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Original Research Article

Effect of Carbon Pricing on Global Environmental Sustainability and Economic Development

Olawale C. Olawore[1]*, Yussuf Olasunkanmi Kuti[2], Kazeem O. Oyerinde[3], Taiwo R. Aiki[4], Oluwatobi J. Banjo[5], Beverly B. Tambari[6], Victor O. Okoh[7], Festus I. Ojedokun[8], Funmilayo C. Olawore[9], Jonathan E. Kozah[10]

[1]University of People, Pasadena, California, United States of America
[2]Cranfield University, Cranfield Village, Bedfordshire, United Kingdom
[3]Euro Akademia, Tallinn, Estonia
[4]University of Derby, Derby, United Kingdom
[5]Estonia Entrepreneurship University of Applied Sciences, Tallinn, Estonia
[6]Tallinn University, Tallinn, Estonia
[7]Estonia Entrepreneurship University of Applied Sciences, Tallinn, Estonia
Bowling Green State University, Ohio, United States
[8]Tansia University, Anamra State, Nigeria
[9]America University for Humanities, Tbilisi, Georgia
[10]New Vision University, Tbilisi, Georgia

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***Corresponding author:** Olawale C. Olawore
University of People, Pasadena, California, United States of America

Abstract

This paper presents a critical strategic analysis of international carbon pricing and its environmental, economic, and social impacts. This discussion will rely on peer-reviewed articles, policy reports, and empirical studies that have been published between 2007-2024. It examines the effect of carbon taxes and emissions trading systems (ETS) in reducing greenhouse gas (GHG) emissions, technological innovation, and long-term structural change using a systematic literature review and content analysis. Distributional equity, competitiveness, administrative capacity, and risk of carbon leakage are also examined in the study. It also analyzes the complementary tools such as voluntary carbon markets, carbon border adjustments (CBAM), revenue-recycling frameworks and just transition frameworks. It shows that carbon pricing alone cannot be used to achieve the level of decarbonization required to meet international climate targets, but is an important pillar when used in conjunction with more robust regulatory, fiscal and industrial policies. International coordination, better policy design, better revenue utilization and social fairness are important in maximizing the effectiveness and legitimacy of carbon pricing across the globe. This paper provides policy implications to policymakers, scholars, and climate negotiators to develop sustainable and equitable carbon pricing systems.

Keywords: Greenhouse Gas Mitigation, Carbon Pricing, Emission Trading System, Carbon Tax, Sustainability, Climate Governance, Green Innovation.

INTRODUCTION

Carbon Pricing as an Imperative to the Climate Crisis:

Climate change is no longer a remote environmental phenomenon, but a characteristic economic and social disaster of the twenty-first century. With the nations addressing the increasing climate risks, including extreme weather and food security and financial stability threats, the question to ask is not whether they can decarbonize, but how to do so promptly, effectively, and equally. Carbon pricing is one of the most argued, but poorly carried out, instruments among the tools at our disposal. It is interesting because of one economic intuition, which is that, should the social cost of GHG emissions be internalized in market prices, society can incentivize innovation, entrepreneurship, and investment to lead to a low-carbon future (Nordhaus, 2019; Stern, 2007).

In spite of this theoretical beauty, the world is much more complicated in practice. Approximately a quarter of the global emissions are covered by some form of a carbon tax or an ETS that is currently applied in over 70 jurisdictions (World Bank, 2023). However there is a great difference in performance. Economies with high income like Sweden and EU have demonstrated that with

high and certain carbon prices supported by powerful institutions, the reduction in emissions do not hurt competitiveness (Aldy & Pizer, 2015; Fischer & Fox, 2012; OECD, 2019). Weaker administration, political opposition, or affordability are common with lower-income and emerging economies, which results in lower prices and slight mitigation (World Bank, 2023; Jakob *et al*., 2015).

These differences disclose more serious tension: carbon pricing is not only an economic tool, but also a political institution. It impacts on livelihoods, affordability of energy, the competitiveness of industries, and development of regions all of which define the level of public acceptance. The question of regressively, fairness, and carbon leakage has been the main point of concern (Aldy & Pizer, 2015; Fischer & Fox, 2012). Therefore, to enhance the legitimacy of carbon pricing and prevent undesirable negative effects, policymakers are increasingly combining it with complementary policies, such as revenue recycling, assistance to the low-income population, just-transition policies, and border policies (ILO, 2015; IPCC, 2022; OECD, 2023).

Another layer of complexity is associated with voluntary carbon markets, international climate finance, and new trade related climate policies. Such systems pose new governance issues related to transparency, integrity, monitoring, and coordination globally (OECD, 2021; RFF, 2019). The terrain is shifting and competitive, and requires a thorough analysis not merely of price comparisons.

It is against this backdrop that this paper synthesizes evidence on the peer-reviewed studies and policy reports published between 2007-2024. It assesses the effect of carbon pricing on emissions, economic performance, technological innovation, equity and institutional development. The aim is not merely to record trends but to get the underlying structural and political realities which predetermine success- or failure-in contexts. Combining the results of the economic, social, and governance aspects, this paper provides a more accurate understanding of what efficient, fair, and sustainable carbon pricing should be.

Research Questions

The Central Research Questions Used in This Study Are as Follows:

1. What are the effectiveness rates of carbon pricing tools such as carbon taxes, ETS, and hybrid tools in lowering GHG emissions in various jurisdictions?
2. How does carbon pricing have economic and social impacts, e.g. impacts on innovation, competitiveness, equity, and income distribution?
3. What have been the political, institutional, and historical factors that influenced the adoption and implementation of carbon pricing in the world and what actions are required to fill the continuing gaps including carbon leakage, policy fragmentation, and uneven ambition?

Research Objectives

The Study Has Three Objectives That are Interrelated:

1. Demonstrate the effectiveness of carbon pricing in decreasing GHG emission between 2007 and 2024 by conducting thematic comparison and cross-country comparison.
2. Evaluate the macroeconomic, social and innovation-related effects of carbon pricing, its contribution to an equitable and just low-carbon transition.
3. Analyze the institutional, political economy, and governance aspects of the design and performance of carbon pricing regimes to understand ways of enhancing the international coordination and policy coherence.

