inputs into the portfolio optimisation model setup. Two optimised portfolios are then derived using Excel Solver under the GRG Nonlinear method. The first optimised portfolio applies the Markowitz mean-variance method of optimisation in order to identify the portfolio with minimum variance, subject to the constraints that weights sum to one and no short selling is permitted. An efficient frontier is also constructed by running ten sequential optimisations across a range of target returns, to map the minimum achievable risk at each point and trace the risk-return opportunity set that is available to an investor for the given stocks. The second method of optimisation maximises the Sharpe Ratio to identify the allocation which yields the highest return per unit of risk.

The risk-free rate used is **6.91%** per annum, which is the midpoint of the risk-free range 6.87% to 6.95% prevailing in March 2026, when the study is being carried out, based on RBI data. This is converted to a daily equivalent using the compound formula as follows:

$$Daily\ Risk\ Free\ Rate\ =\ (1\ +\ 0.0691)^{(\frac{1}{365})}$$

The annualised Sharpe Ratio is calculated by multiplying the daily Sharpe Ratio by the square root of 252.

The sixth component of this study covers dissenting views and grey areas when it comes to carbon pricing and the shift towards green, and uses technical papers and commentaries as sources, and documented cases of pushbacks on institutional scales against ESG mandates, such as the 2024 case involving the Texas State Board of Education and BlackRock.

Through our appendix, we also seek to study the case study of the ongoing West Asian conflict as a geopolitical case study, in order to examine the implications of crises on the Indian market by drawing on various academic and published sources.

4. Carbon Pricing in the Indian Context

Climate justice, energy transformation, and sustainable development will define the development path of India in 2026. Being the most populated nation in the world and the third-largest fossil CO_2 emitter, India can make a significant difference in the condition of the global climate. In 2025, India was the third-largest emitter of greenhouse gases in the world, with estimated emissions of 3.22 billion tonnes of CO_2 equivalent. However, of the 20 largest economies, India has the second-lowest per capita emissions, at 2.2 tonnes per year. As expected, coal remains the dominant fuel in India's power sector, accounting for approximately 70% of electricity generation, while the power sector itself constitutes the largest single source of national CO_2 emissions. However, there is a considerable deceleration in the pace of emissions, especially in the past two years, which could be attributed to growth in renewable energy capacity and improvements in industrial energy efficiency under the PAT Scheme (Padelkar, 2025).

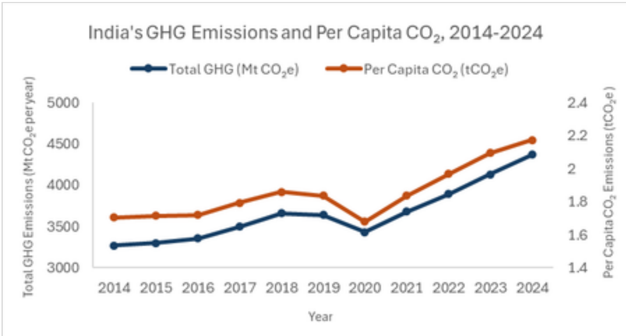

Figure 1: India's GHG Emissions and Per Capita CO_2, 2014-2024

Note: Total GHG emissions data are from the European Commission Joint Research Centre (JRC) and International Energy Agency (IEA) EDGAR database (2024). Per capita CO_2 emissions data are from YCharts (2026). The 2020 dip in both series reflects the temporary contraction in economic activity associated with the COVID-19 pandemic.

Current Landscape:

In 2026, India's carbon markets entered a phase of operationalisation as they transitioned from the efficiency-based PAT programme to the comprehensive Indian Carbon Market. The development of two key streams within the carbon marketplace ecosystem, the Voluntary Offset Mechanism and Compliance

Mechanism, continues in India throughout 2026, with the full-fledged Carbon Market Ecosystem to be operational in late 2026. Legally binding greenhouse gas emission intensity targets in the form of the Carbon Credit Trading Scheme were announced by the government for nine energy-intensive sectors, namely, aluminium, cement, steel, paper, chlor-alkali, fertiliser, refinery, petrochemical, and textile, which represent over 700 companies in all. Carbon Credit Certificates can be issued to companies for surpassing the target GEI fixed by the government from the middle of 2026, extending into late 2026, when the CCCs can start actual trading on power exchanges. Later, a Rs 20,000 crore CCUS incentive scheme was announced in the Union Budget for 2026-2027 as a step towards meeting the 2030 target of reducing the emissions intensity by 45% in India.

Table 1: Major Carbon Pricing Instruments in India

Instrument	Year	How It Prices Carbon	Outcome
Clean Energy Cess (Coal Cess)	2010 → Rs 50/t; hiked to Rs 400/t by 2016	Implicit carbon tax on coal	Generates > Rs 50,000 cr annually for clean-energy fund, but industry calls it distortionary.
Perform, Achieve & Trade (PAT)	2012	Tradable energy-saving certificates vs sectoral baselines	Reduced energy intensity by 15-25% in covered sectors
Renewable Energy Certificates (REC)	2011	Certificate market for clean kWh	Helped build 100 GW+ RE but faced price volatility.
CCTS (Rate-based ETS)	2023	Tradable carbon-credit certificates (CCCs) vs intensity benchmarks	Regulatory framework in force; notified in 2023 and entered its operational phase from 2025.

Carbon Tax: A carbon tax would impose a flat charge on every tonne of CO_2 emitted, offering a straightforward pricing mechanism distinct from intensity-based trading systems. Policy simulations by CSEP (2024) have modelled rates in the range of Rs 1,700-2,600/tCO_2, projecting meaningful emissions reductions when combined with revenue recycling measures. Such a tax could be implemented incrementally through existing fiscal structures, including expansions to the coal cess, currently levied at Rs 400 per tonne of coal. Its primary advantages are price certainty for firms and administrative simplicity, as it does not require the complex cap-setting procedures associated with emissions trading schemes.

Nonetheless, there exist hindrances. Political feasibility remains a constraint, as low-income households, who spend a considerable portion of their income on fuel, bear a disproportionate burden from energy price increases. Additionally, unlike a cap-based system, a carbon tax does not guarantee a ceiling on absolute emissions, meaning environmental outcomes depend significantly on price elasticity and complementary regulatory measures.

ETS/CCTS: The Carbon Credit Trading Scheme (CCTS), India's ETS variant, was notified in June 2023 and became operationally active from 2025. It operates as a baseline and credit-style ETS type. Nine sectors are covered with intensity targets, such as a reduction target of 1-3% for FY26. The scheme is managed by BEE and overseen by CERC.

Disadvantages include the cost of tracking, wherein the initial high costs are not accounted for by MSMEs, the risk of lower prices because of offsets or banking dilution, and the risk of compatibility with CBAM in the absence of absolute caps.

India's strategy for carbon pricing is characterised by a practical and incremental evolution. Although a straightforward carbon tax would be easier to implement, the CCTS better aligns with India's development priorities. Ultimately, the impact of this system hinges on establishing credible pricing and stronger targets over time.

5. Carbon Pricing in the Global Context

Carbon pricing has emerged as one of the key tools in the world's efforts to move towards clean energy. There are 80 carbon pricing mechanisms currently in operation across the globe, and they account for approximately 28% of global greenhouse gas emissions and generate more than USD 100 billion annually (World Economic Forum, 2025). The primary instruments through which this is done include carbon taxes and the Emissions Trading System (ETS), and they represent a shift from purely voluntary climate commitments to frameworks that are regulated and enforceable.

Bodies like the European Union have long seen the need for an urgent response to the imperatives of containing climate change and the need for conformance to the Paris Climate Accords. In 2005, when the EU launched its ETS, it became the first carbon market in the world and one of the largest today. Under the cap-and-trade principle, the EU ETS has the following underlying mechanisms: The "cap" refers to the setting of limits for the volume of GHGs which installations and operators in the scope of the system will be entitled to emit. This is progressively reduced annually in accordance with the EU's climate target, which means that the emissions from covered installations will fall over time. Since its start 20 years ago, the EU ETS has reduced emissions from electricity, heat, and industry by 50 per cent. ETS emissions fell by 5 per cent in 2024 compared to 2023 (European Commission, 2025).

In 2023, the EU brought out a Carbon Border Adjustment Mechanism (CBAM). It is a measure that ensures that the price has been paid for the carbon emissions included in the production of certain goods imported into the European Union. By introducing the CBAM, the member countries within the European

Union are able to prevent 'carbon leakage'. It is a situation where companies within the European Union shift production to other countries where climate policies are less stringent than those within the European Union, or where products produced within the European Union are being replaced by products from other countries that are more 'carbon-intensive'. The impact of CBAM reduces Carbon leakage; however, it does so at a greater economic cost. This mechanism makes energy-intensive industries such as chemicals and metallurgy more expensive, which function as key input suppliers for several other industries. Thus, if not implemented properly, this system could result in economy-wide losses. (European Central Bank, 2025). Carbon pricing schemes are now in place across 53 countries, but the EU ETS is the only system which imposes carbon prices sufficiently high to have a material impact on the economics of decarbonisation in the hard-to-abate sectors (Global trade in the energy transition: Principles for clean energy supply chains & carbon pricing, 2025).

