How effective are carbon pricing mechanisms (carbon taxes vs. cap-and-trade) in reducing CO_2 emissions across OECD countries?

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Abstract

Ever-increasing global CO_2 emissions remain a major contributor to climate change, leading all governments, and especially members of the Organisation for Economic Co-operation and Development (OECD), to employ aggressive mitigation measures. One such measure is the carbon pricing mechanism — in particular, carbon taxes and cap-and-trade programs; carbon pricing mechanisms are seen as a key policy response. The goal of this analysis is to evaluate the relative effectiveness of carbon taxes and cap-and-trade programs for lowering CO_2 emissions among OECD countries.

This research utilizes OECD Statistics, the World Bank Carbon Pricing Dashboard and International Energy Agency (IEA) CO_2 emissions data. This is a large dataset that includes OECD countries that have a carbon tax or a cap-and-trade program, while controlling for GDP per capita, energy mix, industrial share of GDP, and country population size (i.e., energy emissions model). Specifically, the data provides both descriptive comparison and trend analysis.

To-date, preliminary findings indicate that both carbon taxes and cap-and-trade programs have resulted in lower emissions, although there are differences in terms of price, scope, and time-dimensions related to actual policies. The data also seem to indicate that carbon taxes provide traps of additional emissions reductions year on year, while cap-and-trade programs often show larger reductions when discretionary carbon markets tighten up.

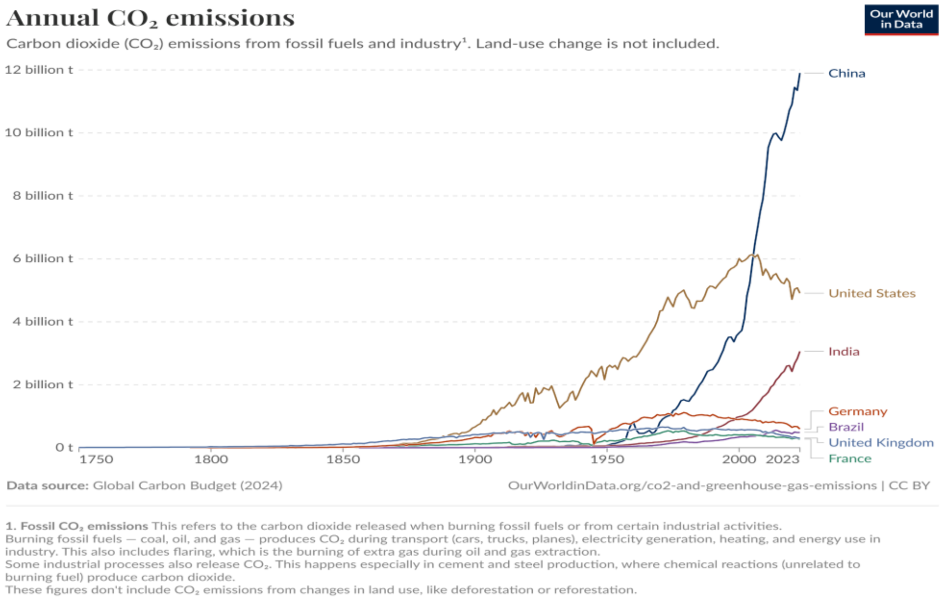
The results highlight the need for policymakers to ensure adequate carbon price levels, broaden coverage, and integrate pricing mechanisms with complementary renewable energy and efficiency policies. These insights can inform future OECD climate strategies and guide the design of carbon pricing in other economies.

Introduction

Climate change is one of the greatest challenges of the 21st century. Rising greenhouse gas (GHG) emissions have caused increase in temperature around the world, extreme weather events, and disruptions to ecosystem. Carbon dioxide (CO_2) is the most significant GHG from human activity, and most CO_2 emissions come from fossil fuel combustion and certain manufacturing processes. In response to rising emissions and temperatures, the members of the Organisation for Economic Co-operation and Development (OECD) have agreed to significant limits under the Paris Agreement to limit global warming to well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit warming to 1.5 degrees Celsius. This will require significant and economically efficient interventions that limits global warming.