METHODOLOGY

This paper is a qualitative research based on a systematic review of the academic and policy literature published between 2007 and 2024. Since the systems of carbon pricing vary in different countries, and the consequences of this policy strongly rely on the political, institutional, and social circumstances, a literature-based approach is the surest means to compare the systems and outline general patterns. This method is based on a broad spectrum of evidence and appraisals as opposed to concentrating on a single dataset or case.

Systematic Literature Review:

The initial step was to carry out a systematic review of the literature. The relevant studies were located with the help of specific searches in such academic databases as Scopus, Web of Science, and Google Scholar, publications of such organizations as the World Bank, OECD, IPCC, UNEP, and IMF. Keywords were carbon pricing, carbon tax, emissions trading system, ETS, carbon leakage, innovation, competitiveness, and just transition.

In developing a strong evidence base, the review only included studies that:

- Were published from 2007 to 2024.
- Examined the environmental, economic or social impacts of pricing carbon.
- Provided empirical statistics or powerful modeling.
- Focused on nation or regional policy situations.

Studies whose methods were not clear, or those that merely reiterated past results or those that were concerned with other environmental policies were not included.

Thematic Content Analysis:

We performed the analysis in two phases after gathering the literature. First, all the studies were coded

with general themes such as price levels, emissions outcomes, tech innovation, competitiveness, equity, political economy, governance, in order to make varied findings fall under distinct categories.

In the second step we sought connections of a deeper kind, such as the restriction of price ambition by political opposition, or the impact of revenue recycling on equity and popular approval. This appearance goes beyond mere summarizing of the work to justify why carbon pricing is effective in different locations.

Comparative Logic and Integrative Logic:

Since the systems of carbon pricing vary in different countries, a comparative perspective was essential. We provided the examples of EU, Canada, Sweden, California, China, Japan, and some emerging economies to demonstrate how the institutional capacity, policy design, and economic structure influence outcomes.

Our summary tables indicate: the range of price levels of carbon, the extent of the coverage, the outcome of mitigation, the purpose of the revenues, and measures of just-transition. The integration step is where the results of the environmental, economic, and governance aspects are integrated. It does not only address the question of whether carbon pricing is effective, but in what circumstances it yields greater and more equitable results.

Study Limitations:

The quality and consistency of available studies determines the strength of our conclusions as we did not use new data but published ones. Differences in the national approaches to reporting, monitoring and evaluation cause inevitable differences. We alleviate these by triangulating findings of numerous studies of high quality and where evidence is uncertain.

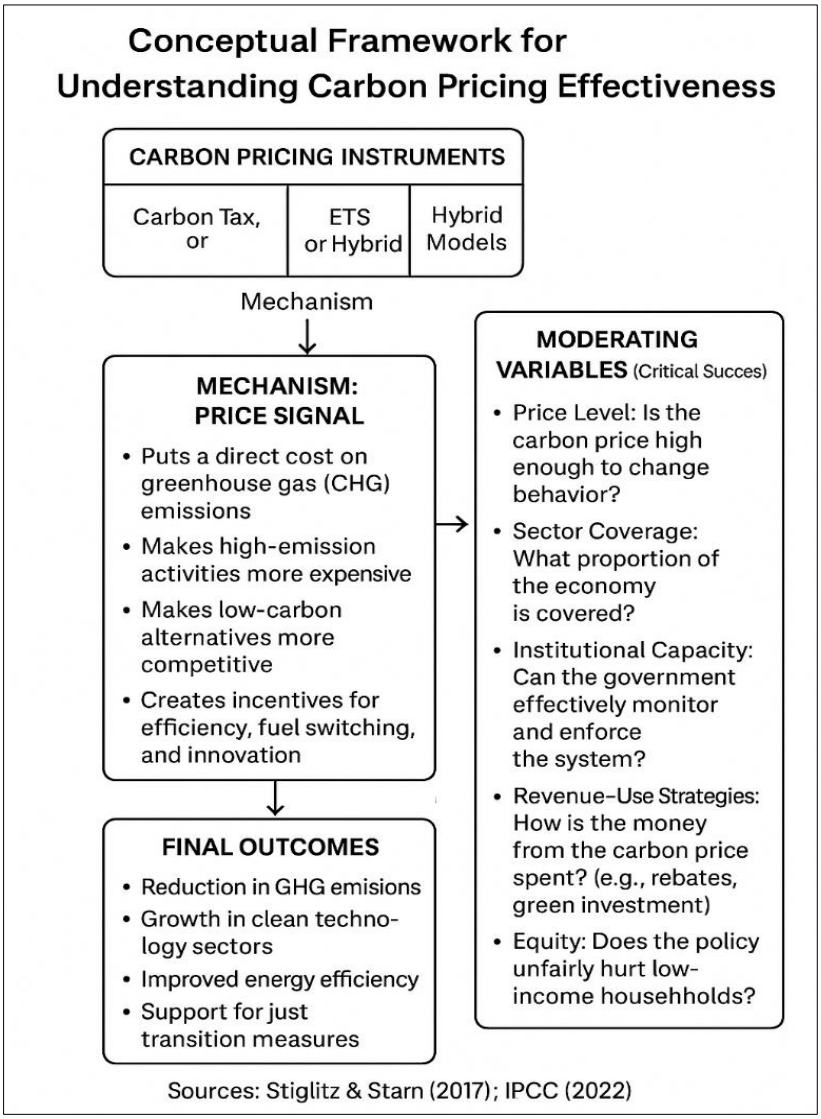

Figure 1: Conceptual Framework for Understanding Carbon Pricing Effectiveness

Figure 1: This illustrates how carbon-pricing instruments, i.e., carbon taxes, can help establish price signals that can change behavior, investment choices, and technology choices to result in environmental and economic benefits of reduced emissions, cleaner technology, and the promotion of just-transition measures. The effectiveness of such channels in their entirety depends on several moderating variables: price levels, coverage of the sector, institutional capacity, political acceptance, revenue-use strategies, competitiveness, and equity (Stiglitz & Stern, 2017; IPCC, 2022).

