

A Nonlinear Analysis of Carbon Pricing Mechanisms: Comparing the Economic Impacts of Carbon Tax and Emissions Trading Schemes in Developing Economies

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Abstract:

This study evaluates the relative effectiveness of Carbon Tax and Emission Trading Schemes (ETS), for developing economies, in promoting economic growth as well as emission reductions. A systematic literature review (SLR) analyzing 36 studies is employed for this purpose. Findings reveal that Carbon Tax brings temporary economic deceleration but fuels long-term sustainability with clearer direct impacts. ETS also achieves the same objectives with greater flexibility thereby offsetting the negative impacts of Carbon Pricing via price volatility. Revenue recycling is a key tool to address economic disbenefits. This study sheds an urgent light on the imperatives for region-specific policy designs and forthcoming hybrid mechanisms as well as longitudinal socioeconomic effect investigation among underrepresented developing regions.

Keywords: Carbon Tax, Emission Trading Schemes, Developing Countries, Systematic Literature Review

1. Introduction

In the current dynamics of the world, developing economies are facing a dual challenge. Most development policies tend to promote economic well-being, whereas environmental policies restrict the same (El-Ashry, 1993). Therefore, it is imperative for economies around the world to sustain rapid economic growth while also addressing environmental degradation alongside the pressing issue of climate change. The UN (n.d.) records that over 3.2 billion people, almost 40%, of the global population have been negatively impacted by land degradation. Around \$577 billion of annual crop production globally, is at risk. Additionally, almost 25% of the overall greenhouse gas emissions are caused by the clearing of land, crop production, and the excessive use of fertilizers. The case is quite alarming. Most nations across the world have predominantly focused on industrialization and economic expansion. This has helped in poverty reduction and improvement of living standards. Industrialization exhibits an increase in productivity within sectors besides structural changes which is accompanied with massive economic growth (Erumban & de Vries, 2021; Kniivila, 2007). However, this approach comes with increased carbon emissions and harm to the environment. Industrialization records a significant positive relation with environmental degradation across Asia-Pacific nations such as India, Pakistan, and many more (Ahmed et al., 2022; Farooq et al., 2019; Parveen et al., 2019). This is not limited to this region only. As economies transfer to more sustainable models of development, the implementation of carbon pricing mechanisms such as Carbon Tax and Emission Trading Schemes (ETS) become mandatory. These tools have emerged to mitigate environmental damage while ensuring long-term growth.

Carbon pricing involves assigning a cost to carbon emissions. UNFCCC (2023) recognizes carbon pricing as a cost-effective means to reduce greenhouse gas emissions as the costs are borne by

companies and societies via an array of impacts. It creates a financial incentive for businesses and industries alike, to reduce their carbon footprint. The two primary forms of carbon pricing are Carbon Tax and ETS. The former imposes a fixed cost on carbon emissions directly whereas the latter establishes a market for trading emission permits. It facilitates firms to buy or sell allowances depending on their emission needs. As of 2023, carbon pricing revenues recorded a total accumulation of \$104 billion with around 75 carbon pricing instruments across the world (World Bank Group, 2024). This captures the growing popularity of carbon pricing mechanisms. These mechanisms are widely used in reducing emissions, however, their impact on economic growth remains relatively unexplored. This is particularly true in terms of developing economies.

In developing nations across the world, the introduction of carbon pricing presents unique challenges. The initial stage of policy adoption involves political hurdles (Rabe, 2018) followed by spillover effects from high to low-income nations, post-introduction of high carbon prices (WTO, 2022). Developing nations tend to rely heavily on carbon-intensive industries for economic development. The costs associated with carbon pricing are substantial and may potentially hinder short-term growth. It may increase the costs of production and result in reduced competitiveness. Although emission pricing may reduce emissions, they might not be enough (Tvinnereim & Mehlig, 2018) given the adverse repercussions caused due to the taxes on production. Moreover, these economies do not have adequate financial and institutional capacities to implement and manage carbon pricing mechanisms effectively. It often results in certain unintended consequences economically, with limited environmental gains. However, despite these shortcomings, the opportunities posited by such pricing in developing economies are plenty. It helps economies transform into a greener and more sustainable growth model. Nations start to invest in cleaner technologies and foster efficient production processes. In the long run, these developments are destined to foster new industries, job opportunities, and improve environmental outcomes. These collectively contribute to a sustainable economic future. Yet the effectiveness of these mechanisms is based on the specific contexts of each economy, the design of the policy, and its implementation.

In this regard, this paper will explore the issues associated with the implementation of Carbon Tax and ETS across developing economies via a systematic literature review. The core objective is to identify which policy is more effective in promoting sustainable economic growth in developing nations. For this purpose, this paper has been divided into 5 sections. The first section encompasses a thorough literature review, followed by a comprehensive discussion of the theoretical framework of the study, the methodology involved in selecting the papers and case studies, and a discussion of the findings. The study will also consider factors such as institutional capacity across developing nations, the design of the policies, and the broader global context. The latter will include the role of international cooperation in achieving climate change goals.