Building on the structure it followed as a member of the European Union, the United Kingdom replaced the EU ETS with the UK Emissions Trading System (UK ETS). Unlike the EU ETS, the UK ETS applies only to energy-intensive industries, power-generating companies, and aviation companies. It also levies an additional tax on fossil fuels called Carbon Price Support (CPS). This tax is paid by electricity-generating companies that use natural gas or coal. The UK also levies a tax called the Climate Change Levy (CCL), which targets non-domestic energy use by businesses and public sector organisations. The UK ETS is designed to mitigate carbon leakage risks through increased free allocations to operators in sectors identified as being at risk.

Examining the decarbonisation strategy of China, a stark difference is seen between the two powers in the initial stages. While the EU plans to move forward with a high carbon price and additional tariffs on carbon-intensive imports, China approached the problem with a different perspective. It has emphasised the stress on the production of green technology rather than emission reduction. The underlying rationale was that advancement in technology would help them reduce the cost of renewable energy and electric vehicles, and ultimately make the energy transition journey smoother with minimal harm to the developing country's GDP. Currently, China is responsible for about one-third of the total global CO2 emissions. China plans to achieve carbon emissions peaking by 2030 and carbon neutrality by 2060 (dual carbon targets). To achieve this, China introduced the '1+N' policy system in 2021, detailing objectives across the economy-wide, sector, and subsector (China's 1+N policy system supports an earlier peak in carbon emissions, 2025).

The introduction of ETS came in China in 2021, which covers around 4000 million tons (Mt) or 40% of its national greenhouse gas emissions (The role of carbon pricing in achieving energy transition in the Post-COP26 era: Evidence from China's industrial energy conservation, 2023). Initially, the ETS only covered the power sector, but in 2025, the government expanded its sectoral coverage to include steel, cement and aluminium industries and announced plans to change its approach from intensity-based to an absolute cap. This raises the country's total carbon emissions from 40% to 60% (China's emissions trading system reforms, 2025). It now addresses some of their most emissions-intensive industrial processes where abatement costs are substantial but technological pathways exist. China's carbon market is still in the stage of early development, and therefore, it is difficult to predict its future.

The Republic of Korea, abbreviated to South Korea, has a national carbon trading system, the Korean Emissions Trading System (K-ETS), which spans most of its carbon emissions from energy consumption. In contrast to other countries, South Korea has a government-run electric power tariff, which means power companies cannot increase the cost of their energy due to carbon taxes. Because power companies cannot pass carbon costs through to consumers via regulated tariffs, both power producers and power consumers effectively bear carbon costs, creating an implicit double-pricing effect. Power plants receive additional free allowances to shield them from the effects of high-priced allowances, making them key buyers and owners of carbon allowances, though they contribute fewer emissions. This also resulted in high prices for other sectors. To ensure the prices do not become too high or unreliable, the government has introduced various mechanisms, which include the issuing of additional allowances, capping allowances saved or borrowed, and ensuring stability in the carbon prices. Overall, the Korean ETS shows that carbon market performance depends not only on how many allowances exist, but also on rules that encourage companies to trade allowances rather than hold on to them for future price increases.

A comparison of the EU, China, and South Korea reveals that the EU ETS remains the most institutionally developed system out of all three. It operates under a legally binding absolute emissions cap that declines annually, ensuring that total emissions decline over time. Carbon prices averaging EUR 60-80/tCO_2e also provide a strong investment signal. The EU also employs the Market Stability Reserve (MSR), which is an automatic mechanism that adjusts the supply of permits in order to prevent price collapses and reduce volatility (Tan & Iyer, 2025). In contrast, China's national ETS initially worked on an intensity-based or rate-based system, and this allowed emissions to grow with economic output, provided carbon intensity improved. Now, China plans to shift toward absolute caps between 2027 and 2030.

South Korea's K-ETS represents a middle ground between the two and works under an absolute cap and covers over 70% of national emissions, making it comprehensive in scope. However, its price levels have been modest, averaging around USD 6-8/tCO_2e in recent reporting, and while most allowances continue to be freely allocated, auctioning is gradually increasing. Market stability relies on a price floor and discretionary government intervention rather than an automatic adjustment mechanism like the EU's MSR. China's regional ETSs also employ discretionary interventions that lack transparency (Tan & Iyer, 2025).

Fundamentally, the EU is seen to rely more on market-based price signals, whereas China and South Korea have adopted a state-coordinated, phased transition model where carbon pricing complements broader industrial and energy policies.

	China ETS	South Korea ETS	EU ETS
Sectors Covered	Power, steel, cement, aluminum	Heat and power, industry, buildings, waste, transportation, public sector	Electricity and heat generation, energy-intensive industries, aviation, maritime transport
GHG Coverage	Current: 60% of national CO_2 emissions 2027: 75% of national CO_2 emissions (estimate)	79% of national GHG emissions	40% of EU's GHG emissions
Regulated Gases	CO_2 (power, steel, cement, aluminum), CF_4 & C_2F_6 (aluminum)	CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6	CO_2, N_2O (nitric, adipic, and glyoxylic acids, glyoxal), PFCs (aluminum)
Cap Setting	Current: Intensity-based cap 2027: Absolute cap	Absolute cap	Absolute cap
Cap Reduction Measure	Pending	Adjusted administratively	Fixed, progressive annual percentage reduction
Allowance Allocation	100% free distribution	90% free distribution, 10% auctions	43% free distribution, 57% auctions

Figure 2: Emissions Trading System (ETS) Comparison for China, South Korea, and the EU

Source: IEEFA

Note: CO_2 = carbon dioxide; CH_4 = methane; N_2O = nitrous oxide; HFCs = hydrofluorocarbons; PFCs = perfluorocarbons; SF_6 = sulfur hexafluoride; C_2F_6 = hexafluoroethane.

Japan wants to achieve net-zero emissions by 2050, and has anchored its pathway in the Green Transformation (GX) initiative, which is its ten-year decarbonisation strategy. The core of this framework is the GX Emissions Trading Scheme (GX-ETS), which is set to transition from a voluntary phase to a mandatory mechanism in FY2026 for large emitters of GHGs. The government also aims at mobilising ¥150 trillion in public and private investment over a decade, supported by ¥20 trillion in GX Economic Transition Bonds. Several carbon pricing instruments have been combined to help meet the target, including an existing carbon tax, GX-ETS, and a carbon levy (GX-Surcharge) to be introduced from 2028 (International Carbon Action Partnership, n.d.). Unlike the more aggressive approaches seen in places such as parts of Europe, Japan has adopted a phased, growth-oriented carbon pricing framework designed to minimise the disruption caused while gradually strengthening the market signals.

It introduced the "Growth-oriented Carbon Pricing" concept, an industry-friendly approach that seeks to link its carbon pricing revenues to climate transition bonds (Liu & Jin, 2025). Another key role in its strategy is played by the bilateral Joint Crediting Mechanism (JCM), which now includes 31 partner countries. This is intended to co-finance emission reductions abroad that Japan can claim toward its own targets, though its success depends on a strong domestic price signal. A key point of current friction is the proposed price corridor for FY2026. The Ministry of Economy, Trade and Industry, Japan, has proposed a range of ¥1,700-¥4,300 per metric ton of CO2 equivalent. This has been criticised by project developers and stakeholders in the JCM who argue that a higher band of ¥4,000-¥6,000 is necessary to provide the confidence needed to unlock private capital (S&P Global, 2026).

Other countries are making progress in similar directions as well. Brazil established a national emissions trading system in December 2024, around the time of finalisation of Article 6 market mechanisms at COP29. Turkey, too, approved an emissions trading framework in July 2025.

However, this expansion brings forth a significant contradiction. Despite the fact that coverage continues to broaden, effectiveness remains largely unclear. Less than 1% of global emissions face direct carbon prices at or above the levels recommended by the High-Level Commission on Carbon Prices to keep global warming below 2°C (World Economic Forum, 2025). Further, there is a fundamental capital allocation failure at play. Emerging economies account for over 80% of global energy demand growth, but more than 90% of the increase in clean energy investment since 2021 has been concentrated in advanced economies and China (World Economic Forum, 2025).

The current structural misalignments seen represent deep systemic issues, which are particularly acute in smaller developing economies. Emerging economies face substantially higher costs of capital for renewable energy projects than developed markets do. This creates a cycle where limited investment goes on to perpetuate fossil fuel dependence, which in turn increases climate vulnerability and financial risk. Typically, climate finance flows through project-based mechanisms for which extensive upfront capacities are needed before project implementation, for the purposes of feasibility studies, Environmental Impact Assessment (EIA), and stakeholder engagement, among others. The transition requires not only renewable capacity deployment but substantial investments in grid infrastructure, energy storage, and integration capabilities. These requirements represent additional capital burdens that are even more challenging for emerging economies already struggling to finance basic renewable infrastructure. Thus, some countries are not able to access the required finance to establish the needed RE systems because of a lack of institutional capacity. The Dominican Republic's seven-year process from initial ETS consultations in 2017 to pilot design illustrates this mismatch (UNFCCC, 2025).