LITERATURE REVIEW

The Carbon Pricing Mechanisms: Taxes, Cap-and-Trade, and Hybrid Systems

The literature concerning the carbon mechanisms of pricing, such as carbon taxes, cap-and-trade systems (ETS), and hybrid models, has increased exponentially over the past years. These instruments are aimed at internalizing the cost of carbon emissions, which will stimulate investments in low-carbon technologies and reduce greenhouse gas (GHG) emissions (Doepping-Hildebrandt *et al*., 2024).

Carbon taxes place a certain price on every tonne of CO_2 (or its equivalent) and provide predictability and certainty to businesses. Empirical evidence shows that carbon taxes can reduce emissions; however, they must be planned, include some sectors, and be realized within the framework of specific policies (Klenert *et al*., 2018).

The emission cap and trading are established through cap-and-trade systems. This generates cost-effective cuts by allowing the firms that have lower abatement costs to sell surplus permits. It has been indicated that ETS may be better in areas where the abatement expenses are diverse and the monitoring is strong (Doepping-Hildebrandt *et al*., 2024).

Hybrid systems combine the stability of taxes and flexibility of markets, including a price floor/ceiling or tax regime that is adjusted based on the result of emissions. Their usage is an indication of the increasing variety of policy instruments globally (Goulder & Schein, 2013; Stavins, 2022).

The Global Ambition Gap and Carbon Price Levels:

The price level determines the success of any carbon pricing system. Despite the increased use of carbon taxes or emission trading systems (ETS) by more countries, the price levels remain largely too low to make a meaningful behavioral change, technological innovation, or national pathways remain on track with the Paris agreement. The World Bank (2023) states that over 70 jurisdictions have already adopted a price on carbon, which is over 23 per cent of the total global emissions but the degree of ambition varies widely across different jurisdictions.

Stronger price signals have been embraced by advanced economies. The ETS in the EU maintains the prices at EUR 80-EUR 100 per tonne due to stricter caps and market stabilizing reforms. Sweden operates one of the highest carbon taxes in the world of approximately US 137 per tonne and reduced emissions without growth slowdown (OECD, 2019). In Canada, the federal price on carbon is CAD $65 per tonne, and will increase to CAD $170 per tonne by 2030. The cap-and-trade system in California establishes a minimum price of about 30 US dollars per tonne by the legal reserve prices (CARB, 2023). By comparison, the national ETS in China, which is restricted to power generation, trades under $10 per tonne, which is indicative of its youth, narrow scope and poor compliance (World Bank, 2023).

Such discrepancies explain one of the problems around the world: the average price is approximately 22 per tonne- far lower than what science and economics need to reduce emissions. High-Level Commission on Carbon Prices (Stiglitz & Stern, 2017) proposed that the majority of the nations should price carbon at a range of 50 to 100 tonne by 2030 to remain on 1.5 2 C trajectories. The IMF (2021) validates that the global prices should be increased, particularly in the biggest emitters, to avoid lock-in and bridge the ambition gap.

Low Prices are kept by a Series of Factors:

The unwillingness of the population to pay more on energy; lobbying by the energy-consuming industries; the insufficient administrative capabilities in the developing economies; the subsidies on fossil fuels that distort the market. Prices lower than 30 USD/ tonne are not likely to motivate firms to invest in clean technology or substantial reduction of emissions.

To solve these issues, global entities and economists are campaigning against unilateral price floors worldwide. The IMF (2021) suggests differentiated minimums; $75 in developed countries, $50 in developing countries, and $25 in low-income countries, to balance between competitiveness and leakage and to provide investors with predictable signals. A concerted effort will enable nations to reduce ambition without being unfair or volatile.

Carbon pricing can only work to its full potential when the price is high, predictable and cross-border harmonized. It is also crucial to raise global ambition and cover more sectors with clean-energy investment, industrial transition support, and strong social protection to make sure that the carbon pricing would provide actual emissions reduction and a fair route to the climate targets.

Carbon Pricing Performance Comparative Regional Analysis:

The carbon pricing regimes among different regions are quite different, and they contribute to the understanding why some jurisdictions experience greater

emissions decrease than others. It has been demonstrated that greater prices, foreseeable policy paths, and robust institutional structures are generally the most effective towards providing the most significant climate results (World Bank, 2023).

The most established carbon market in the European Union is the EU Emissions Trading System (EU ETS). Its prices have stabilized at EUR 80-EUR 100 per tonne. Since 2018, the number of covered emissions has reduced by 37 percent compared to 2005 due to reforms (European Commission, 2023). This is made successful by the reduction of the cap, increased monitoring and tightened Market Stability Reserve.

Sweden has one of the highest carbon taxes in the world, approximately 137 per tonne, but has reduced its emissions by over 30 per cent since 1990 and has been enjoying high economic growth (OECD, 2019). This example demonstrates that economic prosperity can exist with high predictable carbon prices.

The hybrid system of Canada, a combination of carbon tax and output-based pricing system, was at CAD 65 per tonne in 2023 and is set to increase to CAD 170 by 2030. The government recycles income by using household subsidies, which increase the support of the populace and alleviate distributional impact (IMF, 2023).

The cap-and-trade program in California has a price floor of about 30 tonnes. California continues to record stable emission cuts, particularly in the electricity and industry despite the fact that they are lower than those in the EU or Sweden (CARB, 2023). The national ETS in China which is the biggest in terms of volume is currently trading at below 10 per tonne. Although it has enhanced the quality of data, transparency, and power-sector monitoring, the low price cap restricts the effect of mitigation in the short-term (World Bank, 2023). China is intending to spread the ETS to other sectors.

Important lesson: The most significant improvements are observed in jurisdictions whose price signals are more stable and higher, like EU and Sweden. Lower priced or less sector covered areas such as China get smaller effects. Strong institutions, transparency, and sound revenue recycling create trust in the public and guarantee sustainability of policy in the long run (Pizer & Aldy, 2016).