Research Question: *How do carbon tax and emission trading schemes (ETS) impact economic growth in developing nations? Which mechanism is more effective in balancing environmental sustainability with economic development?*

In order to answer the above question, the following hypotheses will be tested with the help of the systematic literature review:

Hypothesis 1: *Implementation of a carbon tax in developing economies results in short-term negative effects on economic growth, however, it fosters long-term sustainability alongside environmental benefits.*

Hypothesis 2: *Emission Trading Schemes (ETS) will have a more immediate positive impact on economic growth as compared to a Carbon Tax due to its flexibility. However, the direct emission reductions might be weaker.*

***Hypothesis 3:** A hybrid approach combining a Carbon Tax and an ETS will be more effective in balancing economic growth and emission reduction.*

2. Literature Review

2.1. An Overview of Carbon Pricing Mechanisms

Carbon pricing is a crucial tool for reducing greenhouse gas (GHG) emissions. It simultaneously addresses climate change. The global political economy of climate change faces a key obstacle concerning free-riding on essential international public goods (Weitzman, 2016). Internal carbon pricing, in this regard, can bridge the gap that exists between strategy and decision-making (Klevtun & Nilsson, 2021). Pricing carbon dioxide emissions internalizes the environmental costs of carbon pollution. Several carbon pricing instruments exist that include ETS, carbon taxes, a credit mechanism, RBCF, and internal carbon pricing (World Bank Group, n.d.). They are evaluated on the basis of several factors. Policymakers usually consider their effectiveness, economic costs, ability to deal with uncertainties, their distributional impact, and the extent of promoting the development and deployment of clean technology (Parry, 2012). Based on these factors two primary forms of carbon pricing are Carbon Tax and Emission Trading Schemes.

Carbon tax is a direct approach to reduce emissions. It usually involves a fixed price per ton of carbon emitted. Metcalf and Weisbach (2009) discovered that almost 80% of US emissions can be captured by taxing around a thousand taxpayers only, which can be increased up to 90% if modest additional costs are added. This figure captures the efficiency of carbon taxes across developed economies such as the US. A well-designed carbon tax scheme can mitigate the risk of climate change, minimize emission reduction costs, and enhance innovation in low-carbon technologies while simultaneously raising public revenue (Marron & Toder, 2014). This tax is usually applied across sectors which are carbon-intensive as a financial incentive to push industries toward green technologies. The advantage of such a tax is the certainty in price. It allows policymakers to predict the cost of emissions thereby simplifying budgeting and planning for industries. However, a high tax for sectors which focus on carbon-intensive trade will reduce the production of goods across these sectors only, and increase it in equal or more amounts across sectors that are non-cooperative, globally (Hoel, 1996). This raises concerns about its efficacy. Carbon taxes may increase inequality (Fremstad & Paul, 2019), raise free-riding concerns among retailers who are better informed (Nie et al., 2020), underscoring a trade-off between equity and efficiency (Wang et al., 2016), without considerable emission reductions. Therefore, a thorough evaluation system is mandatory.

On the other hand, ETS also known as a cap-and-trade system, sets a cap on total emissions. It allows businesses to buy and sell emission allowances within that cap. It is usually managed by a governing jurisdiction where the allowances to emit are distributed to entities that are liable (World Bank, n.d.). Companies that were able to reduce emissions can sell their allowances. Those firms which need to emit more are supposed to purchase additional allowances. Current research on reduction of emissions focuses on the introduction of options contracts that would limit the carbon footprint with increased flexibility (Wang et al., 2018). Therefore, this flexibility offered by ETS is its core advantage. It allows firms to minimize costs by trading permits while introducing a level of price volatility that allows prices of carbon to fluctuate based on market dynamics (OECD, 2021). Interestingly, ETS caps carbon emissions at a certain pre-decided level that is not the case under carbon taxes.

Figure-1 shows that jurisdictions under which direct carbon pricing instruments such as ETS and carbon taxes are used alongside domestic carbon crediting mechanisms. There are almost 89 jurisdictions, 50 national and 39 subnational, that use compliance instruments. Out of these 36 have implemented ETSs and 39 have used carbon taxes (World Bank Group, n.d.). This demonstrates the popularity of these carbon pricing mechanisms. Figure-2 records the contribution of global government

revenues that have been generated by carbon pricing. While EU ETS itself has generated around \$75 billion in 2023, carbon tax has around \$29.3 billion in share (World Bank Group, n.d.). This establishes that ETS is extensively favored over carbon taxes too.

Compliance carbon pricing instruments around the world, 2024

Map shows jurisdictions with carbon taxes or emissions trading systems implemented, under development or under consideration, subject to any filters applied in the table below the map. The year can be adjusted using the slider below the map.

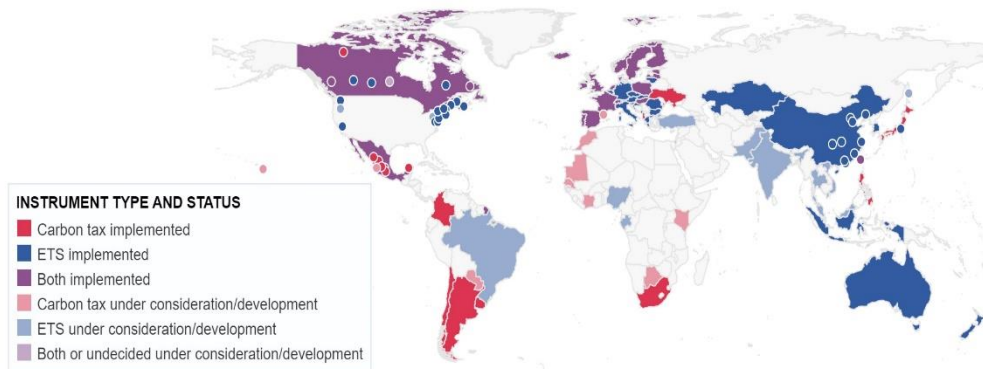


Figure 1: Map showing Carbon Pricing Instruments used around the world (World Bank Group, n.d.).

Carbon pricing revenue, by instrument in 2023

Reflects the contribution to global government revenues from carbon pricing, by instrument

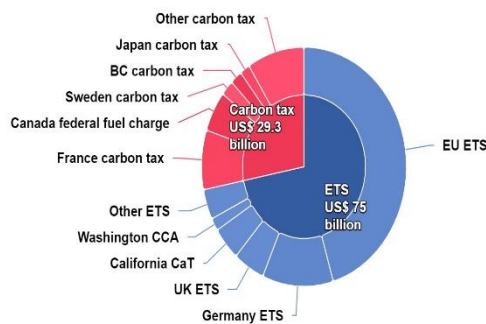


Figure 2: Carbon Pricing Revenue, 2023 (World Bank Group, n.d.).