Studies on the Nordic countries have shown that high carbon prices and energy transition can be made politically sustainable when they are accompanied by the adoption of progressive revenue recycling, stakeholder engagement, and comprehensive support. However, it must be emphasised that carbon pricing is a policy that is inherently regressive by nature, and that the Nordic approach of redistributing revenue through the progressive tax system necessitates state capacity for effective redistribution and political agreement around welfare mechanisms (Nordic Council of Ministers, 2024). The successful implementation of Sweden's policy of offsetting increases in carbon taxes through reductions in income taxes, which effectively neutralised the burden on low-income and middle-income families as emissions from the sector of residential heating dropped by 80-87%, was made possible by high tax-to-GDP ratios, an effective collection mechanism, and consensus on welfare systems (Nordic Council of Ministers, 2024). This model would face difficulties in being replicated in developing countries, whose tax/GDP ratios are half those of the Nordic countries, and who possess limited administrative capacity for targeted transfers.

6. Commodity Market Risk Pricing

The area of climate finance has witnessed tremendous growth in recent times, with considerable attention being devoted to carbon risk in view of the primary role of human carbon emissions in global warming. The study of investors' perception of carbon pricing risk is vital in taking forward the area of climate finance. Carbon pricing can have a considerable impact on the costs of producing commodities, which in turn can impact the market of commodities in an indirect manner through covariance with climate change risk.

An investment shock refers to the uncertainty faced in the real investment of all commodity producers (Wang, 2024). If the investment shock is positive, it implies that there have been technological developments in capital production, resulting in more capital being produced in the future for the same amount of investment. If the investment shock is negative, it implies that less capital is being produced in the future for the same amount of investment, resulting in less supply of commodities. In the context of carbon pricing, an unexpected increase in the price of carbon acts as a negative investment shock in the production of commodities due to its negative impact on the efficiency of investment in commodities.

An increase in carbon pricing will lead to a rise in the cost of investments, not just for high-carbon-emitting commodities like oil and gas but also for other low-carbon-emitting commodities due to a rise in the prices of electricity and transportation. Hence, the unexpected rise in the price of carbon (carbon pricing shock) acts as a negative investment shock for all the producers of the commodities. Commodities that face high levels of investment will be more affected by the carbon pricing shocks due to the large volumes of new capital required.

The carbon pricing mechanisms have a significant effect on the risk premiums in the commodity market through several transmission channels. The effect of the carbon pricing mechanisms occurs when the production processes of the commodities result in the emission of greenhouse gases. The emission of greenhouse gases results in the purchase of emission permits or the payment of the carbon tax, which is then incorporated into the pricing of the commodities. The commodities that are most affected by the carbon pricing mechanisms include carbon-intensive commodities such as coal, conventional steel, and aluminium. The indirect pass-through effect of the carbon pricing mechanisms occurs when the commodities have high energy consumption, even when the production processes of the commodities are environmentally friendly.

Empirical evidence from commodity markets indicates that climate policy commitments have materially differentiated price dynamics across metal categories. Using a difference-in-differences design across eight industrial metals, a working paper by Patnaik (2026) finds that following the Paris Agreement, metals associated with clean energy demand like copper, aluminium, and nickel declined by approximately 31.7% relative to non-green control metals, consistent with markets anticipating supply expansion to meet projected renewable energy demand. Lithium, by contrast, exhibited a 121% price premium, reflecting market expectations of persistent supply constraints given nascent production capacity relative to accelerating electric vehicle demand. These findings demonstrate that international climate policy commitments can induce rapid and heterogeneous repricing across commodity markets even in the absence of binding emissions constraints.

A study by Wang (2024) uses the EU ETS emission allowance prices as a proxy for carbon pricing to analyse that carbon pricing risk is a significant factor in commodity future markets. It shows that the risk premium for carbon pricing is consistently positive across various commodity futures factor models, ranging from 0.065 per cent to 0.085 per cent daily. It also shows that the moving average of the 5-year carbon pricing risk premium estimated shows an upward trend, supporting the argument that the risk premium is increasing over time.

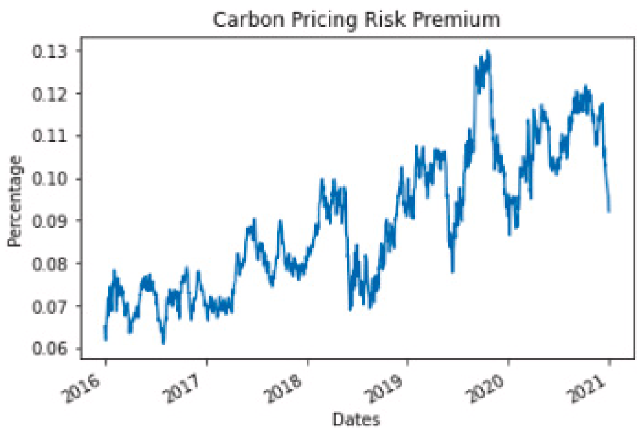

Figure 3: The 5-year Moving Average for the Carbon Pricing Risk Premium

Note: Reprinted from "Carbon Pricing and the Commodity Risk Premium," by Q. Wang, 2024, Journal of Commodity Markets, 36, Article 100447 *https://doi.org/10.1016/j.jcomm.2024.100447*

Kurz and Rubínová (2024), in a WTO Staff Working Paper, find that a 10% increase in a country's carbon tax (10% decrease of fossil fuel subsidies) leads to a 0.3% (0.6%) decline in export capability in the most carbon-intensive industry. On the other hand, industries with low carbon intensity are barely affected: a 10% higher carbon tax reduces export capability by 0.008% (0.06%) in the least carbon-intensive industry.

Financial markets are increasingly pricing transition risk into commodity markets. The growing financialisation of carbon, reflected in the expansion of carbon allowance derivatives and increased institutional participation in emissions trading systems, suggests that carbon exposure is becoming a material consideration in investment and trading strategies (Yang, 2025). Evidence from the EU Emissions Trading System indicates that higher carbon prices are beginning to reshape cost structures across energy-intensive sectors such as steel, aluminium, and fertilisers, although the extent of these effects varies across markets.

In the context of India, the reflection of transition risks can be observed through several markets (Sarkar and Das, 2021). For instance, the trading of Renewable Energy Certificates (RECs) on Indian power exchanges can be considered an important mechanism for ensuring the fulfilment of renewable energy-related regulations. Moreover, the price trends of RECs related to conventional power purchase agreements can also be used to understand the market's view on the deployment of renewable energy.

Narrative economics, which was introduced by Robert Shiller, is a concept that describes the phenomenon of narratives spreading through society in the same way that a virus does. In the context of carbon pricing, narratives can have a very large impact on public acceptance. If carbon taxes are seen as threatening, then public acceptance is lower than it would otherwise be. However, narratives around fairness, national competitiveness, innovation, and cleaner air can increase public acceptance.

Narratives can also impact the rate of the transition (World Economic Forum, 2025). If narratives around renewable energy are negative, then the transition can happen more slowly. However, if narratives around renewable energy are positive, then the transition can happen more quickly. Ultimately, the energy transition is not just about prices and technology. Narratives, or winning narratives, can speed up the deployment of carbon pricing, minimise the backlash, and ensure that people's expectations are more closely aligned with long-run climate objectives. Thus, narrative economics plays a role behind the scenes but is critical in determining the success of climate change policies.

As the price of carbon moves from being an externality to becoming an integral part of the balance sheet, the commodity price structure is changing fundamentally through the following three dimensions:

1. Producers' Response to Market Signals (Cost, Capacity, Capital)

Producers in energy-intensive, trade-exposed industries are increasingly treating carbon not as an externality but as a material driver of investment decisions and marginal abatement costs. The macroeconomic evidence from Europe's carbon pricing experience is instructive here. Känzig and Konradt (2023) find that EU ETS carbon price shocks raise energy prices and headline inflation while reducing GDP, industrial production, and employment, with the economic costs of the carbon market exceeding those of national carbon taxes. This divergence is partly explained by differences in revenue recycling, sectoral coverage, pass-through rates, and monetary policy responses, which are factors that vary considerably across jurisdictions and commodity types.

At the firm level, the evidence on investment responses is more nuanced than a simple cost-push story. Matzner and Steininger (2024) study over 1.2 million European firms and find that higher carbon prices reduce investment on average, but the effect operates primarily through demand-side channels rather than directly penalising carbon-intensive producers. Firms in demand-sensitive sectors, such as construction, see the sharpest declines in investment, sales, employment, and cash flow following carbon price tightening. The policy's transmission is thus broader than its stated targets, affecting the wider productive economy rather than concentrating costs on the highest emitters.

On operational pass-through, the ability of firms to transfer carbon costs to consumers depends heavily on market structure and institutional context. Pass-through in the power sector has been shown to be near-complete in auction-based electricity markets, as documented by Fabra and Reguant (2013) in the context of the EU ETS, primarily because electricity demand is highly inelastic and cost shocks are correlated across generators, leaving firms with weak incentives to absorb rather than pass on carbon costs. For globally traded commodities such as aluminium, however, producers tend to be price takers and face greater margin pressure under national carbon regimes, since they cannot unilaterally raise prices without losing market share to competitors in jurisdictions with lower or no carbon costs.