Table 1: Summary of Price Level and Carbon Pricing Instruments in Selected Areas and observed results

Region / Jurisdiction	Carbon Pricing Instrument	Approx. Price Level	Sector Coverage	Observed Outcomes	Sources
The European Union (EU ETS)	Emissions trading system is based on the market	€80–€100 per tonne	Energy, transportation, aviation.	=37% reduction in covered emissions since 2005	European Commission (2023); OECD (2021)
Sweden	Carbon Tax	=$137 per tonne	Economy-wide (with some exemptions)	>30% emissions reduction since 1990; GDP growth	OECD (2019); Stiglitz *et al*., (2017)
Canada	Hybrid system (carbon tax + OBPS)	CAD $65 (rising to $170 by 2030)	Transport, buildings, industry	Reduced coal use; public support enabled by rebates	IMF (2023); OECD (2021)
California (USA)	Cap-and-Trade (linked to Québec)	=$30 per tonne	Power, industry, fuels	Steady emissions decline in covered sectors	Burtraw *et al*., (2018); CARB (2023)
China	National ETS (Phase 1)	<$10 per tonne	Power sector	Improved reporting; limited mitigation due to low price	World Bank (2023); IPCC (2022)
South Africa	Carbon Tax	=$9 per tonne	Economy-wide (with large allowances)	Early-stage effects; emphasis on equity	IMF (2022); UNEP (2023)

Table 1: The approximate price levels and mitigation results are based on reports of European Commission (2023), OECD (2019; 2021), IMF (2022; 2023), World Bank (2023), CARB (2023), and IPCC (2022). Differences in the coverage of sectors, methods of allocation, and institutional capacity are some of the factors that explain much of a performance disparity across jurisdictions.

Economic Effects of Carbon Pricing: Economic Growth, Competitiveness, and Market Dynamics:

Economic analyses emphasize the point that carbon pricing would result in innovation and energy

efficiency (Resources for the Future, 2019; Stavins, 2022). Nonetheless, it can increase the production cost of carbon-intensive sectors, which can be less competitive and cause carbon leakage, i.e., production will transfer to areas with less effective policies (Doepping-Hildebrandt *et al*., 2024).

The overall effects on the economy are determined by the design of policies, the recycling of revenues, and the complementary actions (Doepping-Hildebrandt *et al*., 2024). International studies identify that ETS implementation also has a relatively higher reduction of emissions compared to taxes, partly because of the differences in conditions of operation and market incentives (Köppl & Schratzenstaller, 2023).

Carbon Revenue Use: Fair, Effective, and Politically Durable Carbon Pricing Systems:

The manner in which governments spend the money generated through carbon pricing is a decisive-yet frequently neglected factor in the performance of policy. The distribution of revenues also affects the efficiency of the economy, the reduction of emissions, the social justice of the society, the political acceptability, and the sustainability of the carbon pricing regime in the long run. According to the OECD (2019) and IMF (2023), revenue recycling can make carbon pricing either a widely-endorsed climate measure or, on the contrary, an issue of significant opposition among the population.

The revenue of carbon can be channeled in various directions with different advantages. The most frequent method to recycle the revenue of carbon is to re-distribute the money to households. Canada and Switzerland, among other countries have demonstrated that regressive impact of carbon-taxes are completely offset by targeted rebates which safeguard low- and middle-income families against the increased cost of energy. IMF (2023) observes that revenue-neutral carbon pricing, which would give all dollars back to citizens, would not increase or decrease the standard of living but would ensure a high level of emissions-reduction incentives.

The other significant application is to decrease other taxes. In some instances referred to as the double dividend, this method enables governments to reduce distorting taxes such as payroll or income taxes, which improves the efficiency of the economy. Empirical studies by Parry and Williams (2010) and Goulder (2013) reveal that carbon pricing can be counterbalanced by labor taxes reduction to reduce the adverse effects on job and competitiveness, which would render the policy more palatable to industry and employees.

More jurisdictions are also spending carbon revenues on clean-energy building and resilient infrastructure. Funding renewable energy, energy efficiency, mass transit, and green technology will hasten the adoption of low-carbon technologies and increase the positive environmental impacts of carbon pricing. According to the World Bank (2023), this approach works particularly well in emerging economies where the gap in investments is large, and the supply of clean-technology is low.

Revenue can also sustain workers and communities that are affected by structural change. According to the IPCC (2022), coal, oil, and gas industries will lose jobs in the process of decarburization. The distribution of revenue to retraining, social protection and regional development makes the transition easier and lessens political resistance. The case of Germany, with its coal phase-out fund, and Spain, with its Just Transition Agreements, show that revenue-based transition policies can create political agreement even in areas where the fossil fuels were historically the foundation of the economy.

Lastly, revenue distribution creates confidence among the population through transparency and accountability. Pizer & Aldy (2016) discover that citizen's support increased carbon costs when they understand revenue utilization and can observe the real gains like improved transit or cleaner air. Such a combination of easy communication and tangible social and economic gains makes skepticism less and increases political sustainability.

Concisely, carbon revenue is not just a by-product, it is a strategic instrument. Effective revenue recycling can safeguard households, promote competitiveness, promote clean-energy investment, and create fairness in the process of the low-carbon transition. Improperly designed revenue systems have the potential to undermine political backing and deteriorate environmental performance. Carbon pricing can only succeed in the long run with transparency, effectiveness, and equitable use of the carbon revenue.

Table 2: Examples of Revenues and Policy Effects of Carbon Pricing

Revenue Use Category	Description	Expected Outcomes	Examples / Supporting Sources
Household Rebates / Social Transfers.	Providing direct payment to families in the form of lump-sum payments or in the form of tax rebates.	Promotes equity, reduces repressiveness, and strengthens popularity.	Climate action incentive in Canada (IMF, 2023; OECD, 2019).
Reducing Other Taxes ("Double Dividend")	Using revenue to lower labor, income, or payroll taxes.	Enhances efficiency in the economy; minimizes distortionary taxation; enhances employment.	Parry & Williams (2010 Goulder, L. H. (2013).
Low-Carbon Investment and Clean Energy.	Investing in renewable energy, energy efficiency, and public transport and innovation programs.	Increases the acceleration of decarburization; enhances the use of technology; facilitates the transition in the long term.	World Bank (2023); OECD (2021).
Industry Competitiveness Support.	Transitional subsidies, output subsidies or decarburization grants on emissions-intensive industries.	Eliminates the risk of leakage; maintains the level of competitiveness; promotes efficiency.	Aldy & Pizer (2015); Fischer & Fox (2012).
Measures of Just Transition.	Investing in retraining, employee welfare and local economic growth in areas that rely on fossil fuels.	Makes it fairer; decreases the opposition to climate policies; secures the vulnerable workers.	ILO (2015); IPCC (2022).
General Budget Revenue	Integrating carbon revenues into national budgets without earmarking.	Easier fiscal aid can prove helpful, yet will decrease the transparency of climate-related spending.	OECD (2019); Dobbeling-Hildebrandt *et al*., (2024).