Carbon prices have been viewed as the main policy instrument aimed at limiting CO_2 emissions. Generally, two methods are implemented - carbon taxes and cap and trade systems. Carbon taxes apply a known price per ton of CO_2 emitted and the total emissions outcome depends on market response. Because a fixed price is applied for emissions, carbon taxes provide certainty about costs. Cap and trade holds the emissions level constant (through the "cap") and allows regulated activities to trade the allowances amongst themselves. With cap and trade there is price variability between allowances, but the quantity is set.

Although both instruments aim to internalize the social cost of carbon and provide price incentives for emission reductions, their actual performance in the real world differ substantially by context. The existing literature typically looks at cases on a country level or considers them entirely separately, and no comprehensive, quantitative, OECD-wide comparisons exist. Consequently, this lack of quantitative evidence hampers policymakers from making evidence-based assessments on which mechanism leads to greater and more consistent emissions reductions.

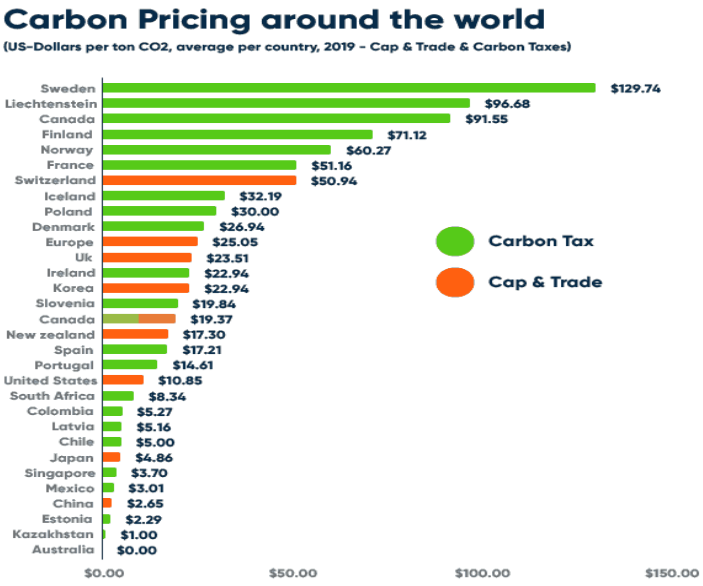


Source:Our World In Data

Literature Review

Global Carbon Pricing Adoption Trends

Carbon pricing—via carbon taxes and emissions trading systems (ETS)—has expanded significantly in recent years. OECD data show that the share of greenhouse gas (GHG) emissions covered by explicit carbon pricing rose from about 32% in 2018 to over 40% by 2021 (OECD, 2022). Despite this progress, coverage remains uneven across countries and sectors, and over half of global emissions are still not priced (OECD, 2023). While the energy crisis temporarily slowed tax-based pricing growth, ETS adoption has gained momentum, with several OECD countries expanding coverage or tightening caps (OECD, 2024).



Source:EcoChain

Prior Studies Comparing Policy Impacts

Empirical research supports the view that both carbon taxes and ETSs reduce emissions, though the magnitude and consistency of impacts vary. Using panel regressions across 121 countries from 1990–2016, (Kohlscheen et al., 2024) find that a USD 10 per ton increase in carbon tax correlates with a 1.3% reduction in CO_2 emissions per capita in the short run and 4.6% in the long run. Best et al. (2020), in a dataset of 142 countries, report that carbon pricing reduces annual emissions growth rates by about 2 percentage points compared to non-pricing jurisdictions. Quasi-experimental analysis by (Andersson, 2019) shows Sweden's carbon tax reduced transport-sector emissions by approximately 11% relative to a synthetic control group of OECD countries.

Theoretical Strengths and Weaknesses of Each Mechanism

Carbon Taxes deliver predictable price signals that are relatively easy to administer, and produce consistent public revenues that can fund climate initiatives (Metcalf &

Weisbach, 2009). However, they may be politically opposed based on perceptions of regressiveness, and they may have to have a high enough price to achieve actual reductions (Sterner, 2012).

Cap-and-trade systems guarantee an emissions quantity outcome and allow flexibility depending on regulated entities. They can achieve cost-effective reductions when well designed (Ellerman et al., 2010). The EU ETS has, for example, demonstrated emissions reductions of 7–10% from 2005–2012, without harming competitiveness (Ellerman et al., 2016). Lastly, ETSs can have issues with price volatility, permit oversupply, and complexity administrative requirements (Tietenberg, 2013).