2. Financial Flows, Portfolio Rebalancing, and Futures

Dong et al. (2025), in an IMF Working Paper, find that firms with higher carbon intensity face a carbon risk premium in the US syndicated loan market, with lenders charging 1-5 basis points higher spreads to borrowers at the 90th percentile of carbon intensity, a premium comparable in magnitude to the credit risk premium for high-default-probability borrowers.

Portfolio rebalancing is the strategic process by which financial actors adjust the composition of their investment holdings to manage climate-related financial risks and capture the benefits of the global green transition. In line with regulations like the Sustainable Finance Disclosure Regulation (SFDR) and standards from the International Sustainability Standards Board (ISSB), this process increasingly focuses on divesting from "brown" (carbon-intensive) assets and scaling up exposure to "green" (low-carbon) alternatives.

The Mechanics of Rebalancing: From "Brown" to "Green"

To decide when and how to rebalance, sophisticated investors use a Shadow Price of Carbon (SPC). This is a theoretical cost assigned to emissions to internalise the global (negative) carbon externality, allowing analysts to see if a project or company remains economically beneficial when its true environmental footprint is factored in.

A critical threshold in this rebalancing act is the "Switching Value". This is the specific carbon price trajectory at which a high-carbon project's Net Present Value (NPV) turns negative, signalling to the investor that it is time to shift capital toward a lower-

-carbon alternative. For example, if the carbon price rises above a certain level, a baseline investment in coal may no longer be viable compared to renewable sources like solar or wind power.

Carbon and energy futures are increasingly interconnected. Flori (2024) finds that the EU ETS allowance market functions as a net receiver of spillovers from energy commodity markets, particularly during periods of market stress, while natural gas and oil prices are among the key drivers of carbon futures movements. This interconnection means that shifts in carbon pricing are increasingly reflected in, and shaped by, broader energy market dynamics.

Carbon futures extend Emissions Trading Systems by allowing firms to trade emission allowances for future delivery, helping markets determine the expected long-term price of carbon. In India's Carbon Credit Trading Scheme (CCTS), Carbon Credit Certificates will be traded on exchanges with prices driven by supply and demand. When regulators signal tighter emission caps, futures prices rise in anticipation, encouraging firms to factor higher carbon costs into current investment decisions and accelerate decarbonisation.

Futures markets also reflect regulatory confidence and credit quality. High-integrity carbon credits that meet the eligibility criteria for compliance systems such as CORSIA tend to attract stronger demand because of their regulatory utility, though the extent to which this translates into documented price premiums in forward markets varies and should be treated as a tendency rather than a settled rule. Carbon prices are increasingly linked to energy markets. In China's national ETS, carbon pricing adds a cost signal to emissions that can influence power-sector investment decisions, often strengthening the economic case for renewables relative to fossil generation, though the degree to which this operates as a stable price floor or universally shifts generation economics depends on design and market conditions.

Finally, carbon futures function as a risk management tool. Companies use internal carbon pricing to test project viability under future price scenarios, while Indian exporters can use domestic carbon markets to manage exposure to the EU's Carbon Border Adjustment Mechanism (CBAM). As India builds trading infrastructure under regulators like the Central Electricity Regulatory Commission and the Bureau of Energy Efficiency, features such as credit banking further strengthen hedging and long-term market stability.

3. Policy Design and Its Impact

The local implementation of carbon pricing has an impact on its effectiveness, especially in developing countries like India. The shift from the PAT (Perform, Achieve, and Trade) scheme to the Carbon Credit Trading Scheme (CCTS) is a shift from an energy-efficiency trading scheme to a carbon-credit trading framework more directly tied to emissions reductions. Ray and Bandyopadhyay (2026), in a policy brief for ICRIER, argue that while PAT delivered incremental efficiency gains through unit-level energy intensity targets, the CTS shifts the compliance metric toward GHG emissions intensity at the sectoral level, introducing broader decarbonisation obligations and market-wide carbon risk beyond individual plant performance.

Interaction Risk and Overlapping Policies: According to OECD (2024), explicit carbon pricing instruments such as ETSs interact with implicit carbon prices embedded in fuel taxes and energy subsidies, jointly shaping the effective carbon signal facing firms. The OECD notes that the 2023 decline in net effective carbon rates partly reflected policy responses to energy price shocks and an increase in fossil fuel subsidies, illustrating how subsidy expansions can dilute the overall carbon price signal.

For early green adopters, these interactions create strategic uncertainty, as inconsistent carbon signals weaken incentives for long-term low-carbon investments. Overlapping policies and continued fossil fuel subsidies can further dilute price signals, increasing compliance costs and slowing the transition away from carbon-intensive assets.

7. Spillover Effects of Commodity Risk Pricing on Related Industries

Chiappari and colleagues (2024) determined that fossil fuels are the primary transmitters of price fluctuations within the energy supply chain. On the other hand, carbon derivatives appeared to absorb these price shocks. An assessment of the European Union Emissions Trading System (EU ETS) discovered that carbon allowance prices were more strongly related to commodities like Brent oil, heating oil, gasoline, and coal, rather than to low-carbon alternative fuels such as propane and ethanol. This suggests that the switching effect between fuel sources, that is the effect where changes are made to the energy mix or energy structure based on the relative costs of fuel and carbon, although theoretically regarded as a driving force, may not actually be the main factor that influences carbon prices, according to empirical evidence. Instead, it is broader market movements that influence carbon allowance pricing, indicating that market conditions are a bigger factor in price behaviour (Chiappari et al., 2024).

In a separate study, Gao et al. (2025) assessed iron ore options listed on the Singapore

Exchange. When comparing the carbon-intensive brown options to the green options, they found that carbon-intensive options have higher climate variance risk premiums and climate skewness risk premiums on average. This difference in premiums is a market indicator of the additional compensation that investors require for these assets that have higher climate-related policy and physical risks.

When it comes to vulnerability, the sector that is the most at risk is agriculture, due to its direct input linkages with energy markets through the usage of fertilisers, irrigation, and transportation, as well as the physical impacts of climate change that it faces. Then, the chemical sector sees the second-highest spillover effects, which can be attributed to high energy consumption during its production processes. However, the metal markets appear to be more resistant to energy price volatilities that arise in the short run due to the physical impacts of climate change, and can thus function as a "safe-haven" during energy market turmoil (Shen et al., 2026).

Industries with high agricultural content in their supply chains are prone to vulnerabilities from the effects of direct energy price transmissions as well as from climate-related production disruptions. The concentration of spillover effects in agriculture suggests implications for the distribution of impacts of food price volatility, which could have a disproportionate impact on the poor. On the other hand, the resilience of metals markets also has implications for economies with high mineral content, which may enjoy portfolio offsetting effects, although this natural hedge may be eroded with the advent of border carbon adjustment mechanisms that penalise extraction and processing.

In the case of India, these effects, alongside domestic structural factors, create risks. The agricultural sector, employing almost half of the workforce and mainly consisting of small farmers and labourers, finds itself exposed to both spillover vulnerability and direct physical climate risks. Along with this, India's electricity sector also generates 70-75 per cent of its total electricity from coal. This high dependence has a structural effect, which means that global fluctuations in the prices of coal can exert upward pressure on domestic energy prices and, therefore, by extension, carbon pricing mechanisms.

Li et al. (2026), in an assessment of China's financial markets, found that there exists a significant spillover effect between energy markets and other financial markets that functions in both directions, with energy commodities primarily driving it. Further, the same research also found that spillovers that arise due to traditional energy commodities like oil, coal, and natural gas are greater than those of new energy commodities, since these play a dominant role in the current structure of Chinese energy consumption (Li et al., 2026). On the other hand, the volatility spillover effect between the new energy market and financial markets is relatively small, which might be because China's new energy market is still in its nascent stages of development. However, the new energy market of commodities like copper, zinc, nickel, and tin has gradually become one of the main initiators of financial market volatility between 2021 and 2023. This indicates the rising significance of energy transition metals. Moreover, the futures prices of these key metals signifies their financial attributes as the inputs for low-carbon products. Delatte and Lopez (2013) also found that dependence between commodity-futures returns and equity markets can be symmetric and time-varying, with co-movement patterns varying across market states.

When the public focuses more of its attention on climate news, price movements and volatility in the energy sector are more likely to leak into other markets, such as the metals market and the agricultural market. Empirical estimates by Shen et al. (2026) demonstrated that when attention to climate issues increases by one standard deviation, spillovers from energy markets to non-energy commodities can rise by about 0.8 percentage points. This is achieved through four routes. The first is changes in information that affect investors' sentiment. The second is through changes in policy expectations that impact investors' perception of environmental regulations and their possible costs. The third is the reallocation of funds of institutional investors in different sectors based on climate news. Lastly, the combined effect of the aforementioned routes is a macro-behavioural factor that strengthens market interconnectedness.

8. Consumer Impact Analysis

In a UN report on Carbon Pricing, the effects of carbon pricing policies on households were differentiated based on 'use-side' impacts or the impact on the relative prices of goods purchased, and consequently, on household expenditure, and 'source-side' impacts or the impact on nominal wages, capital, transfers, and, consequently, household income. The literature also suggests that carbon pricing is generally regressive on the use side, since lower-income households allocate a greater share of their expenditure to necessities that are carbon-intensive in nature, even though their consumption is less in absolute terms.