Table 2: The revenue-use categories and outcomes are based on the established practices in Canada, the EU, and other jurisdictions, which are summarized by the OECD (2019; 2021), IMF (2023), World Bank (2023), and IPCC (2022).

Environmental Impact: Emission, Resource Distribution and Protection of Biodiversity:

In a recent meta-analysis of 21 carbon-pricing schemes around the globe, the statistically significant post-implementation emission reductions following adoption of a policy varied between about 5 percent and 21 percent, but again, the strength varies depending on the scheme and context (Doepping-Hildebrandt *et al*., 2024). Such policies also redistribute resources towards industries with lower carbon content, encourage the use of renewable energy, and help better use non-renewable resources when combined with other environmental control tools, which leads to the protection of biodiversity and long-term sustainability (Hepburn *et al*., 2020; IPCC, 2022).

Just Transition Social Equity and the Distributional Dimensions of Carbon Pricing:

The effects of carbon pricing are usually considered in terms of environmental and economic impact, yet social impacts are also critical. There is a growing literature indicating that carbon pricing can only be effective when it safeguards vulnerable families, helps those in the impacted sectors, and ensures that it does not lose the confidence of the population. These are the issues that are at the core of what is now commonly termed as a just transition.

Carbon pricing has the potential to impact low-income households disproportionately since a bigger portion of their income is used on basic energy and transportation expenditures. Carbon taxes are retrogressive and politically controversial without mitigation measures. According to the International Labor Organization (ILO, 2015) and OECD (2019), these effects can be entirely compensated by fair revenue recycling, in the form of specific rebates, subsidies on public transport, or other taxes. Canadian experience, as well as experience in Switzerland and some EU countries, demonstrate that the distribution of carbon revenues to households does not only make the situation fairer, but also makes people more willing to accept higher carbon prices (OECD, 2019).

Just transition also includes workers and communities whose means of livelihood rely on fossil-fuel-consuming practices. The move towards abandoning coal, oil, and gas can form focal areas of economic instability. According to the IMF (2022), the prices on carbon need to be effective and complemented by labor-market transition policies, including retraining workers, income support, early-retirement benefits, wage insurance and investments that will create new jobs in clean sectors. With these measures, the resistance of workers, unions and local governments who tend to

decide on the political feasibility of climate policy reforms, is minimized.

Considerations of equity are also cross-country. Most developing economies are more susceptible to climatic effects, less financially stable, and their systems of social protections are fewer. According to IPCC (2022), without global support, carbon pricing in poorer settings might be impractical and might lead to poverty increase. Climate-change financing, technology transfer and concessional financing of clean energy and adaptation is necessary to make global carbon-pricing plans equitable and sustainable.

More importantly, carbon pricing can only be legitimate when people trust it. According to a study conducted by Klenert *et al*., (2018) when revenues are spent in a transparent and socially productive manner, citizens are much more likely to endorse ambitious carbon policies. Open communication, inclusive decision-making, and apparent investment in the public goods including energy efficient housing, clean transportation, and community transition funds contribute to creating a long-lasting political support.

Combining these points, one can make a conclusion that carbon pricing is not only an environmental or economic instrument, but also a social contract. Carbon pricing has the capacity to lower emission when it is coupled with fair usage of the revenue, sound labor legislation and well-developed transitional policies and also in improving social harmony. Lack of such measures, even technically sound systems face the risk of being backlashed by the people, political instability, and policy reversal. Just transition is therefore the key to the success, credibility, and social acceptability of carbon pricing throughout the global community.

Table 3 provides a summary of the key factors of a just transition framework that are prevalent in the climate policy literature.

Table 3: The Major Elements of Just Transition in Policies to Price Carbon

Just Transition Component	Description	Intended Outcomes	Examples / Supporting Sources
Household Protection Measures	Rebates, subsidies on energy or compensation to low-income household	Decreases progressively; preserves affordability; fosters public endorsement.	OECD (2019); IMF (2023).
Worker Support & Retraining	Employee placement, wage insurance, and skill development to employees, fossil fuel-based industries.	Protects the livelihoods, facilitates transition in the labor market, and reduces opposition.	ILO (2015); IPCC (2022).
Regional Economic Diversification	Investing in new industries, support to SME and local development in the affected areas.	Stops the decline of regions, lowers inequality, and makes people stronger.	UNEP (2023); Jakob *et al*., (2015).
Social Dialogue & Stakeholder Engagement	Engaging of unions, communities and local governments in planning.	Makes things more legitimate to people, reduces dispute and makes policy design to be better.	ILO (2015); IPCC (2022).
Social Protection Systems	Unemployment benefits, safety nets and transition assistance.	Secures the populations at risk; strengthens equality; secures political tolerance. .	OECD (2019); IMF (2023).
Investment in Public Goods	Clean transport, energy efficiency and health co-benefits funding.	Strengthens equality and spreads the benefits of climate equally.	IPCC (2022); UNEP (2023).

Table 3: highlights some of the most commonly accepted aspects of a just transition framework as found in major works on climate policy, such as ILO (2015), OECD (2019), and IPCC (2022).

Policy Implementation Problems and Success Factors: Case-Study Lessons:

The implementation studies have demonstrated that effective results are based on the carbon pricing policies being carried out with more robust structures of governance within the jurisdiction, transparency, enforcement, and political will (Doepping-Hildebrandt *et al*., 2024).

Carbon pricing is also proposed in case studies to be more effective when it is implemented in combination with complementary policies to fight climate change, e.g., renewable energy subsidies and energy efficiency standards (Resources for the Future, 2019; Stavins, 2022).

New Carbon Pricing Trends: Innovation, Adaptation and Global Cooperation:

The policy of carbon-pricing also develops. Some of the innovations are block chain-based trading, industry-specific pricing, and connecting national schemes. They are moving towards more adaptive and

cooperative international systems that are aligned with the Paris Agreement and Sustainable Development Goals (SDGs) (Magnotti *et al*., 2024).