Economic and Political Factors Affecting Implementation Success

The effectiveness of carbon pricing rests on the acceptance of the public, economic structure, and the design of policies. Recycling revenues to households or businesses as done though Canada's carbon pricing system, can mitigate the distributional consequences and possibly enhance political durability (Rivers & Schaufele, 2015). That said, even if economic considerations are taken into account poor messaging, emotionally charged values, and tangible rise in costs justifies backlashes such as public's opposition to carbon pricing in Canada (Harrison, 2020) and the attempts to repeal cap-and-trade in the United States (Rabe, 2018).

Limitations in Past Research

Most empirical studies analyze one country, one industry, or a short post-implementation interval (Andersson, 2019). There are very few cross-OECD country comparisons that analyze both mechanisms at the same time. In addition, datasets such as the OECD's Effective Carbon Rates provide solid data on carbon pricing, but there is little on the effectiveness in terms of emissions outcomes, nor is there a consistent, comparable measure of emissions outcomes across mechanisms (OECD, 2023).

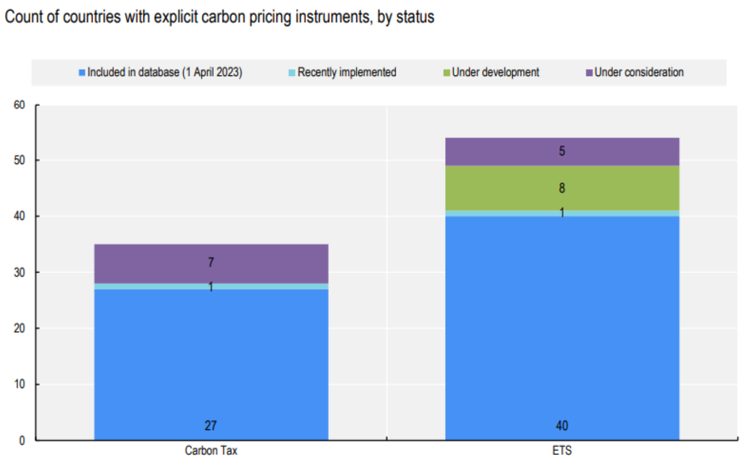
Methodology

This study relies on secondary data from OECD Statistics, the World Bank Carbon Pricing Dashboard, and IEA CO_2 emissions datasets to ensure consistency and comparability across OECD countries. The period of analysis spans 2000–2023, capturing both early and recent adopters of carbon pricing. The sample includes OECD members implementing either a carbon tax—levied on CO_2 emissions or the carbon content of fuels—or an emissions trading system (ETS) with fixed caps and tradable allowances. Countries without carbon pricing are considered for comparative context. The analysis involves descriptive statistics, trend comparisons, and cross-country evaluations to assess differences in CO_2 reduction outcomes, while controlling for key factors such as GDP, energy mix, and industrial activity.

Results

Number of OECD countries using each mechanism.

The World Bank Carbon Pricing Dashboard and OECD reporting indicate that the overwhelming majority of OECD countries have set up at least one carbon pricing instrument (a carbon tax or an ETS) at some level of government or jurisdiction. OECD reporting (Effective Carbon Rates 2023) and World Bank State & Trends 2023 show quite a few national or subnational instruments which cover OECD members, worldwide there has been ~75 such instruments as of 2023.

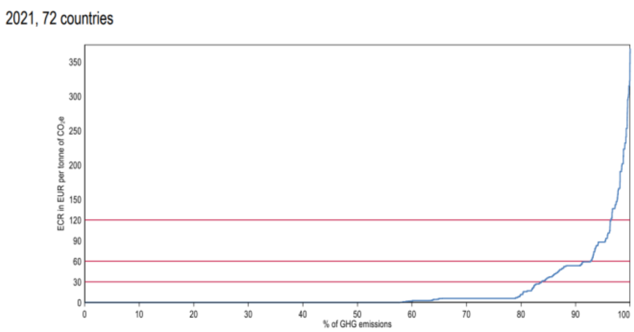


Source: OECD

Average carbon price, duration, coverage.