2.2. Carbon Pricing in Developed versus Developing Nations

Existing literature primarily focuses on the carbon pricing mechanisms adopted in the developed nations. Post the Paris Agreement on Climate Change that occurred in 2015, most European nations are focused on stabilizing greenhouse gas emissions at a net zero level (Hepburn et al., 2020). These nations have been some of the early adopters of carbon pricing. They have leveraged advanced financial systems alongside robust regulatory frameworks that have allowed comprehensive implementation of carbon emission reduction measures. Lamb et al. (2022) found that 24 nations had successfully sustained economic growth besides reduced emission reduction, and 22 of these nations were European. The remaining two were the US and Jamaica. This is primarily because these nations have increasingly utilized renewable energy instead of fossil fuels (European Environment Agency, 2024). Increased investment in green and clean technology, sustainability-oriented innovation, has decoupled innovation and growth (United Nations Environment Programme, 2011). The lack of these in the developing nations including some developed ones across Asia and Africa has constrained these nations from following the same pathway.

The developing nations face unique challenges in implementing carbon pricing mechanisms. They need to prioritize between economic growth and environmental sovereignty with the former gaining

higher ground due to increased competitiveness. These nations are dependent on carbon-intensive industries as a source of foreign exchange, fiscal revenue, jobs, and income (Magacho et al., 2023). A carbon tax or ETS on these industries would potentially slow down growth and exacerbate poverty. This was observed across nations in the Sub-Saharan African regions, Ecuador, and many more. (Alaganthiran & Anaba, 2022; Alvarado & Toledo, 2017). These nations tend to lack institutional capacity that would help them to effectively formulate carbon pricing policies. Moreover, weak regulatory systems and corruption also undermine the effectiveness of such policies. This causes uneven implementation and minimal environmental impact. Moreover, financial constraints faced by developing nations also mitigate investments in innovation (Ayalew & Xianzhi, 2020). Given these adverse consequences, most developing nations would fluster to undertake carbon pricing. However, this is not the case. Enhancing acceptability of carbon prices with appropriate use of revenue raised (Klenert et al., 2018) and a proper policy design does help reduce reductions while sustaining growth as observed across all EU nations. If carbon emissions are observed across a large number of economic sectors, the control of emissions should be placed on a cross-section of firms (Zhang, 2016). Therefore, the effectiveness of these programs remains under scrutiny as the results of their ability to balance economic growth and environmental sustainability are ambiguous. However, a well-designed approach can help foster the dual scenario.

3. Theoretical Framework

The application and effectiveness of carbon pricing mechanisms involve several theoretical concepts. Pigou (1920) in his *Economics of Welfare* stated that economists ought to correct market failures by introducing pricing especially when there is a difference between marginal social cost and marginal private cost. The simplest solution to this would be a tax, however, things are not this simple. A tax on carbon internalizes the negative externalities of pollution by attaching a cost to emissions. This would provide firms an incentive to invest in cleaner technologies. However, studies have found that a tax, viz a viz, a carbon tax will introduce a long-term drag in the economy which can be solved only if other tax revenues are cut short, deficit is reduced, and expenditures toward long-term economic growth increase (William III, 2015). Moreover, estimating the costs of carbon is complicated as industries often entail hidden carbon costs that are embedded in the supply chain (Ma et al., 2023). Additionally, markets entail risks. The energy-intensive sector also tends to oppose such taxes to remain competitive while encompassing proportionally more carbon emissions (Meyer et al., 2011). Such factors impede the ability of economies to administer carbon pricing as short-term economic growth is negatively affected. This is particularly true for economies that have carbon-intensive industries.

The market-based environmental policy framework supports the use of ETS. Emission trading is a market-based policy tool that adheres to the principles of climate change mitigation in the context of cap-and-trade systems (International Carbon Action Partnership, n.d.). ETS creates a market for emission allowances. The flexibility of ETS is primary as it allows firms to reduce emissions at the lowest cost possible. This makes it an attractive option for economies that look towards balanced growth and sustainability. However, the price volatility in the carbon markets and the hidden carbon costs as posited by Ma et al. (2023), introduce uncertainty. This is particularly true in the context of developing nations where the regulatory frameworks are weak. Moreover, the nexus of direct state intervention coupled with private-sector-led growth and development has also resulted in reduced economic regulation across industries (Hafeez, 2003). These reasons combined may alter the efficiency of the ETS but the figures tend to be less intense than that for carbon taxes given the design of the policy framework and varied institutional frameworks across developing nations.

Furthermore, the study also derives inspiration from the Environmental Kuznets Curve (EKC). EKC is a hypothesized relationship between several environmental degradation indicators and per capita

income (Stern, 2014). This approach proposes that the indicators tend to rise initially as an economy witnesses an increased rise in per capita income, then falls (Stern, 2004). The fall happens because these economies which are now wealthier, start investing in environmental protection once their prior need of increased growth is fulfilled. Carbon pricing mechanisms in this context may accelerate this transition along the EKC. They do so by promoting greener, more sustainable growth without compromising on economic development.

Based on the above theories, this study has formulated the corresponding hypotheses mentioned earlier. In this regard, it is posited that carbon tax may lead to short-term economic slowdowns. However, they do foster long-term sustainability. ETS, on the other hand, provides immediate flexibility via price volatility. The study will thus evaluate the hypotheses through case studies of both developed and developing economies in order to assess the effectiveness of the chosen mechanisms in achieving sustainable economic growth with reduced emissions.