Upper-income households bear a larger burden of the carbon tax due to their higher consumption levels in absolute terms, but the burden falls more heavily on the poor when we assess the impact relative to income.

According to Dorband et al. (2019), India is among only five countries out of eighty-seven examined where more than half of the population belongs to the lowest income group and income losses exceeding 2.5% of disposable income are faced at a carbon price of USD 30 per tonne of CO_2.

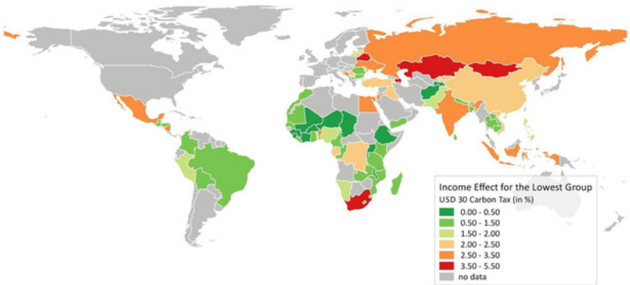

Figure 4: Income losses (as per cent of disposable income) for the lowest income group when applying a price of USD 30 per ton CO_2.

Note: Reprinted from Poverty and distributional effects of carbon pricing in low- and middle-income countries: A global comparative analysis, by I. I. Dorband, M. Jakob, M. Kalkuhl, & J. C. Steckel, 2019, World Development, 115, pp. 246-257 (https://doi.org/10.1016/j.worlddev.2018.11.015).

Another analysis by the IMF (Alonso & Kilpatrick, 2022) suggests that the average household welfare loss in India would be approximately 3% of initial consumption at USD 50 per tonne of CO_2. Food and consumption goods are especially carbon-intensive sectors in India, in which poorer households are found to spend a majority of their income; thus, carbon pricing is found to be regressive in India.

Comparing across rural and urban segments, rural employment is more adversely impacted by Carbon Pricing than urban employment, owing to the concentration of manufacturing and mining outside urban areas (Chadha et al., 2025), in turn adversely impacting rural incomes more than urban incomes.

Sectoral variation by end-use also exists. For instance, according to EDF (Barata et al., 2024), upper-income households have higher transport expenditures, which renders carbon pricing on transport progressive in its distributional effect. In contrast, food and energy sectors exhibit the opposite, with regressive outcomes given their greater share in low-income household expenditures.

Combined, these factors influence the overall investment and risk environment in which investors operate. A carbon pricing regime seen as regressive or inequitable may attract political resistance, thus introducing policy uncertainty that complicates long-term capital allocation (Chandra, 2021).

9. Investment Strategies: A Quantitative Analysis

The increasing presence of carbon pricing has begun to significantly alter the risk-return investment scenario for investors in India and globally. As discussed, the Carbon Credit Trading Scheme, the expansion of the disclosure norms by SEBI under the Business Responsibility and Sustainability Reporting

(BRSR) regime, and the exposure to the EU's Carbon Border Adjustment Mechanism implies that carbon risk is now not just relegated to a footnote in investment decisions but has become a key investment driver. In this scenario, two investment strategies can be discerned: one that is highly aggressive and focused on green and transition instruments, and another that is relatively more conservative in its approach.

The Basis for Differentiated Strategies

Before looking at each strategy, it is important to note the basic financial rationale for differentiation strategies in the first place. The body of literature on carbon risk pricing has consistently demonstrated that assets classified as being carbon-intensive bear a unique and increasing risk premium. An investor could mitigate this ex-post risk by adjusting the weighting of carbon-intensive stocks to a lesser degree and increasing the weighting of energy efficiency stocks, and the cost to the investor for this de-risking is statistically negligible in risk-return space (Benedetti et al., 2021). This is a critical point to note, and it is important to realise that there is no inherent cost to de-risking away from carbon-intensive assets, which is at the heart of the rationale for each of the strategies outlined below.

In addition, the data available on the Indian markets specifically supports the notion that ESG-based indices are not insulated from the broader markets. In this regard, studies undertaken to measure the performance of ESG-based indices listed on the major stock exchanges in India relative to broader market indices using multifactor models over the period between 2011 and 2023 show that there is a bias towards larger-cap and growth stocks over smaller-cap and value-based stocks, which mirrors the growth bias and preference for larger-cap stocks that exist in ESG-based strategies. This has important implications for portfolio construction, where ESG-based strategies show a bias towards well-capitalised stocks but, by the same token, limit diversification at the smaller-cap end.

In a study on Green Portfolio Optimisation by Mishra et al. (2023), the results indicated that climate-related variables such as physical risk and transition risk can explain a substantial portion of return variation. Further, scenario analysis conducted showed that green portfolios perform comparably to the BSE-100 under baseline conditions, and that they significantly outperform under high-risk and stress scenarios, with superior risk-adjusted returns across all cases. This signifies that as climate risk increases, the value of going green in our portfolios would increase as well. Further, when it comes to India's debt markets, a study by Singh et al. (2025) finds that green bonds have an alpha comparable to traditional bonds, and at the same time, the presence of a modest green premium or a "greenium" indicates that investors are willing to accept yields that are slightly lower in exchange for environmental attributes, signifying the increasing internalisation of transition risk in the pricing of instruments. From this, we can reinforce a key insight: carbon risk is increasingly priced, but not yet perfectly priced, and there is potential for capturing upside by strategically positioning one's investments. In the following section, we try to do the same by presenting two strategies, one that is highly aggressive and focused on green and transition instruments, and another that is relatively more conservative in its approach.

Quantitative Study

To empirically evaluate the arguments outlined above and the general discussion around green and non-green portfolios, this study undertakes a quantitative analysis of ten NSE-listed Indian stocks spanning the period 2015 to 2025, comprising five green (renewable energy) stocks and five non-green (fossil fuel and heavy industry) stocks. Daily adjusted closing prices were used to compute log returns. Four naive portfolio strategies were constructed using fixed weights, and two optimised portfolios were derived using Markowitz mean-variance optimisation and Sharpe Ratio maximisation.

Selected Non-Green Stocks:

Coal India, ONGC, IOC, Tata Steel, NTPC

Selected Green Stocks:

Tata Power, Suzlon, JSW Energy, NHPC, SJVN

The four naive portfolio strategies were taken to be:

1. A fully Green portfolio, comprising the five green stocks, equally weighted.
2. A fully Non-green portfolio, comprising the five non-green stocks, equally weighted.
3. A 75-25 Approach with 75% weight being given to green stocks and 25% to non-green stocks.
4. A 50-50 Approach with the green stocks and non-green stocks having equal weight.

Based on RBI data for March 2026, the risk-free rate[1] ranged from 6.87% to 6.95%. A midpoint value of 6.91% was therefore used in this study.

Table 2: Descriptive Statistics Naive Portfolios

Portfolio	Daily Mean	Annual Mean	Daily Std Dev	Annual Volatility	Skewness	Kurtosis	Observations	Sharpe Ratio
Green	0.000507	12.77%	0.015947	25.32%	-0.4506	4.159	2,725	0.2313
Non-Green	0.000286	7.20%	0.013089	20.78%	-0.6228	5.859	2,725	0.0138
75-25	0.000451	11.37%	0.014098	22.38%	-0.6221	4.847	2,725	0.1995
50-50	0.000396	9.98%	0.012900	20.48%	-0.7480	5.558	2,725	0.1500

Here,

Annual Mean = Daily Mean x 252

[1] A constant 6.91% benchmark is applied across 2015–2025, though actual risk-free rates ranged from approximately 6% to 8%. We acknowledge that this may overstate or understate Sharpe Ratios in certain sub-periods where prevailing rates differed significantly.

$$\text{Annual Volatility} = \text{Daily Std Dev} \times \sqrt{252}$$

$$\text{Sharpe Ratio} = \frac{\text{Annual Mean} - 6.91\%}{\text{Annual Volatility}}$$

Analysis of the Results

The Green portfolio delivered the highest average daily return of 0.000507, translating to an annualised return of 12.77%. The Non-Green portfolio, by contrast, yielded a substantially lower daily mean of 0.000286, or 7.20% per annum, which is nearly half the green portfolio's return over the same period. The 75-25 and 50-50 portfolios yielded returns of 11.37% and 9.98%, respectively, consistent with their proportional green allocation.

In terms of risk, the 50-50 portfolio recorded the lowest annual volatility at 20.48%, followed closely by the Non-Green portfolio at 20.78%. The Green portfolio, while delivering the highest return, also carried the highest volatility at 25.32%. What this suggests is that while green stocks have outperformed in terms of raw returns, they have done so with comparatively higher return fluctuations, which is consistent with the growth-stage characteristics of India's renewable energy sector.

Further, all of the four portfolios exhibit negative skewness, indicating a left-tailed distribution, meaning large negative daily returns occurred more frequently than large positive ones. This was most pronounced in the 50-50 portfolio (-0.748), suggesting greater asymmetric downside risk in the balanced blend. All portfolios exhibit excess kurtosis (kurtosis > 3), confirming the presence of fat tails and the higher probability of extreme return events relative to a normal distribution. This is particularly notable for the Non-Green portfolio (kurtosis = 5.86), which shows the heaviest tails.