Carbon Markets and Voluntary Markets and Integrity:

Besides managed carbon-pricing mechanisms, voluntary carbon markets (VCMs) have expanded rapidly because companies strive to achieve net-zero goals. These markets also allow firms to obtain carbon credits generated in other projects such as reforestation, renewable energy, or even carbon capture projects. Even though VCMs can redirect funding to climate mitigation (particularly in the third-world countries), their effectiveness depends on the quality of the environmental soundness of the credits issued (World Bank, 2023).

According to recent research, there are still concerns about additionally, over-crediting, permanence, and double counting. A study on several offset programs found that some of the projects would have occurred without carbon finance, which meant that the credits did not show real emission reductions (IPCC, 2022). Such problems of integrity have weakened the trust of the people and cast doubt on whether VCMs are actually working towards the global climate objectives.

New governance structures are coming up to fill these gaps. To set minimum quality carbon credit standards, the Integrity Council of the Voluntary Carbon Market (ICVCM, 2023) introduced its Core Carbon Principles, yet the Voluntary Carbon Market Integrity Initiative (VCMI, 2023) provides a general overview of the way companies may utilize offsets in a credible manner. These are supposed to help in increasing transparency, improving verification, and making the carbon credits be based on actual and measurable climate benefits.

Nonetheless, even quality offsets are not able to replace profound emissions cuts in company operations. The IPCC (2022) and ICVCM (2023) recommend that voluntary markets will serve as a complement, as it will not delay the decarburization that is needed but will benefit hard-to-abate sectors. The integrity, avoidance of green washing, and consistency of VCMs with Article 6 of the Paris Agreement are also subjects of concern in the future viability of the system.

Carbon Border Adjustments and Global Trade Implication:

Carbon border adjustment mechanisms (CBAMs) are becoming a key instrument in the management of carbon leakage, which is a key issue whenever countries have varying prices on carbon. Leakage is a practice of companies moving their production to areas with less stringent climate policies, compromising the environmental soundness of carbon pricing systems (Aldy & Pizer, 2015; Fischer and Fox, 2012). CBAMs will serve to level the costs of carbon on imported goods by imposing a charge on imported products based on the carbon content, so that domestic producers who pay a price on carbon can have their costs matched with foreign producers who are not required to pay a price.

The European Union has also led the way with its CBAM which initially focuses on carbon-intensive products including steel, cement, aluminum, and fertilizers. Even though the CBAM is still in its transition stage, it is an important advancement in the field of international climate governance due to its incorporation of domestic pricing of carbon with trade policy. Studies indicate that border adjustments can decrease the risks of leakage and can assist in ensuring industrial competitiveness in the face of increased carbon pricing (Carbone and Helm, 2019; Cosbey *et al*., 2019).

Nevertheless, there are also crucial equity and governance issues with CBAMs especially to developing nations that are major exporters of energy-intensive products. The IPCC (2022) and OECD (2021) also state that carbon border measures can increase the existing inequities in the global trade unless it is complemented by the necessary support, such as technology transfer, capacity-building, and differentiated implementation. Moreover, successful CBAMs must have strong emissions-accounting mechanisms that would prevent duplication and promote fairness within jurisdictions (Cosbey *et al*., 2019).

With the globalization of carbon pricing, carbon border adjustments will become more and more important to climate and trade policy. They are effective when they are designed transparently, in accordance with international trade rules and closely collaborate with the developing economies to prevent unintentional economic damages. CBAMs can support domestic carbon pricing and increase the global climate ambition when applied in a responsible manner.

Carbon Pricing Political Economy and Governance:

The success of carbon pricing is not only through economical design but also through political institutions, stakeholder liking, and ability to govern. These policies are a result of negotiations between governments, industry groups, labor unions, and the civil society in many countries. The power, consistency, and reliability of the pricing systems are typically determined by political processes rather than technical aspects (Pahle *et al*., 2018; Hepburn *et al*., 2020).

Sustainability is contingent on the manner in which the concerned governments manage resistance of affected industries and consumers. The energy-intensive industries tend to oppose the high prices of carbon due to the fear of losing competitiveness. The policymakers ease these concerns by implementing free allocations, transitional exemptions, or output-based pricing

mechanisms (Aldy & Pizer, 2015; Fischer and Fox, 2012). As much as these actions drop the intensity of politics, they may also undermine decarburization motivations.

Institutional capacity is also important. Compliance and trust among the population are developed by transparent measurement, reporting, and verification (MRV) systems like the EU ETS and the California cap-and-trade program (Burtraw *et al.,* 2018). On the other hand, ineffective governance compromises the performance of policies. The signal on the carbon price is less credible when there is inconsistency in implementation and inaccuracy of the data (World Bank, 2023).

The history of the world reveals the impacts of politics on the course of events. In Japan, policy competitiveness and policy adequacy led to a small tax design (Kameyama *et al*., 2019). The lack of federal action in the United States led to regional programs such as the Regional Greenhouse Gas Initiative (RGGI) and California cap-and-trade system, which can serve as an example of how climate policy can advance despite federal stagnation on progress at the nationwide level (Burtraw *et al*., 2018). Political issues of energy affordability and equity are troubling many developing economies and are hindering adoption and constrain price ambition (Jakob *et al*., 2015).

International politics make it complicated. The impact of exposure to global supply chains, trade competitiveness pressure, and geopolitical relationships on domestic carbon pricing decisions (Cosbey *et al.,* 2019). The trade relations between countries tend to change climate policies to prevent a loss of market share or carbon border adjustments by important trading partners.

In brief, carbon pricing is more of a political institution than a financial institution. Political legitimacy requires strong governance, good stakeholder interaction, clear enforcement and clear long term direction. Even well-constructed pricing systems fail to provide a sustained reduction in emissions without the support of politics.

DISCUSSION OF FINDINGS

Environmental Sustainability Implications, Mitigation, Adaptation, and Resilience: Incorporating Carbon Pricing into Larger Sustainability Initiatives

The pricing of carbon is no longer a theory but a successful tool to cut emissions. In a 2024 meta-analysis, Doepping-Hildebrandt *et al*., (2024) analyzed 21 pricing schemes on carbon all over the world and found that 17 of them led to significant emissions reductions, with an average of 5 to 21 in the years after the schemes were implemented. Carbon pricing has obvious outcomes when it is designed and implemented properly.