4. Methodology

This paper employs a systematic literature review (SLR) approach in order to evaluate the impact of Carbon Tax and ETS on economic growth and sustainability. It is heavily inspired by Green (2021) that underscores the significance of carbon pricing in climate change. Green suggests that aggregate emission reductions are usually limited between 0%-2% per year, however, the variation differs remarkably across sectors. This study provides a narrow basis for evaluating the impact of carbon pricing policies across developing nations. Therefore, the research builds on the foundation laid by it and follows a similar but more sophisticated structure. In order to ensure a comprehensive analysis of the literature, systematic research was conducted using multiple databases. These included Google Scholar, JSTOR, Scopus, and Science Direct besides institutional repositories such as IMF, World Bank, and OECD. Studies included in the analysis were generally published between the years 2008-2023. Due to this Timilsina and Shrestha (2002) a study based in Thailand, was excluded from the discussion. This is crucial such that the most recent developments in carbon pricing mechanisms are included only. The SLR approach allows a structured and comprehensive evaluation of existing research. It ensures that the findings are based on a broad range of peer-reviewed studies and reports. Note that the methodology is designed primarily to identify common trends, challenges, and opportunities that would be useful in designing proper carbon pricing mechanisms. It provides a robust foundation that enables readers and policymakers to understand the effectiveness in various multifaceted contexts.

4.1. Research Design

The SLR was performed on the basis of the PRISMA guidelines. PRISMA, short for, Preferred Reporting Items for Systematic Reviews and Meta-Analysis, has 27 checklist items that address introductions, methods, discussions, and results of a SLR (PRISMA Statement, 2020). These ensure transparency and replicability in the review process. The aim of this methodology was to gather all relevant literature on the economic and environmental impacts of carbon pricing mechanisms in developing economies. The focus however was particularly on studies that identify the effectiveness of Carbon Tax and ETS in reducing emissions while enhancing economic growth.

The following research questions guided the review conducted:

1. How do carbon tax and ETS affect economic growth in developing nations?
2. What is the impact of carbon tax and ETS on emission reductions in these economies?
3. What are the challenges and opportunities associated with the implementation of carbon pricing mechanisms?

4.2. Selection Criteria

The search terms used across the academic databases were as follows:

- Carbon tax economic impact on developing economies
- Emission Trading Schemes economic impact on developing economies
- Carbon pricing and GDP growth in emerging markets
- Carbon tax and ETS emission reductions

The studies were included in the analyses if one or more of the following criteria were met:

- The studies one of either peer-reviewed studies, reports, or working papers
- Studies focused on developing economies specifically to analyze the effects of carbon pricing mechanisms
- Certain studies across developed nations such as the US and some others in the EU were included for comparison purposes
- The research provided quantitative or qualitative assessments of economic growth or emission reductions as outcomes of carbon pricing mechanisms

Studies were excluded if:

- The focus was entirely on environmental policies which were completely unrelated to carbon pricing like Finon (2019). This study focused specifically on the use of non-price instruments such as efficiency standards, regulations that are market-oriented, and clean technology subsidies, demonstrating their credibility over carbon-pricing instruments.
- The studies lacked quantitative or qualitative data on the economic or environmental impacts of the chosen carbon pricing mechanisms.
- The studies that were not peer-reviewed
- The studies which focused on certain sectors only such as tourism (Meng & Pham, 2015; Tol, 2007).

4.3. Data Extraction and Categorization

The studies were analyzed on the basis of the economic and environmental outcomes of the chosen carbon pricing mechanisms. A total of 36 studies were identified. Each study was then subjected to a rigorous data extraction process. The following points were noted:

- Study title, Authors, and Year of Publication
- Country/Region of focus
- Type of carbon pricing mechanism evaluated, i.e., Carbon Tax or ETS
- Findings – both environmental, recorded via emission reductions, and economic, accounted as reductions in welfare or GDP.
- Additional information specifying the challenges and policy recommendations if any.

The studies were then categorized on the basis of the type of carbon pricing mechanism evaluated, the geographical region covered, and economic and environmental impact to examine the trade-offs between them. As certain studies focus on a collective list of countries such as ASEAN nations (Nurdianto & Resosudarmo, 2016), or OECD nations (Noubissi et al., 2023), it is difficult to segregate the nations under the categories of developed and developing individually. Singapore among the ASEAN nations is one of the most developed nations of the world, whereas all other nation in the group is transitional. Hence, these nations are considered on the basis of majority and are included under the developing category. For OECD nations, as most of these countries are considered developed, hence, the studies focusing on these nations are included in the developed category.

4.4. Synthesis of Results

Once the data was extracted and categorized, the results were synthesized by identifying common themes and trends across all studies.

5. Findings

Analysis of 36 studies comparing Carbon Tax and Emission Trading Schemes (ETS) between developing countries and developed economies has been concisely captured in Table-1. 18 out of the 36 studies focused on developing nations whereas 12 were conducted across developed nations, and were included for comparison purposes. 6 studies expanded over several regions have been segregated (Figure-3). These studies, such as Pryor et al. (2023), Duggal (2023), etc., which had an extensive geographical span were considered separately. The observations across each region were segregated before being included in the analysis. The regional distribution of studies is shown in Figure-4. In most cases, carbon tax delivered modest emission reduction of around the order of 10-12% while more substantial reductions on average between 15% and 20% were achieved through ETS (shown in Figure-5 and Figure-6), particularly in countries that had developed market structures. The effects on economic growth differed across locations. Carbon Tax was associated with an average mild decrease in emission reductions and tended to have a short-term negative effect on GDP (Figure-6). ETS, on the other hand, seemed to put the least burden on GDP (Figure-6), keeping economies steady in the short term. Revenue recycling, where utilized, helped prepare for unwelcome economic results, particularly when combined with Carbon Tax. Overall, ETS was found to be best at delivering on environmental goals alongside maintaining economic stability, while Carbon Tax worked well over time to reduce emissions but needed careful policy design to avoid hurting economies. Moreover, carbon tax was also observed to be extremely popular among developing economies as against ETS which was widely adopted across the developed nations such as the US and EU. These nations have set the trend for carbon pricing which the developing nations should follow to reach their net-carbon emission goals.