The Green portfolio yields the highest Sharpe Ratio of 0.2313, significantly outperforming the Non-Green portfolio's ratio of 0.0138. This is a key finding of the study: on a risk-adjusted basis, green stocks have delivered substantially superior performance. The 75-25 blend (Sharpe = 0.1995) and the 50-50 blend (Sharpe = 0.1500) both perform well relative to the pure non-green portfolio, suggesting that even partial green allocation leads to greater portfolio efficiency.

Table 3: Individual Stock Statistics (Daily, 2015-2025)

Stock	Category	Daily Mean Return	Annual Return	Daily Std Dev	Annual Volatility
COALINDIA	Non-Green	0.000018	0.45%	0.018677	29.65%
ONGC	Non-Green	0.000017	0.43%	0.021147	33.57%
IOC	Non-Green	0.000399	10.06%	0.01919	30.46%
TATASTEEL	Non-Green	0.000588	14.81%	0.022693	36.02%
NTPC	Non-Green	0.000406	10.22%	0.016466	26.14%
TATAPOWER	Green	0.000562	14.16%	0.021572	34.24%
SUZLON	Green	0.000472	11.90%	0.035807	56.84%
JSWENERGY	Green	0.000568	14.32%	0.026914	42.72%
NHPC	Green	0.000526	13.25%	0.019953	31.67%
SJVN	Green	0.000405	10.20%	0.021458	34.06

Among the non-green stocks, Tata Steel (14.81% annualised) and NTPC (10.22%) emerge as relatively stronger performers. In contrast, Coal India and ONGC exhibit near-zero daily mean returns (approximately 0.000018), indicating stagnation or negligible return generation over 2015–2025.

Among the green stocks, Tata Power (14.15%), JSW Energy (14.32%), and NHPC (13.25%) stand out as high-return candidates. Suzlon, while delivering moderate returns (11.90%), exhibits the highest annualised volatility (56.84%), making it the riskiest stock in the sample.

Next, we come to the Markowitz optimisation, which minimises portfolio risk (standard deviation) subject to the constraints that portfolio weights sum to one and no short selling is permitted. The GRG Nonlinear solving method was employed in Excel Solver, initialised with equal weights of 0.1 per stock.

Table 4: Markowitz Minimum Variance Portfolio

Stock	Category	Optimal Weight
COALINDIA	Non-Green	**13.03%**
ONGC	Non-Green	**2.32%**
IOC	Non-Green	**23.65%**
TATASTEEL	Non-Green	**8.33%**
NTPC	Non-Green	**26.09%**
TATAPOWER	Green	**1.47%**
SUZLON	Green	**3.27%**
JSWENERGY	Green	**1.20%**

Table 4: Markowitz Minimum Variance Portfolio (Contd.)

Stock	Category	Optimal Weight
NHPC	Green	**8.92%**
SJVN	Green	**11.71%**
Portfolio Return (Daily)		**0.000377**
Portfolio Risk (Daily)		**0.011988**

The resulting minimum variance portfolio is dominated by non-green stocks, with NTPC (26.09%), IOC (23.65%), and COALINDIA (13.03%) receiving the largest allocations. This is expected, as these stocks tend to exhibit lower individual volatility and lower correlation with the broader portfolio attributes that Markowitz optimisation prioritises when the sole objective is risk minimisation without regard to return.

The green stocks collectively receive approximately 26.6% of the portfolio (TATAPOWER 1.47%, SUZLON 3.27%, JSWENERGY 1.20%, NHPC 8.92%, SJVN 11.71%), with NHPC and SJVN being the primary green contributors. These two stocks are among the least volatile green stocks in the sample, which explains their inclusion in a minimum risk framework.

The portfolio achieves a minimum daily risk of 0.011988, the lowest achievable under the given constraints, further confirmed as the bottom of the efficient frontier curve plotted in Figure 1.

Further, we conducted Sharpe Ratio maximisation to identify the portfolio that yields the highest return per unit of risk, using a risk-free rate of 6.91% per annum (daily equivalent: 0.000183, derived using the compound formula). Excel Solver was run using the GRG Nonlinear method to do the same.

Table 5: Maximum Sharpe Ratio Portfolio

Stock	Category	Optimal Weight
COALINDIA	Non-Green	**0.00%**
ONGC	Non-Green	**0.00%**
IOC	Non-Green	**9.22%**
TATASTEEL	Non-Green	**26.71%**
NTPC	Non-Green	**6.90%**
TATAPOWER	Green	**19.64%**
SUZLON	Green	**3.13%**
JSWENERGY	Green	**8.96%**
NHPC	Green	**25.44%**
SJVN	Green	**0.00%**
Portfolio Return (Daily)		**0.000532**
Portfolio Risk (Daily)		**0.014**
Daily Sharpe Ratio		**0.0249**
Annualised Sharpe Ratio		**0.3952**

The Sharpe Ratio optimal portfolio is notably more balanced between green and non-green stocks than the Markowitz Minimum Variance Portfolio.

TATASTEEL (26.71%) and NHPC (25.44%) receive the largest allocations, followed by TATAPOWER (19.64%) and IOC (9.22%). COALINDIA, ONGC, and SJVN are entirely excluded (0% weight), as their low returns fail to compensate for their contribution to portfolio risk.

The green stocks account for approximately 57.17% of the Sharpe optimal portfolio (TATAPOWER + SUZLON + JSWENERGY + NHPC), indicating that maximisation of risk-adjusted returns favours green stocks. This is a significant finding in our study: when returns are evaluated relative to risk, the composition of the portfolio shifts favourably towards renewable energy stocks.

The annualised Sharpe Ratio of 0.3952 substantially exceeds those of all naive portfolios, confirming that optimisation delivers superior risk-adjusted outcomes compared to naive fixed-weight strategies.

Further, the efficient frontier maps the minimum portfolio risk achievable at each level of target return. It was constructed by running ten Solver optimisations, each minimising portfolio risk subject to a specific daily return constraint ranging from 0.00029 to 0.00056.

Table 6: Efficient Frontier Data Points

Target Return (Daily)	Minimum Risk (Daily)
0.00029	0.012251
0.00032	0.012098
0.00035	0.012012
0.00038	0.011988
0.00041	0.012025
0.00044	0.012135
0.00047	0.012353
0.0005	0.012947
0.00053	0.013935
0.00056	0.015318

Note: The row containing target return = 0.00038, minimum risk = 0.011988 indicates the global minimum variance portfolio.

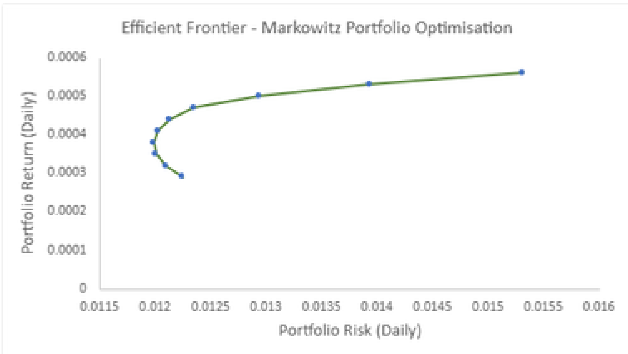

Figure 5: Efficient Frontier Chart

Upon plotting the points, we obtain Figure 5.

The efficient frontier follows the expected bullet-shaped curve, with the minimum variance point occurring at a target return of 0.00038 with a minimum risk of 0.011988. Above this point, higher returns are achievable only by accepting greater portfolio risk, reflecting the fundamental risk and return trade-off.

The upper segment of the frontier (return > 0.00038) represents the set of efficient portfolios from which a rational investor would choose based on their individual risk tolerance. The lower segment (return < 0.00038) represents dominated portfolios, as they carry the same risk as a higher return portfolio and would not be selected by a rational investor.

Summary

To synthesise the findings of our study, the following table (Table 7) and charts (Figures 6 and 7) provide a visual summary of portfolio performance across all strategies and highlight differences when it comes to return, risk, and risk-adjusted efficiency, as well as asset allocation, enabling clearer comparison.