OECD Effective Carbon Rates identifies that there are numerous countries with low effective carbon prices; only a minority of total emissions are priced higher than typical policy thresholds (for example EUR 30/t or EUR 60/t). OECD summary statistics indicate only about 16% of global emissions were priced at ≥EUR30/t in the 2021 baseline, and only ~ 7% at ≥EUR60/t (OECD, 2022/2023). Similarly, the World Bank (State & Trends 2023) reports most carbon prices remain below levels consistent with Paris level pathways, global median explicit carbon pricing is low.

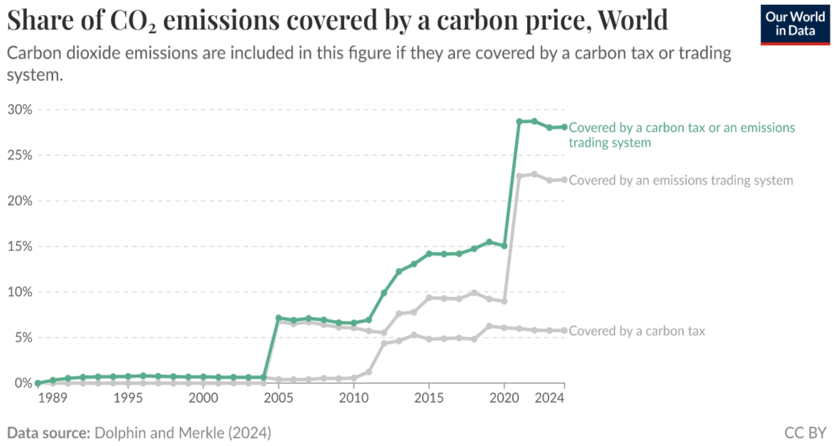
Distribution of Effective Carbon Rates



Source: OECD

This chart shows that most countries put little or no cost on most of their greenhouse gas emissions. Only a small part faces high prices that can really push companies to cut pollution. Countries that set high, steady prices on more emissions generally reduce CO_2 faster, no matter if they use a carbon tax or a trading system.

Policy duration: Carbon taxes in OECD countries range from long established (e.g. Sweden in the 1990s) to more recently adopted; and ETS implementations also vary (e.g. EU ETS since 2005, newer national ETS in some OECD).

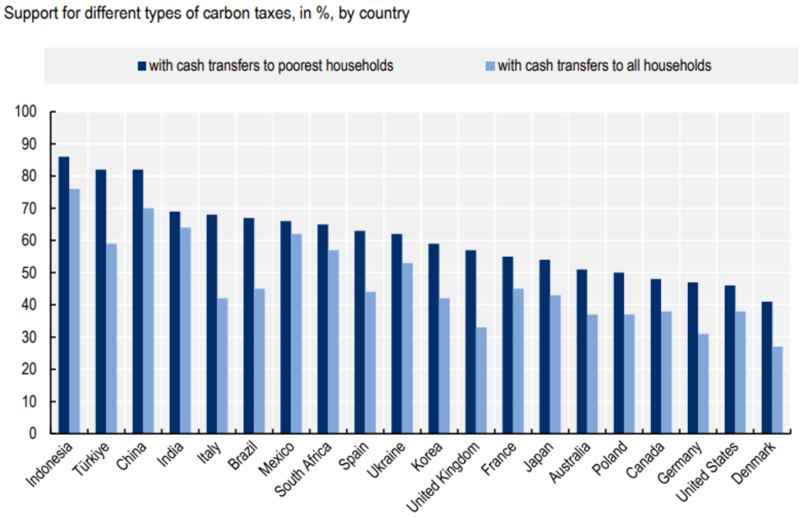


Source:Our World In Data

The graph indicates that an increasing share of CO_2 emissions globally are being priced—through a carbon tax or through an emissions trading system. The largest jumps, in particular after 2005 and after 2020, are attributable to the expansion in emissions trading systems, while the share covered by carbon taxes has been more modest. In summary, coverage is on the rise which means a larger share of emissions are now being regulated to incentivize reductions.

Coverage: Coverage (share of national emissions covered) varies widely—OECD reports indicate large heterogeneity across sectors (power and industry more commonly covered;

transport and agriculture less so). OECD finds only a partial share of national emissions are under explicit prices (OECD, 2023).