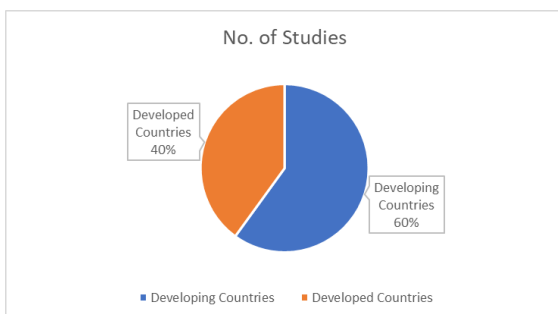


Figure 3: Distribution of number of studies across developed and developing nations

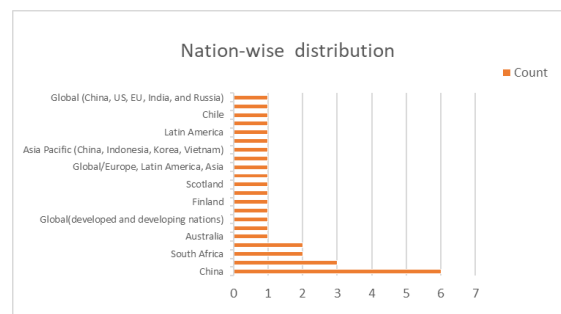


Figure 4: Nation-wise distribution of the studies

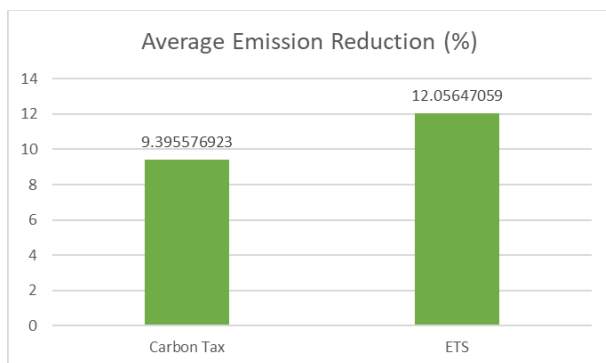


Figure 5: Average Emission Reduction – Carbon Tax versus ETS

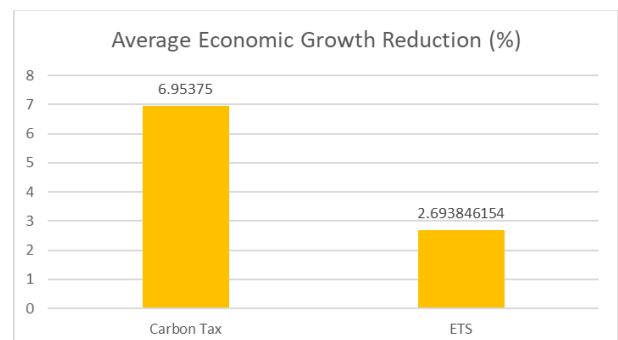


Figure 6: Average Economic Growth Reductions – Carbon Tax versus ETS

Table 1: Findings from the SLR

	Author(s)	Policy Type	Period	Coverage	Methodology	Findings	Additional
1	Morris (2015)	Carbon Tax	2010	Global/United States	input-output analysis to estimate retail price increases and consumer price effects using household spending data	Low-income households are more burdened by taxes. About 11% of the revenue should be extracted from low-income households.	Economic growth in the short run is hindered as production costs might increase, affecting low-income households more in terms of job losses and increased prices. Long-run impacts might be positive.
2	Aldy (n.d.)	Carbon Tax	2020	United States	Review and Act-Learn-Act Policy framework, economic modeling	Supports phased carbon tax policy updates using empirical evidence recording a welfare gain of \$4.8 billion in 2020 with subsequent growth in the next 5 years.	Phased-adaptive carbon tax efficiently reduces emissions. Regular reviews of tax rates ensure accurate mitigation of adverse economic impacts, especially on low-income households.
3	Pryor et al. (2023)	Carbon Tax/ETS	2023 data	Global/Europe, Latin America, Asia	Data-driven analysis of economic and environmental impacts	30% emission reduction due to EU ETS. Stead decline in Latin America using Carbon taxes. China's pilot	A well-designed carbon-pricing policy is crucial.

						ETS launched in 2021 have also shown early signs of emission reduction. More data is necessary for Latin American and Asian nations for robust trend analysis.	
4	Duggal (2023)	Carbon Tax/ETS	2020-21	Asia Pacific (China, Indonesia, Korea, Vietnam)	Policy analysis and review of carbon pricing	China's ETS reduced emissions in the power sector by 4000 MtCO ₂ . Indonesia's cap-trade-and-tax witnessed slow but effective progress as the nation is highly dependent on fossil fuels. Korea's ETS covers indirect emissions at lower prices.	Carbon pricing should be flexible and should consider regional/local dynamics. It is crucial to include indirect emissions and provide rebates to support vulnerable sectors.