Table 7: Portfolio Comparison Summary

Portfolio	Annual Return	Annual Volatility	Sharpe Ratio	Strategy Type
Green	12.77%	25.32%	0.2313	Naive
Non-Green	7.20%	20.78%	0.0138	Naive
75-25	11.37%	22.38%	0.1995	Naive
50-50	9.98%	20.48%	0.15	Naive
Min Risk (Markowitz)	9.50%	19.03%		Optimised
Max Sharpe	13.40%	22.24%	0.3952	Optimised

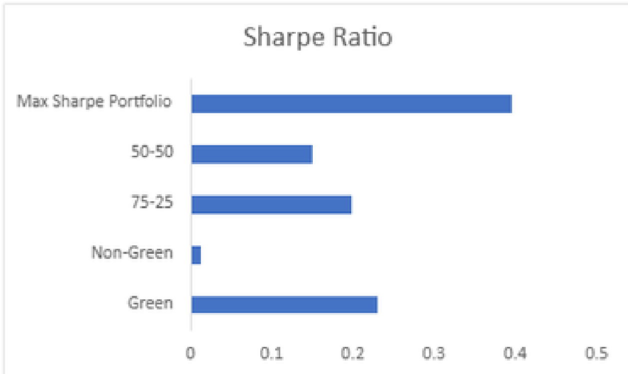

Figure 6: Sharpe Ratio Bar Chart

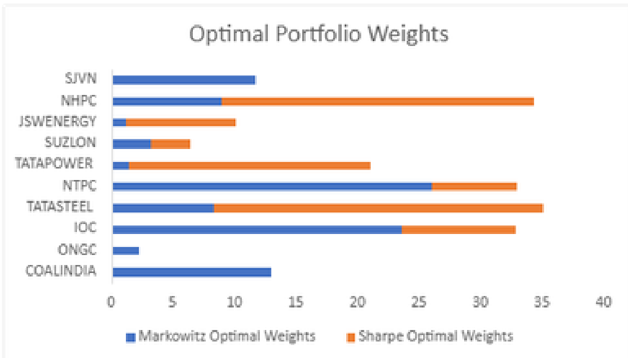

Figure 7: Optimal Weights Stacked Bar Chart

Aligning with our study and analysis, as India navigates its energy transition, numerous financial analysts and investment platforms are seen talking about the growing importance of a well-balanced and diversified portfolio, along with an increase in ESG investment. An India-based financial company, StockEdge, published an article outlining the importance of investing in green assets and energy transition, especially in the current geopolitical situation and instability. Global tensions reshape capital flows and supply chains. ESG stocks have evolved from a niche preference into a critical strategic pillar for investors seeking resilience. Even during a volatile environment, when traditional energy or carbon- heavy associated assets struggle, ESG stocks offer a rather stable portfolio to the investors that a non-green asset portfolio would struggle to match. When two market indices of India, Nifty 50 (non-green) and Nifty 100 ESG (green), are compared by the company, it was found that as of 3rd January 2025, ESG stocks had outperformed the Nifty 50 over the past years, with a return of 15% compared to the Nifty 50's 11%.

The risk-return dynamics of green equities are grounded in both empirical performance data and investor preference theory. Longitudinal index data indicate that the FTSE Environmental Opportunities All Share Index outperformed the FTSE Global All Cap by 5.9% and exceeded oil and gas sector returns by 19.8% over a five-year horizon (Clements et al., 2022). It should be noted, however, that this performance advantage reversed in 2022, with green equities underperforming broader markets amid elevated valuation premiums and sectoral weakness in renewable energy (Clements et al., 2022). This differential is theoretically anchored in Pástor et al.'s (2020) equilibrium model, which demonstrates that investor utility derived from holding green assets generates sustained demand, reducing the cost of capital for ESG-compliant firms and elevating their market valuations. This stability effect is particularly pronounced in developing economy contexts: Singh and Jaiwani (2024), drawing on panel data across 93 global energy sector firms, find that strong ESG propositions reduce share price volatility for firms in developing nations, a finding with direct relevance to the Indian market. Carbon-intensive firms, by contrast, face compounding transition costs and regulatory penalties as compliance frameworks tighten, structurally elevating their risk profile relative to green counterparts. That said, green outperformance is partly contingent on climate-concern shocks rather than representing a persistent unconditional premium (Pástor et al., 2021), a limitation that tempers deterministic conclusions about long-run green equity dominance.

As India aims to expand its renewable energy market to increase its total electricity-

-producing capacity, Morgan Stanley remarks that this could be an excellent time for Indian investors to enter into 'Green Investment' and to start investing in ESG assets. According to the company, India's current net energy import burden is approximately 3% of the GDP. As India expands its renewable energy market, it creates new opportunities for Indian investors and reduces the financial burden on the country's economy. The company remarks that India's unique combination of environmental challenges, development goals and rapid growth creates a set of clean energy goals and investment opportunities that cannot be seen in any other emerging markets. Taken together, the evidence suggests that green portfolios in India offer relatively stronger risk-adjusted returns compared to carbon-intensive alternatives, though this advantage remains sensitive to policy continuity and market conditions.

10. Dissenting Views on Carbon Pricing, Green Investment, and Energy Transition

In the previous sections of this paper, an affirmative thesis has been laid down about the importance and benefits of Carbon Pricing, Green Investment, and Energy Transition for India's long-term economic development. However, it is imperative that we also look into opposing arguments against these propositions to get a better and more balanced understanding of the theories laid out.

Though carbon pricing has seen success in some of the more developed nations or the Global North, the effectiveness and impact of carbon pricing differ for developing nations. When we look into the case of India, one of the most serious challenges that we face is that the carbon tax is structurally regressive in nature, which is an inherent feature of the instrument. This critique has been advanced with particular force in the recent CSEP technical paper on carbon taxation in India. In this paper (Chadha et al., 2025), using an Environmentally Extended Social Accounting Matrix for India 2019-20, it is found that a carbon tax applied to emissions-intensive sectors would cause total employment to decline by 0.95% to 1.44%, with rural employment more adversely affected than urban, which is a direct consequence of the concentration of industrial and mining jobs in rural areas.

According to the CSEP study, a carbon tax with no revenue recycling would make consumption inequality worse because poorer households would have to devote a much higher percentage of their income towards purchasing primary and secondary sector products, which would face the highest price increases in the event of a carbon tax being introduced. The rural regions were found to be more vulnerable, owing to their consumption of high-energy products, with the Gini coefficient rising at the national level because of the carbon tax policy scenario. The carbon taxation approach has been criticised by the opponents of the policy precisely for causing such results, making the tax extremely unpalatable and unfair from a social perspective in a developing economy. In essence, according to one interpretation of this situation, the carbon tax would represent a consumption tax on the necessities of the poor.

Another critical question raised by the critics is about the historical responsibility and the essential imbalance of carbon emissions between income levels. An article in the Institute for New Economic Thinking by Rohit Azad and Shouvik Chakraborty pointed out that the top 10 per cent of India's population is responsible for carbon footprints that are seven times larger than those of the lowest decile. Furthermore, the bottom 70 per cent of India's population emits less carbon than would be expected from their population ratio. This implication contradicts the fundamental principle behind carbon pricing according to the demand side; if the poor are not the main producers of carbon emissions, then increasing the cost of fossil fuel will affect those people who are less responsible for the environmental problem. Furthermore, the two authors observe that indirect taxation through a carbon tax affects the poor more than the rich because, unlike the latter, the former spend a larger share of their income on such goods as compared to their total income.

In addition to considering the carbon policies themselves, the implied support of green and ESG investments in this paper as a superior approach for India's capital markets should be subjected to rigorous consideration. The case for ESG investing, despite its compelling logic when viewed from the perspective of sustainability, has faced criticism from many sides: methodological, economic, and political.

Investing according to the principles of environmental, social, and governance is increasingly being targeted politically, especially in light of the claims made by conservative politicians that such investments are more about promoting social agendas than financial gains. In 2024, the Texas State Board of Education passed a resolution ending an $8.5 billion investment by BlackRock, a global asset management firm managing the $53 billion Texas Permanent School Fund, according to state legislation prohibiting investment in businesses considered anti-fossil fuel. Such cases are not limited to the United States alone. The opposition to ESG investing reflects a growing movement among stakeholders who believe that ESG imposes non-economic considerations on investments.

11. Conclusion

This paper has examined carbon pricing and the green transition through a wide lens, tracing their implications from the design of India's Carbon Credit Trading Scheme to the risk premiums embedded in commodity futures, from the architecture of global ETS systems to the Sharpe Ratios of NSE-listed portfolios. What emerges is not a simple verdict, but a nuanced picture of an economy navigating the difficult space between development imperatives and climate accountability.

India's position in this transition is structurally distinctive. With per capita emissions of just 2.2 tonnes annually, among the lowest of the world's major economies, and yet a total emissions footprint of 3.22 billion tonnes, the country embodies the central paradox of climate justice: it has contributed least to the historical accumulation of atmospheric carbon, yet faces some of the steepest costs of adaptation. The CCTS, with its intensity-based, baseline-and-credit architecture, represents a pragmatic acknowledgement of this reality. Rather than imposing absolute caps that would penalise economic growth, it creates a market signal calibrated to India's federal structure, sectoral diversity, and developmental stage. The evidence from comparable systems, particularly the Chinese ETS's recent expansion and Japan's growth-oriented GX framework, supports the view that intensity-based entry points can evolve into more stringent absolute mechanisms, provided regulatory credibility and institutional capacity are built in the interim.

The comparative analysis of global carbon pricing architectures reveals a clear hierarchy of institutional development, with the EU ETS standing as the most mature and price-effective system, supported by automatic stabilisation mechanisms and prices averaging EUR 60-80 per tonne. However, it also reveals the limits of model transfer: Sweden's successful carbon tax relied on a tax-to-GDP ratio and administrative infrastructure that developing economies cannot readily replicate. India's hybrid approach, combining a carbon tax floor for non-CCTS sectors with tradable intensity credits for obligated entities, is therefore not merely a political compromise, but a design philosophy suited to its own constraints. Revenue recycling, particularly through Direct Benefit Transfers to the bottom forty per cent, is critical to neutralising the regressive distributional impact identified in the CSEP modelling, where an uncompensated carbon tax would depress rural employment and worsen the Gini coefficient.

