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Carbon Trading: A Comprehensive Analysis of Market Architecture, Implementation Challenges, and the Path to Net Zero

Katiki Srikar[1], Muddana Sri Sai Charan Satya[2], S. Satish[3], T. Sunil Kumar[4], P. Varalakshmi[5]

[1]Assistant Professor, Agricultural Extension, School of Agriculture, GIET University, Gunupur
[2]Assistant Professor, Department of Soil Science and Agricultural Chemistry, School of Agricultural Sciences, Malla Reddy University.
[3]Assistant Professor, Agricultural Economics, School of Agriculture, GIET University, Gunupur
[4]Research Associate, Regional Agricultural Research Station, Chintapalle
[5]Assistant Professor, Department of Soil Science and Agricultural Chemistry, School of Agricultural Sciences, Malla Reddy University

*Corresponding Author
Katiki Srikar*

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INTRODUCTION

Carbon trading is a market mechanism established to mitigate greenhouse gas emissions by treating the right to release carbon dioxide (CO_2) as a tradable commodity. The system originates from the Kyoto Protocol and is further operationalized under the Paris Agreement to facilitate international cooperation. The core philosophy of this mechanism is the "polluter pays" principle, which internalizes the social and environmental costs of emissions, holding industrial entities financially accountable for their atmospheric impact. By establishing a monetary value for carbon, the market incentivizes firms to innovate and adopt cleaner technologies where the marginal cost of abatement is lowest.

The Mechanics of Trading Systems

A. The "Cap and Trade" vs. "Baseline and Credit" Models

The most prominent framework is the Cap-and-Trade model, where a regulatory body sets an absolute limit (cap) on total emissions, which decreases annually to align with climate targets. This cap is divided into allowances, typically representing one metric tonne of CO_2 equivalent (tCO_2e). In contrast, Baseline-and-Credit systems do not have an explicit aggregate cap but issue credits to entities that reduce emissions below a specific historical or performance-based level.

B. Allocation of Permits

Companies obtain allowances through two primary methods:

- **Auctioning:** Firms bid for permits, a process that generates significant public revenue from global carbon pricing mobilized over $100 billion for public budgets in 2024.

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- **Free Allocation (Grandfathering):** Permits are given away based on historical emissions to protect trade-exposed industries from carbon leakage the relocation of business to countries with laxer rules.

C. Carbon Offsets

Offsets allow entities to fund emission-reduction projects outside the regulated sector (e.g., reforestation, renewable energy farms) instead of reducing internal emissions. While intended to provide flexibility, recent comprehensive reviews suggest many offset programs have failed to deliver real climate impact due to issues like non-additionality (funding projects that would have happened anyway).

Major Global Carbon Markets

The global landscape has evolved from fragmented regional experiments into a digitally integrated ecosystem.

- **European Union- Emissions Trading System (EU-ETS):** The world's first major system, covering power generation and heavy industry. It recently saw prices hit €100 per tonne, creating a record high cost for pollution.
- **China National ETS:** Launched in 2021, it is the world's largest market by covered emissions (approximately 5 billion tonnes of CO_2) and is currently transitioning from intensity-based benchmarks to absolute emission caps.
- **North American Markets:** The California Cap-and-Trade Program and Québec's system are successfully linked via the Western Climate Initiative (WCI), with Washington State currently pursuing integration into this market.
- **Emerging Markets:** Countries like India and Brazil are developing regulated frameworks, such as India's Carbon Credit Trading Scheme (CCTS) and Brazil's SBCE, the latter of which includes provisions to share revenue with Indigenous communities.

The Role of Integrity and Uncertainty

The effectiveness of these markets is heavily influenced by global uncertainty. Economic Policy Uncertainty (EPU) and Geopolitical Uncertainty (GPU) such as the war in Ukraine heighten carbon market risks, increase information asymmetry, and can lead to volatility clustering, which delays long-term investment in clean technology.

To ensure market integrity, initiatives like the Integrity Council for the Voluntary Carbon Market (ICVCM) have established Core Carbon Principles (CCPs) to set a global threshold for high-quality credits. Similarly, the Voluntary Carbon Markets Integrity Initiative (VCMI) provides a Claims Code of Practice to prevent greenwashing by ensuring corporate claims are based on high-integrity actions.

Challenges and Criticisms

Despite its potential, carbon trading faces significant hurdles:

- **"Pay to Pollute":** Critics argue that the system allows wealthy corporations to purchase "licenses to carry on polluting" rather than fundamentally transforming their energy usage.
- **Environmental Justice:** Cap-and-trade can create pollution "hotspots" in low-income areas if dirty facilities simply buy credits instead of cleaning up local air quality.
- **Resource Allocation Inefficiency:** Empirical studies in China indicate that while carbon trading improves capital allocation efficiency, it can negatively affect labor allocation efficiency if not supported by government intervention.

The Future: Article 6 and Digitization

The finalization of the Article 6 rulebook at COP29 is a transformative milestone, establishing rules for decentralized (Art 6.2) and centralized (Art 6.4) international trading. Key innovations include:

- **Corresponding Adjustments:** An accounting rule ensuring that emission reductions are not double-counted by both the buyer and the seller country.

- **Carbon Border Adjustment Mechanism (CBAM):** EU-led initiatives to tax imports based on carbon content, forcing global exporters to adopt carbon pricing.
- **Digitization:** The use of Blockchain and AI for real-time Monitoring, Reporting, and Verification (MRV) is improving transparency and reducing transaction costs.

CONCLUSION

Carbon trading is a market-based instrument designed to cut greenhouse gas emissions by making the right to emit carbon dioxide a tradable asset, based on global pacts like the Kyoto Protocol and Paris Agreement. It follows the polluter-pays rule, making companies financially responsible for their pollution and pushing them toward low-cost clean tech upgrades. Carbon trading is a critical transitional tool toward Net Zero, provided it is governed by high-integrity standards and integrated with direct regulatory policies. Success depends on moving beyond "zero-sum" compensation and ensuring that the market drives actual atmospheric benefits while supporting social equity and technological innovation.

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