5	Mengistu et al. (2019)	Carbon Tax	2018-2030 (based on data projections)	Ethiopia	Computable General Equilibrium Model, multiple revenue cycling scenarios	Emissions are expected to reduce from 1.1 to 3.8 million tons (2018-2030) based on the recycling scenario. GDP is expected to be 0.52% lower as compared to the initial rate of 0.38%.	carbon tax on fossil fuels reduces emissions but the impact in Ethiopia is modest due to its low fossil fuel consumption. Revenue from taxes estimated around \$786-\$798 million annually, can be reinvested in green innovation. Moreover, the carbon policies should account for rural-urban disparities
6	International Monetary Fund, African Department (2023).	Carbon Tax	2019-2030 (based on projections)	South Africa	Computable General Equilibrium Model, input-output analysis, Carbon Pricing Assessment Tool (CPAT)	Carbon tax rates are expected to rise to \$30/tCO ₂ by 2030 which would reduce emissions to the expected target of 377-453 MtCO ₂ e by 2030. GDP growth is expected to reduce slightly from 0.04 to 0.12% between 2022-2030 aligning	Carbon taxes are expected to rise up to \$120/tCO ₂ by 2050 gradually to reach emission targets. The carbon budget should be integrated with better carbon tax systems for better alignment with NDC targets.

						with NDC targets.	
7	Meng et al. (2012)	Carbon Tax	2012 onwards	Australia	Static Computable General Equilibrium Model with an environmentally extended Social Accounting Matrix (SAM).	Emissions reduced almost 12% post-2012 compared to 2004-2005. The baseline in those years was 587Mt which is equivalent to 70Mt of CO2 reductions. Carbon was priced at \$23 Australian per ton. Real GDP decreased by 0.59% under the carbon tax-only scenario. Real GNP grew around 0.87% in a tax + compensation scenario to boost household incomes.	Carbon pricing is effective in reducing emissions. However, it requires higher prices to meet Australia's 80% reduction target by 2050. Compensation to households offsets the negative impacts of tax by preserving income and demand. Stationary emissions from industries such as coal and gas are the primary sources of reduction.

8	Conefrey et al. (2013).	Carbon Tax	2010-2020	Ireland	HERMES macro-economic model, Computable General Equilibrium Model, simulations under different tax recycling scenarios	Emission reductions were around 2% from the non-traded sectors when a tax of 20 euros/tCO ₂ is applied. GDP falls by 0.21% as output declines in the manufacturing and service sectors. However, GDP increases by 0.39% when the carbon tax revenues are recycled through income tax reductions.	To achieve a double dividend, policymakers should recycle carbon tax revenues to reduce income instead of lump-sum transfers. A unilateral carbon tax transfer may lead to competitiveness issues if not coordinated with the EU. Additionally, carbon leakage needs to be addressed by aligning Ireland's carbon pricing with EU policies.
9	Lin and Jia (2018)	Carbon Tax	2017-2030	China	Dynamic Computable General Equilibrium (CGE) Model	Emission reduction up to 15.11 billion tons between 2017-2030 based on tax rates (10-100 yuan per ton). High carbon taxes result in GDP reductions of 0.004% to 0.256% by 2030.	Higher tax rates are crucial to achieving higher emissions reductions. Energy-intensive sectors should be taxed more with subsequent relief measures to mitigate the adverse negative impacts.

10	Allan et al. (2014)	Carbon Tax	2014-2020	Scotland	AMOSENV I CGE Model	Emissions reduced by 31% to 39% achieving the 37% target. GDP declined by 2.68% in the long run when revenues were recycled externally. It increased between a range of 0.26-0.83% when revenues were recycled through income tax reductions.	Carbon tax needs significant revenue recycling to mitigate negative economic consequences. Reduction in income tax might help stimulate economic growth and employment resulting in a double dividend.
11	Liu and Lu (2015)	Carbon Tax	2015-2030	China	Dynamic Computable General Equilibrium (CGE) Model (CASIPM-GE)	Emission reductions were between 7.04% and 8.49%. GDP reduction was between 0.23%-1.17% with production tax deduction minimizing economic impact.	Using carbon tax revenue to reduce production tax yields the lowest economic cost while achieving emission targets. Deducting consumption tax with carbon tax revenue provides the largest emission reduction.
12	Noubissi et al. (2023)	Carbon Tax	1994-2018	36 OECD countries	Double-Difference Model, Fixed effect techniques, Driscoll and	CO2 emission reduces via environmental taxes	Taxes should be strengthened quantitatively and qualitatively across

					Kraay, Lewbel 2SLS and Quantiles methodologies		transporting and manufacturing sectors specifically.
13	Benavente (2016)	Carbon Tax	2010-2020	Chile	Static Computable General Equilibrium Model with 23 industries and 23 commodities with SAM	Emissions were 20% below 2010 levels with a carbon tax rate of \$ 26 USD/tCO ₂ . GDP decreased by 2-2.3%.	Imposing tax on producers is more effective than applying it to producers and consumers. The renewable energy sector is expanding while the carbon-intensive sectors are contracting significantly.
14	Ayu (2018)	Carbon Tax	2010-2030	Indonesia	Dynamic Energy Computable General Equilibrium Model using a GTAP-E Framework	Carbon tax reduced emissions by 9.6% under \$20/tCO ₂ scenario. GDP declined by 0.07%.	Higher carbon taxes are crucial to meet Indonesia's emission reduction goals accompanied by revenue recycling to support household consumption.
15	Zhou et al. (2011)	Carbon Tax	2011-2020	China	Dynamic energy-environment economy CGE Model covering 39 sectors	Emissions reduced by 4.52% for tax rate of 30 RMB, 8.59% for a rate of 60RMB, and 12.26% for 90RMB by 2020 compared to baseline. GDP reduces by 0.11% to 0.39%. CO ₂	The economic cost of Carbon Tax is modest with minimal impact on GDP. Policymakers should consider recycling carbon tax revenues and improve energy efficiency.

						intensity/GDP decreases by 34.79%-39.92% given efficient energy solutions.	
16	Yoshino et al. (2021)	Carbon Tax	2005-2020	Japan	Structural Vector Autoregression (S-VAR) technique and Theoretical General Equilibrium Model	An increase in carbon tax records a negative relationship with real GDP.	Reforms+Revolution alongside refunding of carbon tax revenues, and adoption of long-term policy promoting net-zero GHG emissions by 2050 are crucial
17	Moosavian et al. (2021)	Carbon Tax	2017	Iran	General Equilibrium Model of non-linear system of equations	Taxation without redistribution decreases welfare and household consumption by 6.2%. However, with redistribution, the indices rise by 0.8%. GDP decreases by 1.7%-2.1% and CPI increases by 6.4% to 8%.	Carbon taxation with redistribution is suitable to reduce GHG emissions.
18	Frey (2017)	Carbon Tax	2007	Ukraine	Static Computable General Equilibrium (CGE) Model	Reduction rates were around 0.19% at 0.26UAH/tCO ₂ . The impacts on	Tax of 40UAH/tCO ₂ is required to meet 22% reduction target. Revenue recycling is necessary.