The financial dimension of carbon pricing, explored in the third and fourth sections, confirms that carbon risk has crossed the threshold from externality to priced factor. For India, this has concrete implications. Domestic credit markets are beginning to price transition risk through green bond issuance and sustainability-linked financing. International exposure to CBAM means that India's steel and aluminium exporters face a de facto shadow carbon price from the European Union regardless of domestic policy choices. The CCTS, in this context, is not merely an environmental instrument but a strategic trade tool, one that allows Indian exporters to demonstrate that carbon costs have been internalised domestically, reducing CBAM liabilities and retaining revenue within the country's own fiscal architecture. Wang (2024) documents a consistently positive daily carbon pricing risk premium of 0.065-0.085% across commodity futures, with the five-year moving average on an upward trend; Gao et al. (2025) further show that carbon-intensive commodity options carry higher climate variance and skewness risk premiums than green counterparts.

The empirical analysis of NSE-listed green and non-green stocks from 2015 to 2025 provides perhaps the most direct contribution of this paper. Across 27,250 daily observations, the green portfolio delivered an annualised return of 12.77% against the non-green portfolio's 7.20%, with a Sharpe Ratio of 0.2313 against a near-negligible 0.0138. This is not a marginal difference; it is a structural divergence that has compounded over a decade. The Markowitz minimum variance optimisation and Sharpe Ratio maximisation exercises further demonstrate that the efficient frontier available to Indian investors includes meaningful allocations to green stocks not because of ethical obligation, but because of superior risk-adjusted performance. However, the higher volatility of the green portfolio, 25.32% annually versus 20.78% for non-green, is a reminder that India's renewable energy sector remains in a growth stage, subject to regulatory uncertainty, financing constraints, and policy discontinuities. The value of going green is real, but it comes with commensurate risk. The near-zero annualised returns of Coal India (0.45%) and ONGC (0.43%), contrasted with JSW Energy (14.32%) and Tata Power (14.16%), are the clearest illustration of this divergence.

The dissenting perspectives examined in the final section are not peripheral concerns to be dismissed. The critique that carbon pricing is structurally regressive in the Indian context, disproportionately burdening rural households who bear the least responsibility for emissions, is empirically grounded and politically consequential. The opposition to ESG investing, illustrated by the Texas State Board of Education's divestment from BlackRock, reflects a broader contestation about whether financial markets should serve environmental objectives or remain narrowly focused on risk-adjusted returns. These tensions do not invalidate the case for carbon pricing or green investment. Still, they do impose constraints on how policies are designed and how their benefits are communicated. An India that introduces carbon pricing without robust revenue recycling, or that promotes ESG frameworks without addressing their methodological inconsistencies and exclusions of small-cap and value stocks, will face both distributional failures and political backlash that undermine the long-run credibility of its climate framework.

Taken together, the findings of this paper point toward a set of conditional conclusions. Carbon pricing, in the form of the CCTS supplemented by phased fiscal instruments, is economically viable and politically navigable for India, provided it is accompanied by progressive revenue recycling, phased sectoral expansion, and a credible regulatory trajectory that gives industry the certainty needed to plan capital investment. The green transition is already being priced into Indian equity markets, and investors who have recognised this have earned superior risk-adjusted returns over the past decade. The financialisation of carbon risk, through commodity futures, credit spreads, and equity factor models, is not a future phenomenon but a present reality that India's financial institutions, regulators, and exporters must actively incorporate into their decision frameworks. The geopolitical pressures of CBAM further mean that the cost of inaction, of remaining outside credible carbon pricing frameworks, is no longer merely environmental but commercially and diplomatically significant. The supply disruption risks illustrated by the West Asian conflict further reinforce this case, as non-green portfolios face direct input cost pressures while the relative economics of renewable energy strengthen.

India stands at a fork in its climate policy path. One road leads to a reactive, compliance-driven adoption of carbon pricing imposed partly by external trade pressures, with distributional costs borne disproportionately by those least able to carry them. The other leads to a proactively designed, Indianised system, one that uses carbon revenues to fund the just transition for coal workers in Jharkhand, solar irrigation for farmers in Maharashtra, and EVs for autorickshaw drivers in Delhi, while simultaneously building the institutional infrastructure for a credible, growing carbon market. The evidence assembled in this paper suggests that the second path is not only more equitable but also more economically rational. The question is not whether India will price carbon; the CCTS, CBAM exposure, and market forces make some form of pricing inevitable, but whether it will do so on its own terms, in a manner that serves Viksit Bharat while honouring its obligations to the global commons.

The energy transition is ultimately neither a technical problem nor a financial one alone. It is a problem of political economy, of convincing societies to accept present costs for future benefits, and of ensuring that those costs fall on those most capable of bearing them. In India, with its scale, diversity, and developmental aspirations, getting this balance right will matter not just for its own 1.4 billion people, but for the credibility of the entire global project of managed decarbonisation. This paper has attempted to illuminate the contours of that challenge. The work of meeting it remains ahead.

Appendix

The West Asian Conflict and Its Implications for India's Energy Markets:

At the time of writing this paper, we are witnessing a consequential geopolitical shock, one that is being felt deeply in every country. The escalation of conflict in West Asia from early 2026 onwards has seen coordinated strikes by the USA and Israel on Iran, which was then followed by Iran responding by targeting US bases and energy infrastructure assets across the Gulf region. This quick turn of events transformed what appeared to be a regional confrontation into a systemic disruption of global energy flows (Kumar, 2026).

According to ICRA (2026), the nations drawn into this conflict account for 30% of the world's crude oil production and 17% of the global gas output. Further, the closure of the Strait of Hormuz, even if only partial and intermittent, poses significant global risks, as the passage handles the transit of 25% of global seaborne oil shipments and 20% of LNG exports. Of importance, in light of India's interest, is that the Strait of Hormuz carries about 80% of its exports to Asian markets, and the conflict has disproportionately affected import-dependent economies.

Such geopolitical events clearly and evidently have considerable effects on global energy markets, affecting the volatility of commodity prices and the incorporation of risk premiums into crude oil prices in particular, as a result of markets pricing in potential supply-side disruptions.

India, being a significant importer of energy resources, imports 85% of its crude oil and a substantial share of its natural gas, consuming roughly 5.5 million barrels per day (Moneycontrol, 2026). The country's vulnerability to such shocks is, at its core, a structural problem, as West Asian countries such as the UAE, Saudi Arabia, Iraq, Kuwait, and Qatar form key suppliers for us. LPG is another segment which carries a great risk and significant domestic implications in case of disruption, with over 330 million LPG consumers and the bulk of consumption being met by imported LPG that gets to us via the Strait of Hormuz. Although India has diversified the suppliers it sources crude from, a substantial portion of energy imports remains exposed to geopolitical chokepoints, particularly for gas-based supply chains (Moneycontrol, 2026). Therefore, the sensitivity of domestic energy prices to global commodity cycles is likely to increase as fluctuations in international prices are directly felt in India's import costs. As a result, global price volatility becomes an important factor in domestic pricing and inflation dynamics.

Consequently, escalation in conflict led to a sharp increase in global crude prices, with brokerage firm Prabhudas Lilladher estimating that India's annual oil import bill could rise by over $70 billion as prices are unlikely to return to pre-conflict levels in the near term (ET EnergyWorld, 2026). This results in a greater current account deficit and exerts pressure on the exchange rate (ICRA, 2026). Further, fuel has a higher weight in wholesale inflation as compared to consumer inflation, which accounts for stronger and more immediate effects at the producer level (ICRA, 2026). Inflation then holds back the RBI from cutting repo rates, which further keeps risk-free rates high, and as a consequence, portfolios face a higher return threshold that must be achieved to be able to generate excess returns. This makes crude oil prices a primary transmission channel of economic shocks due to the conflict. Another channel is formed by remittances, which see the origin of a significant share of inflows in West Asia. Disruptions to employment conditions in the region may affect these flows and further influence external balances (ICRA, 2026).

Moreover, we see asymmetric sector-specific implications arise that are especially important for investment strategy. On the import side, sectors such as the fertiliser sector face cost pressures due to their dependence on imported inputs, such as urea and gas-based production. On the export side, sectors which export a large portion of their trade to West Asia face demand and logistics risks. Some examples of such sectors are the agriculture sector, gems and jewellery, and apparel. For example, Basmati rice, which sees 70-75% of its annual export value directed to these West Asian markets, risks seeing order delays and cancellations (ICRA, 2026). Another consideration is that shipping costs have seen an increase due to higher insurance premiums and rerouting, raising overall costs and shipping time, and affecting profitability (ICRA, 2026). With fossil-fuel dependent industries facing direct cost pressures, while simultaneously, high crude makes renewable energy cheaper by comparison, this leads to a stronger investment case for green energy and thus, headwinds for non-green stocks, in contrast to a tailwind for green stocks. This can be seen, for instance, in India’s push towards solar energy post the Russia-Ukraine conflict from 2022.

Overall, the implications for non-green stocks in the face of such conflicts are clear. Non-green portfolios not only see higher input cost risks and more vulnerability to energy shocks, but also lower return premiums over risk-free rates. On the other hand, a case for a tilt towards green portfolios is reinforced by geopolitical risks.

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