Nevertheless, carbon pricing alone will not be sufficient to tackle the challenge. The OECD (2023) highlights the fact that carbon pricing should be embedded in the context of a broader climate policy, i.e., it should be regarded in the context of taking into consideration the notion of clean-energy investment, behavioral incentives, plans of adaptation, and effective cooperation at the international level. Carbon pricing cannot achieve the amount of decarburization needed to achieve net-zero targets without supporting policies. Its message is clear: it has to be a main pillar and not an independent tool.

Creating Innovation based on Market Signals:

Putting a price on emissions changes the manner in which firms consider costs and investments. Carbon pricing also alters the investment preferences, making the polluting firms less attractive and the clean technologies more attractive. A study by Marin, Vona, Consoli, and Popp (2023). Concluded that an increase in the future price of carbon by one dollar increased low-carbon patent applications by 1.4% in 2 years.

Expanding on this, Van den Bergh (2021) discovered that environmental costs are reflected in the price of energy with a carbon content, and firms are likely to develop and use cleaner technologies when such costs are part of the energy costs. Carbon pricing will therefore not only help decrease the amount of emission but also create an economic space where low-carbon solutions can be developed in the future.

Adaptation, Resilience, and Equity:

There is the need to reduce emissions, but the societies need to adapt to the consequences of climate like climate change and extreme weather. The revenue can be used to finance adaptation activities (e.g., resilient infrastructure and early-warning systems) with the help of an effective carbon tax (World Bank, 2022). Equity is also important. Unless it is protected, carbon pricing might disproportionately affect low-income households. Revenue can be used by the governments in the form of rebates, subsidies on the public transport, or job-transition programs (OECD, 2023; ILO, 2015). Such a strategy helps to make a fair transition and increase the level of acceptance of the population.

The Holistic Policy Framework:

The regulations, clean-energy investments, and social protection are to be combined with carbon pricing. Combined with those factors, it will lower emissions, foster innovation, and become more resilient over the long run (IPCC, 2022). To achieve the desired results, it is necessary to have well-planned policies that are just and directly linked to larger climate and development policies.

The purpose of carbon pricing in meeting the climate targets: Empirical evidence shows that companies and industries react to carbon prices. Doepping-Hildebrandt *et al*., (2024) stated lower emissions on an average basis in carbon-pricing areas. However, the OECD (2023) cautions that in order to achieve the Paris Agreement and in particular the 1.5°C goal, prices should be higher and more uniform across the board and supported by auxiliary policies like clean-energy rollout and energy-saving enhancements.

Innovation and Adaptation to Low-Carbon Technologies: The climate transition is a successful process driven by innovation. Carbon pricing is found to give long-term indications that motivate investment in innovative technology (Marin *et al*., 2023). When the companies estimate the higher costs of CO_2 in the future, there is a high possibility that they will invest in low-carbon research and development. Van den Bergh (2021) confirms that energy prices with carbon make whole sectors turn to sustainable innovation. The long-term impact is a shift of the technological frontier to normalized solutions of clean energy.

Supply Chains, Structural Transformation, and Industrial Sectors:

Carbon pricing reforms industries are not only through innovation. Döbbeling-Hildebrandt *et al*., (2024) discovered that the emission reductions were uneven across the sectors, and this was based on the way the pricing system was established and the exposure of the sector to the cost pressures. Practically, pricing is a reason to inspire firms to reconsider supply chains, increase efficiency, and make business models sustainable-oriented. In the long term, this helps to facilitate a wider structural change in the direction of less carbon-intensive systems to more resilient systems.

Global Strategic Considerations: Policy Coordination, Trade and Governance: Carbon pricing is not a concept that operates on its own especially in the contemporary globalized economy. In a situation where a number of countries implement high prices, and others do not, border leakages will occur, jeopardizing the objectives of climate and competitiveness. There is a need to coordinate international policies. Such instruments as border carbon adjustments, standardized emissions accounting, and international agreements can be used to provide a level playing field and to make carbon pricing more effective. However, it is possible to design policies that reinforce each other and not weaken the other when the countries act predictably, transparently, and collaboratively (Aldy & Pizer, 2015; OECD, 2023)

Figure 2: International Diversity and Policy Fragmentation in the implementation of carbon pricing

Figure 2: illustrates that policies of carbon pricing vary across countries and regions in terms of price levels, coverage, institutional strength, and utilization of revenues. The implementation failure leads to price distortions, the threat of carbon leakage, and competitiveness problems; the global governance should be harmonized (Dobbeling-Hildebrandt *et al*., 2024; OECD, 2023; IPCC, 2022).

International Diversity, Policy Fragmentation and Global Strategic Coordination:

Carbon pricing is practiced globally, but its unequal implementation leads to the fragmentation of the system as a company can shift to the jurisdictions with lenient policies (World Bank, 2022; CPLC, 2023). In more aggressive jurisdictions, carbon leakage is punished because a company can move to the jurisdiction with weaker policies (OECD, 2023).

Harmonization and cooperation of policies are therefore required. Such instruments as the Border Carbon Adjustments (BCAs), which have already been piloted by the EU, can contribute to the level of the playing field; that is, carbon intensity can be introduced into the rules of trade (World Bank, 2022). The efforts to develop carbon-price signals and emission-accounting conceptions include the High-Level Commission on Carbon Pricing and the Carbon Pricing Leadership Coalition, which is important in terms of the cross-border harmonization of signals (CPLC, 2023).

According to recent studies, the price signals are potentially reinforced with the assistance of the coordinated carbon-pricing programs, i.e., the connection of the system of emissions trades with the EU or with other partner areas (World Bank, 2023; OECD, 2023). Fragmented systems, on the other hand, obstruct the goals of mitigation and competitiveness.

Carbon pricing would have to be integrated into an internationally consistent structure to achieve global climate goals, namely, clear rules, effective monitoring, and policies to adapt as economies and technologies evolve. The IPCC (2022) has suggested that the cooperation of countries is not a choice but the foundation of a fair, ambitious, and effective pricing system.

Table 4: A Snapshot of Ambition and Implementation Global Carbon Pricing in 2023-2024.