						GDP were small but positive across scenarios entailing revenue recycling.	
19	Nurdianto and Resosudarmo (2016)	Carbon Tax	2004 onwards	ASEAN	Multi-Country CGE Model (ISRA-ASEAN)	Emission reductions were 1-6% with GDP contractions of 0.2% to 1.7% across nations.	Countries with energy subsidies such as Indonesia, Malaysia, and Singapore witnessed positive GDP effects
20	Khastar et al. (2020)	Carbon Tax	2019-20	Finland	GTAP-E General Equilibrium Model (CGE)	Emissions reduced between 6.9% to 29.5% with subsequent welfare losses of \$412 million - \$3.5 billion. The GDP decline for the highest tax rate of \$150 was significant	Higher tax rates lead to significant emission reductions but GDP also decreases simultaneously. Coal emissions are reduced the most.
21	Beck et al. (2015)	Carbon Tax	2008-2012	British Columbia (Canada)	Static Computable General Equilibrium (CGE) Model	Emissions reduced by 9.14% compared to the baseline year of 2008. Welfare reduced by 0.01%	Revenue-neutral carbon tax is progressive due to recycling measures.
22	Nong et al. (2020)	ETS	2020 onwards	Vietnam	CGE model (GTAP-E)	Emissions were reduced around 18%	Expanding ETS to cover all industrial

						compared to baseline years, and 28.67% under an expanded ETS system. GDP declined by 4.57% in Scenario 1 and 1.78% in Scenario 2.	sectors reduced economic costs.
2 3	Hu et al. (2020)	ETS	2005-2015	China	Difference-in-Difference Model	CO2 emission reduced by 22.8% in pilot areas and 15.5% in non-pilot ones.	Policy effects are driven by technical efficiency and structural improvements.
2 4	Zhang and Zhang (2021)	ETS	2013 onwards	China	Difference-in-Difference Model with dynamic panel data for 30 provinces	ETS has statistically significant negative effects on growth economically with a gradual increase in differences over time	Empirical investigations regarding the efficiency of ETS is crucial.
2 5	Jung and Song (2023)	ETS	2005-2020	Global (developed and developing nations)	Environmental Kuznets Curve (EKC) and multivariate regression analysis	ETS reduced carbon emissions per capita in decoupled nations and slowed it down across non-decoupled nations. ETS had minimal negative	ETS is an effective market-based mechanism as it is a flexible tool that allows comprehensive climate policy changes to ensure long-term carbon neutrality.

						impacts on GDP	
26	Oliveira (2020)	ETS	Post 2020	Latin America	Dynamic Recursive Computable General Equilibrium Model	Emission reductions have occurred with considerable redistributions of financial flows from Brazil and Mexico to Latin America.	Additional sectors need to be considered for the comprehensive evaluation of ETS on emission reductions
27	Anger (2008)	ETS	Post 2020	EU and linked ETS regions (Canada, Japan, Former Soviet Union)	Multi-country equilibrium model	Linking EU-ETS with non-EU schemes showed minor adjustments that achieved emission reductions post-Kyoto protocol. The economic benefit for EU was small with 1% increase in compliance costs however other nations derived significant benefits.	Liked EU-ETS with non-EU schemes provides minimal benefits. Expansion of ETS increases the burden on non-energy intensive sectors.

28	Masseti and Tavoni (2012)	ETS	2013-2050 (predictive analysis)	Asia (China, India, South Asia, South-East Asia)	WITCH model	ETS will achieve an expected reduction of 30-50% in emissions in 2050. GDP losses might range from 2.6% to 5.5%	Developing Asia is crucial for global emission reduction as the expected reduction across this region would account for 50% of the global sum.
29	Zhang and Wei (2010)	ETS	2005-07 (Phase 10)	EU	Empirical Analysis of EU ETS	Mixed results regarding emissions but it is expected to reduce in the future with limited economic impact	Allocation efficiency is crucial to prevent unforeseen consequences.
30	Lin and Jia (2017)	ETS	2017-2030	China	Dynamic Computable General Equilibrium Model	CO2 will reach the maximum by 2030 after which it will stabilize. Total reduction would be 12.05 Bt-CO2 via ETS between 2017-2030. Commodity prices however would increase from 0.12-1.64%.	Industry-covered ETS in China will induce the patterns of emissions as posited by EU ETS and Midwest Greenhouse Gas Reduction in the US.

3 1	Dissanayake et al. (2020)	Carbon Tax/ ETS	2020 onwards	Indonesia	CGE model using the GTAP-E simulation analysis	ETS achieved an emissions reduction of 15%. GDP declined by 0.11% for both Carbon Tax and ETS whereas fuel tax increased GDP by 0.29%	Either a carbon tax of \$36/ton or an ETS is needed to meet Indonesian emission needs. Fuel tax has a positive short-run GDP effect.
3 2	Venmans (2012)	ETS	2005-2012	EU	Multi-criteria evaluation based on a review of 115 studies	EU ETS reduced emissions by 2.5% to 5% between 2005-07. Emission reductions improved in the second phase due to stricter caps. The economic effects were negligible.	Over-allocation needs to be avoided.
3 3	Marin et al. (2018)	ETS	2005-2012	EU	Propensity score matching and Difference-in-Difference approach	Reductions were significant in Phase 2. Firms generally pass on costs to the consumers with no significant negative effects on performance. Labor productivity improved	Policies should focus on cost pass-through mechanisms and maintain strict caps on allowances

						alongside turnover and markup	
3 4	Qi and Weng (2016)	ETS	2016-2030	Global (China, US, EU, India, and Russia)	CGE Model	ETS reduced emission reduction costs and achieved lower prices of CO ₂ . The expected global price by 2030 is \$29.83/tCO ₂ with countries such as US and EU experiencing more significant reductions. Economic performance improved across US and US and the other nations benefitted from lower carbon prices and permit sales	ETS markets should be linked to boost international trade
3 5	Kalaba (2020)	Carbon Tax	2019-present	South Africa	Policy Analysis	The nation has committed to reduce emissions by 34% in 2020 and 42% by 2025 with	Tax can negatively affect consumer welfare due to rising prices.