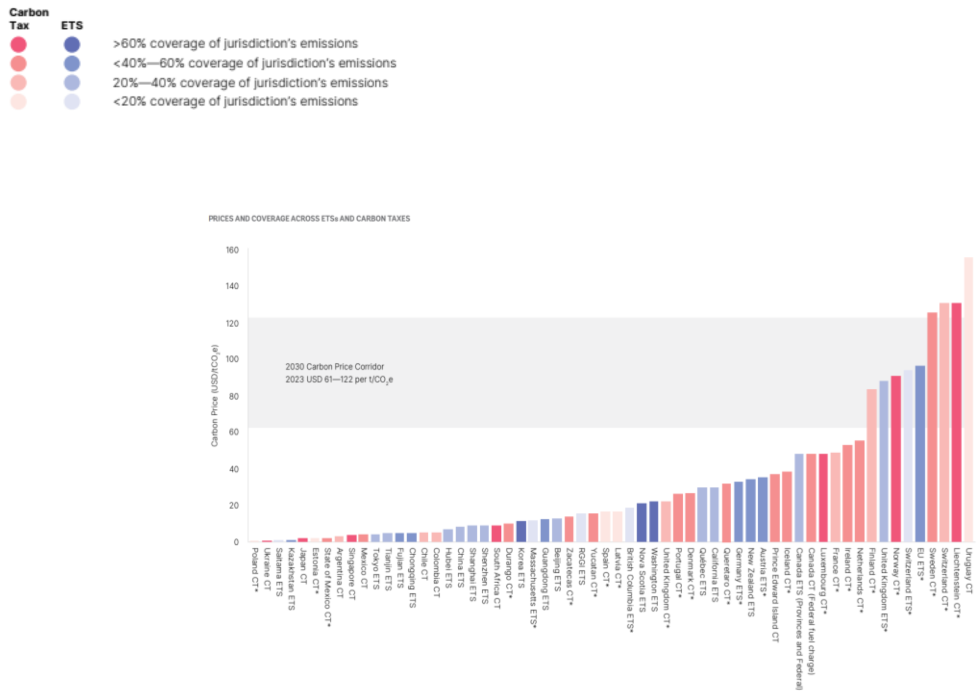


Source: World Bank Group

This chart depicts overall public support for carbon taxes in various countries. Overall, support is highest when the revenue is given back to the poorest households as a cash benefit (dark blue), versus giving the revenue back to all households (light blue). Countries with the highest overall support for a carbon tax included Indonesia, Turkey, and China, whereas Denmark, US, and Germany indicated the least. In conclusion, indicating that low-income groups being targeted for benefits make carbon taxes seem more tolerable..

Relation between carbon price level and % emission reduction.

- ***Literature reports*****:** Cross-country empirical studies (e.g., Kohlscheen et al., 2024; Best et al., 2020) find a **statistically significant negative relationship** between higher carbon prices and CO_2 emissions growth, though effect sizes are modest and vary by specification (short- vs long-run). Higher prices and broader coverage are associated with larger reductions.



Source: World Bank Group

This chart compares carbon prices (in USD per tonne CO_2) across countries and systems, including Emission Trading Schemes (ETS) and carbon taxes (CT). Prices range from almost zero; with some countries, like Ukraine and the United States, having caused and continuing to cause emissions and cost at almost zero price. Prices are high over $130 with systems such as Uruguay. The grey shaded area highlights the recommended 2030 price corridor ($61- $122) needed to achieve the climate targets. Many of those countries are well below this range, meaning the carbon price charged is too low to encourage meaningful emission reduction.

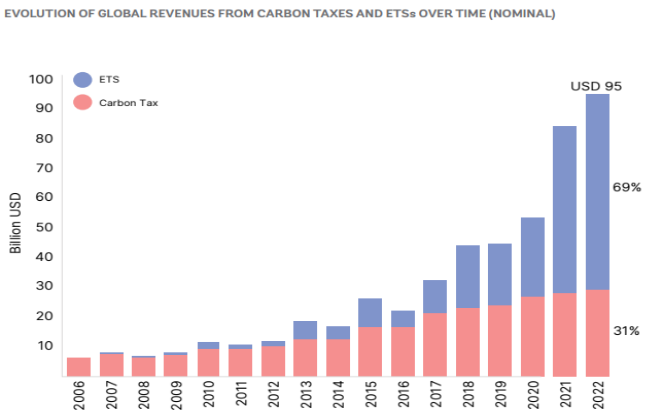
Key Observations:

Which mechanism shows stronger average reduction over time?