Region	Jurisdiction & Instrument	Price (USD/tCO_2e)	Ambition Level
Europe	Sweden (Carbon Tax)	=$137	High
Europe	EU ETS	$90 - $110	High
North America	Canada (Federal Carbon Tax)	=$65	High
North America	California, USA (Cap-and-Trade)	=$30	Medium
Africa	South Africa (Carbon Tax)	=$9	Low / Emerging
Africa	Kenya	Planning Stage	Planning
Africa	Senegal	Planning Stage	Planning

Table 4: Global Context Only about 23 percent of the world emissions are priced by carbon but the amount of the pricing is drastically different, which raises competitiveness issues and contributes to the requests of the international price floor (World Bank, 2023).

The Evaluation of the Value of Carbon Pricing in World Climate Regulation and Cooperation:

Finally, carbon pricing can be applied to close the gap between environmental ambition and economic reality by enhancing the delivery of climate objectives by cutting emissions further, investing in clean technologies, and making more informed consumer decisions. The effectiveness of carbon pricing when introduced intelligently can be seen in the literature of Doepping-Hildebrandt *et al*., (2024) and Cantone *et al*., (2023), but it requires being extensive, carefully planned, and part of a coordinated policy. The prices should be pegged to international systems, with the assistance of government policy, and adjusted to changing economic and climatic conditions. Carbon pricing can only achieve its agendas as a major contributor to international climate collaboration and regulation at this point.

Future Research Limitations and Directions

Despite the extensive research on carbon pricing, there are still major drawbacks that hamper our capacity to assess its environmental and economic impacts in the long run. The major issue is how to separate the impacts of carbon pricing with other related climate policies, including renewable energy subsidies, efficiency standards or industrial regulations. According to the OECD (2021) and RFF (2019), carbon pricing is most often not implemented alone, and it is difficult to track the effects of identified emissions decreases to one tool.

The other limitation is related to data quality and consistency, particularly in the developing and emerging economies. The ineffective monitoring, reporting and verification (MRV) systems can cause uncertainty of the real level of emissions, compliance and responsiveness to price signals (World Bank, 2022; OECD, 2023). Such inadequacies complicate cross country comparisons and may lead to an over or under

estimate of the actual effectiveness of the carbon pricing systems.

A third limitation is that most empirical studies are limited to short periods. Many of the largest carbon pricing systems, such as ETS in China and recent reforms to the EU ETS are relatively new, and their long-term impacts on innovation, structural change, and competitiveness cannot be fully evaluated as yet (IPCC, 2022; Kameyama *et al.,* 2019). The studies must be extended over time to determine how price signals influence the investment cycles and technology adoption.

Moreover, the majority of studies concentrate on high-income areas that have well-developed institutions, including the EU and North America. Less attention is paid to low-income countries. Within such environments, the policy outcomes are influenced by political-economic limits, energy-affordability issues, and low administrative capacity (Jakob *et al*., 2015). Further empirical research is required to demonstrate how pricing of carbon may be adjusted to the development requirements of the low-income areas.

Finally, the available literature is likely to ignore the social consequences on a larger scale, including the labor-market impacts, the distributional impacts, and the rightfulness of politics. Even though equity is gaining more acceptance (ILO, 2015; OECD, 2019), there is limited evidence on the social implications of carbon pricing, particularly in the vulnerable populations.

Future Studies Should Therefore Concentrate On:

- Long-term analyses of the effects of carbon pricing in increasing systems (IPCC, 2022).
- Better MRV and harmonized emissions-accounting systems so that they could make more cross-country comparisons (Cosbey *et al*., 2019).
- Comprehensive evaluation of the carbon pricing in developing economies, incorporating the political-economy limitations (Jakob *et al*., 2015).
- Experimental studies on carbon pricing and complementary policies (e.g. subsidies and standards) (OECD, 2021; RFF, 2019).
- Social and labor impacts, including the impact of carbon pricing on employees, processes of just transition, and equity (ILO, 2015; OECD, 2019).

Overall, though carbon pricing is one of the most effective mechanisms of decarburization, to further develop the evidence base, more long-term, more representative, and global research is needed.

CONCLUSION

This paper prove that carbon pricing, in terms of carbon taxes, emissions trading, and hybrid models, remains among the most effective and economically efficient tools of decreasing greenhouse-gas emissions and promoting structural change in the long term. Even within regions and across different policy designs, it has always been demonstrated that properly designed schemes reduce emissions, enhance innovation in clean-technology and boost the economic basis of a low-carbon transition. The effectiveness of this mechanism lies in the fact that it aligns market incentives to the environmental goals, it internalizes the actual cost of carbon in firms and it focuses investment in cleaner production and consumption.

Nevertheless, the study establishes that carbon pricing will not be sufficient to achieve the magnitude and pace of decarburization that is required to address global climate goals. Policy design, price ambition, sectorial coverage, and most importantly the use of revenues is vital in its environmental and economic success. Carbon pricing will not provide optimal results without complementary policies like the introduction of clean-energy, energy-efficiency policies, industrial-transition policies, and strategic government investment. Ineffective carbon-pricing programs may aggravate inequality, impose greater burdens on households with low incomes, and create competitive issues with industries that are highly dependent on emissions. The risks may be addressed through the targeted recycling of revenues, social protection, and strategic industrial policy.

The results also show the increased importance of global coordination. In a globalized economy where production and investment can move across borders quite freely, the risk of carbon-leakage increases and joint efforts on climate can be undermined by unequal systems of carbon-pricing. The border-carbon adjustments, harmonized emissions accounting and cooperative implementation of the Paris Agreement under Article 6 can mitigate the difference and enhance global performance. Due to increased carbon pricing, policy compatibility, transparency, and predictability will be the key to remaining competitive and enhancing global mitigations.

Overall, carbon pricing is not a silver bullet but it is one of the main pillars of contemporary climate governance. Combined with a wider set of regulatory, fiscal and innovation-based policies, it can provide strong incentives to reduce emissions, create technological transformation, and sustain a just and strong shift. The future of carbon pricing in the development of a sustainable and inclusive economic future will rely on strengthening international collaboration, improving equity concerns, and raising the level of carbon-price ambition.

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