						the help of carbon taxes. Production costs increase which leads to adverse economic impacts	
36	Koh et al. (2021)	Carbon Tax/ETS		Developing Nations	Semi-systematic literature review	Carbon pricing successfully reduces emissions. It is progressive for the rural cohort and regressive for urban ones.	Revenue recycling mediates the Suits Index alongside Gini coefficients.

6. Discussion

As the research question was addressed throughout the study via a systematic literature review (Table-1), several key insights were obtained. It was observed that *Hypothesis 1*, stating that carbon taxes result in short-term negative economic impacts but foster long-term sustainability, failed to be rejected. Several studies including Mengistu et al. (2019), Pryor et al. (2023), Nurdianto and Resosudarmo (2016), Frey (2017), and several others confirm the same. Nations such as China, Ethiopia, Ukraine, and ASEAN countries, among others, witnessed slight reductions in GDP post-implementation of carbon taxes. However, the long-term effects did promote sustainable growth. Most of these countries implemented redistribution of revenue. The nations were thus able to invest in greener technologies in the long run that not only improved productivity and efficiency but also allowed sustainable economic growth with reduced emissions. Additionally, *Hypothesis 2*, which posited that ETS entails more immediate positive impacts on economic growth than Carbon Tax but weaker emission reductions, was rejected. The studies equally focused on developed nations as well. These nations, as observed by Qi and Weng (2016), Anger (2008), Hu et al. (2020), Venmans (2012), and others, higher average rates of emission reduction were accompanied with lower negative economic impacts for ETS. This in fact is an ideal outcome which often fails to realize in the context of developing nations, given their unique circumstances. This discrepancy was perhaps due to the fact that most developing nations have resorted to the use of Carbon Taxes. These include nations such as China, India, Japan, etc. The focus on developing nations might have skewed the distribution in favor of ETS schemes. Finally, the last hypothesis, *Hypothesis 3*, suggesting a hybrid approach to tackle the trade-off between economic growth and environmental protection, fails to be rejected. Kalaba (2020), Dissanayake et al. (2020), and Duggal (2023) record the efficiency of a hybrid model across South Africa, Indonesia, China, Korea, and Vietnam. Although this hypothesis is partially supported given the limited number of studies that focus on the same, the nations that benefit from such an approach are enough to establish

the efficacy of this model. A hybrid approach across developing nations is destined to be effective in reducing emissions as much as carbon taxes while offsetting the negative economic impacts, especially when revenue recycle is considered, via the flexibility offered by ETS.

7. Conclusion

This study aimed to examine the relative contribution of Carbon Tax and Emission Trading Schemes (ETS) towards promoting both economic growth and sustainable emission reductions in developing economies. Based on a systematic literature review (SLR) of 36 studies, it is apparent that the two mechanisms are effective in supporting climate change and have different effects on economic stability and sustainability. The results suggest that a Carbon Tax can have short-term offsetting growth costs, with long-term environmental and economic returns, while ETS offers immediate flexibility with fewer short-run output disruptions. One key finding is that revenue recycling, using proceeds from carbon pricing to offset negative economic impacts, worked particularly well in growth-focused emerging economies with carbon-dependent industries. China, Indonesia, and South Africa, balanced economic output and environmental goals using these techniques. Though more common in developed regions like the EU, ETS holds promise for adaptation into developing economies due to its potential relevance for complex market dynamics.

However, like any other study, this too is not devoid of certain limitations. The SLR approach to research is comprehensive but it does entail certain drawbacks. The studies included were restricted to Asia, Latin America, and Africa, leaving other regions, such as the Middle East or Central Asia, underrepresented. Although there was one study that was based in Iran, the massive underrepresentation questions the robustness of the analysis. Additionally, the studies focused on countries that already use Carbon Tax or ETS, omitting nations in the early stages of developing carbon pricing policies. The study period between 2008 to 2023, may miss recent progress in carbon pricing or new policy designs like hybrids combining features from both Carbon Tax and ETS. Although most studies do suggest the use of a hybrid model to utilize the benefits of both while offsetting the negativities, the research on this particular field is limited. There were also variations in data between regions and sectors, and most studies used modeling projections rather than real-time data, introducing uncertainty into forecasts. Furthermore, there is a methodological limitation with SLR, as it depends on the depth and breadth of the included studies, potentially leading to a bias towards optimistic assessments of carbon pricing mechanisms.

The drawbacks however open up areas for future research. Future research should broaden the geographic and sectoral scope, particularly focusing on neglected developing regions, such as the Middle East and Central Asia. There should also be more real-time data on the impacts of hybrid systems combining Carbon Tax and ETS. These systems could provide a more balanced solution for emerging economies. Comparative studies between developed and developing nations could reveal how developing economies can replicate or modify successful policies. Research should also explore the long-term impacts of carbon pricing mechanisms on income inequality and employment trends, especially in developing economies. As carbon pricing goes global, understanding its societal implications will be essential for creating fairer and more effective policies. Studies on technological innovation and green investments could further guide policymakers. Therefore, while this study offers valuable insights into Carbon Tax and ETS, more robust research is needed for global and regional applications especially across developing nations.

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