- Aggregated evidence indicates both of these mechanisms are likely to reduce emissions, but that carbon taxes tend to produce more consistent year-on-year decreases (particularly if tax levels are predictable and if the revenue is recycled), while cap and trade systems produce larger reductions, especially in tightening markets or when permit availability is restricted (Andersson, 2019; Ellerman et al., 2016; Kohlscheen et al., 2024). The OECD reports reinforce the importance of price level and coverage, not just instrument type, for effectiveness.

Influence of price levels and coverage scope

- ***Price level matters:*** The previous OECD and World Bank reports highlight that for the explicit carbon pricing found in the most recent version of the OECD benchmarking report, only a small portion of emissions are priced at ≥ EUR30/t or more as shown by results from the previous report; only countries with pricing above this level seem to show more clear effects. Higher prices → greater reductions in cross-country studies (Kohlscheen et al., 2024).
- ***Coverage matters:*** Where the pricing instrument covers large shares of national emissions (power generation, industry nonroad sources), the reductions in national emissions are larger. Conversely sectors that generate emissions but are not subject to a price signal (i.e. agricultural emissions and road transport emissions in some schemes) will mute the economy-wide effects.



Source: World Bank Group

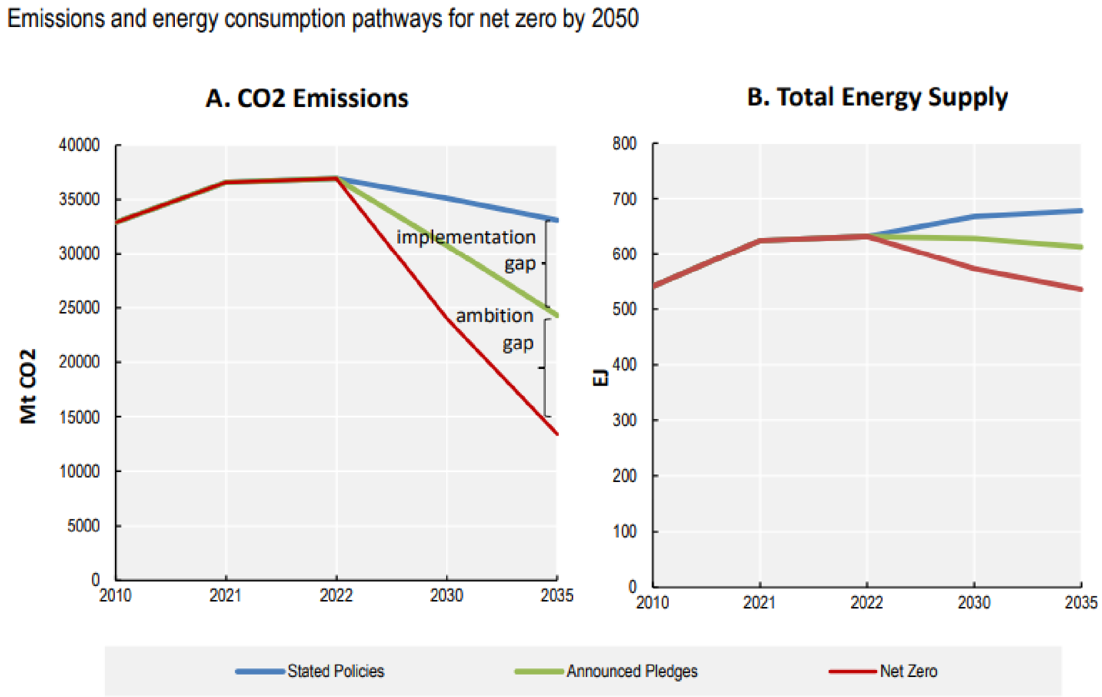
Discussion

Interpretation of results.

Drawing together the descriptive and empirical evidence highlights that CO_2 emissions are reduced using carbon taxes and cap-and-trade systems. However, they reduce emissions in distinct ways. Carbon taxes tend to result in steadier year-on-year reductions because they deliver a constant price signal, which can be planned against, either to households or firms (Andersson, 2019). Carbon taxes show smoother reductions in emissions because price signals are consistent, while cap-and-trade systems promise a quantity of emissions which can produce sudden, shorter-term declines, including significant reductions (in both magnitude and speed) if the cap is tightened or permits shift ing of the market clearing price to a higher price – yet both can be ineffective or sporadic if soft permits are available (Ellerman et al., 2016). Thus, which is "better" is a function of the policy objectives: carbon taxes are good when price certainty and incrementally reducing emissions is the goal whereas an ETS is preferred to strictly manage emissions quantity, but only if it has a credible cap.

Economic and policy context shaping outcomes.

Effectiveness is not immediate, three important design and contextual characteristics are (1) the level of effective price – all emissions reductions are larger for higher effective prices, regardless of instrument (OECD, 2023); (2) the scope -- systems that cover a higher share of national emission sources (power, industry, transport) create larger impacts across the economy; and (3) institutional credibility for offsets and complementary policies – recycling of revenues, backstops for regulation, investments in new clean technologies consolidate political acceptance, multiplying the effectiveness of emissions reductions (Rivers & Schaufele, 2015; OECD, 2022).



Source: OECD

Case examples

Sweden exemplifies how a long-standing, relatively high carbon tax with revenue recycling and targeted policies resulted in sustained emissions declines consistent with an expanding economy (Andersson, 2019). In contrast, the EU ETS illustrates the case of how a cap system can provide measurable reductions at scale, but also illustrates how initial lack of performance was a consequence of excessive permit allocation, lack of adequate phases, and price volatility; subsequent reforms (market stability reserve, more stringent caps) improved the program's performance (Ellerman et al., 2016). In both Sweden and the EU, it appears that design features (tax rates, permit allocation) and ability to reform matter more than instrument type alone.

Limitations and Caveats.

Several limitations dampen conclusions. First, gaps in data and heterogeneity (national versus subnational; sectoral exclusions) makes direct comparisons complex.

Second, there are time lags with respect to policy adoption and observable effects, therefore, short periods of post-policy implementation could provide an incomplete picture of long run effects. Third, associated policies (renewable subsidies, efficiency standards) complicate reliable attribution to pricing. Fourth, political economy factors, such as public acceptability, compensatory measures, and legal stability, affect implementation and effectiveness, but are difficult to consistently capture in a cross-national sense.

Policy implication

Policymakers should prioritise credible, sufficiently high carbon prices and broad coverage, pair pricing with targeted complementary measures, and design adaptive mechanisms (price floors, market stability tools, revenue recycling) to combine the predictability of taxes with the quantity certainty of ETSs. Choosing—or combining—mechanisms should be driven by national policy goals, institutional capacity for market governance, and the ability to protect vulnerable groups while maintaining political durability (OECD, 2023; Metcalf & Weisbach, 2009).

Conclusion

This research aimed to assess the relative efficiency of carbon taxes and cap-and-trade to reduce CO_2 emissions across OECD countries using secondary data from the OECD, World Bank and IEA. The average carbon prices, the uptake, and the resulting reductions were compared to show that carbon taxes exhibited average, consistent, and ultimately predictable reductions over time, especially in countries with the highest and steadily increasing price levels (e.g., Sweden, North, etc). Cap-and-trade systems, while effective in some contexts—most notably after EU ETS reforms—show greater variability in impact, often tied to market design, allowance surplus, and political adjustments.

In conclusion, the evidence suggests that a highly stable price—regardless of mechanism—is key to sustained emission reductions, although carbon taxes appear to display more transparency and predictability, and cap-and-trade systems can require a much higher degree of market design to guarantee an absolute cap.

Future research could expand the comparison to developing economies, sector-specific effects (for example, industry versus transport) and dynamic modelling to include technology change and response adaptations of behaviour. These analytical efforts would further clarify how pricing instruments can be used to support or complement global climate obligations and emission reductions resulting from the Paris Agreement.

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