Capable

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Lessons from carbon pricing in Europe: Beyond effectiveness

The European Union Emissions Trading System (EU ETS) is the world's largest carbon market and a cornerstone of the EU's strategy to combat climate change. It is a primary tool for reducing greenhouse gas emissions in energy-intensive sectors and plays a central role in achieving the EU's climate targets. This Policy Brief highlights several critical aspects of the EU ETS's performance, including its demonstrated ability to reduce emissions even at relatively low prices compared to social cost of carbon estimates.

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Highlights

The European Union Emissions Trading System (EU ETS) is the world's largest carbon market and a cornerstone of the EU's strategy to combat climate change. As the primary tool for reducing greenhouse gas emissions in energy-intensive sectors, it plays a central role in achieving the EU's climate targets, including the ambitious goals outlined in the European Climate Law and the European Green Deal. By capping emissions and enabling trade, the EU ETS provides a cost-effective pathway for industries to transition toward decarbonization while fostering innovation in low-carbon technologies. Research into the EU ETS is essential to ensure it continues to evolve as an effective and equitable instrument for achieving climate neutrality by 2050.

The CAPABLE project has utilized state-of-the-art and novel methodologies to conduct in-depth research on the European Union Emissions Trading System (EU ETS), providing comprehensive evidence of its effectiveness and evolution as a climate policy instrument. Through rigorous meta-analyses, econometric studies, and modeling approaches, the research reveals the successes and challenges of the world's largest carbon market, offering crucial insights for policymakers and market participants alike. The findings demonstrate that while the EU ETS has achieved significant emission reductions and developed into a mature market mechanism, there remain important opportunities for optimization and improvement.

The research reported in this policy brief highlights several critical aspects of the EU ETS's performance, including its demonstrated ability to reduce emissions even at relatively low prices compared to social cost of carbon estimates. Ultimately, the ETS carbon price rose to high levels compared to other national policies worldwide, facilitated by a gradually increasing price trajectory, allowing for political acceptance and industry adaptation. The research also highlights the increasing sophistication of market participants and the emergence of a notable divide between firms in their approaches to decarbonization.

The research also highlights the increasing sophistication of market participants and the emergence of a notable divide between firms in their approaches to decarbonization. Furthermore, research in the CAPABLE project has investigated how effectively carbon pricing drives emission reductions, how firms respond to price signals, and what factors shape decision-making across different sectors. However, differences in perspectives between academic disciplines highlight the need for improved communication and knowledge exchange to refine policy design.

These issues are central to ensuring that the system incentivizes decarbonization across a wide range of industries and promotes investment in cleaner technologies. At the same time, understanding the dynamics of the allowance market, which is influenced by market behavior, speculation, and policy announcements, is essential to maintain confidence in the system. Without stable and transparent market operations, the EU ETS risks undermining its credibility and the trust of both market participants and policymakers. Carrying out a microdata analysis of

transactions and applying key network metrics would improve market oversight and help detect anomalies, further strengthening the system's transparency and resilience.

As part of the Fit-for-55 policies, the EU works toward broader climate targets. Expanding the scope of the EU ETS is, therefore, another focus of the CAPABLE project. Extending carbon pricing to additional sectors, such as buildings and transport, can help address emissions in areas currently outside the system's scope, ensuring a more comprehensive approach to decarbonization. Similarly, mechanisms like the Carbon Border Adjustment Mechanism (CBAM) are critical for addressing carbon leakage and incentivizing stronger climate action internationally.

These insights come at a crucial time as the EU implements its Fit-for-55 package and considers further refinements to its carbon pricing mechanisms, which are presented in some detail in the following sections. The evidence suggests that while the ETS has proven its worth as a cornerstone of EU climate policy, targeted interventions could enhance its effectiveness and ensure more consistent participation across regulated entities.

Key Policy Messages

- The EU Emissions Trading System (EU ETS) has significantly contributed to EU emission reductions, even before the prices started to surge after the two ETS reforms in recent years. Transitioning from free allowance to auctioning reduced emissions and had minimal effects on employment and inequality.
- While ETS 2 provides a cost-efficient framework for reducing emissions in buildings, complementary policies are essential to balance household affordability concerns with broader economic impacts, ensuring a just and effective transition.
- Strong policy signals and a predictable framework have successfully enhanced the short-term and long-term credibility of the EU ETS. This allowed market actors to act with greater foresight and increase their certificate banking in order to take into account future certificate scarcity, which likely contributed more than half (50 EUR/tCO2) to the observed EUA price increase from 2018 to 2023.
- However, speculative activity in the EU ETS between 2017 and 2022 caused significant price volatility and deviations from fundamental values. This highlights the need for robust policy design, clear communication to mitigate market instability, and a possible reform to the MSR.
- The detection of anomalies in the EU ETS and market oversight can be improved by performing a microdata analysis of the physical transfers of permits and applying key network metrics to capture market activity.
- The success of the EU Carbon Border Adjustment Mechanism (CBAM) hinges on robust industrial policies, global cooperation, and effective carbon pricing frameworks. Climate clubs initiated by economically influential countries, combined with well-designed border carbon adjustments, can facilitate substantial international cooperation.

Carbon Pricing: How Effective Is It, and What Are Its Broader Impacts?

Carbon pricing is a key tool for reducing emissions, but its effectiveness and broader impacts remain subjects of ongoing debate. Recent research provides new insights into how well carbon pricing works and its economic consequences and exposes gaps in our understanding.

The EU ETS is at the heart of the EU climate policy. The ambition is to decarbonize the EU economies by putting a price on CO2 emissions. But how effective has carbon pricing, particularly the EU ETS, been? A comprehensive meta-analysis of carbon pricing schemes, drawing from 483 effect sizes across 80 causal ex-post evaluations, has provided robust evidence of the effectiveness of carbon pricing as a policy tool (Döbbeling-Hildebrandt et al., 2024).

The analysis reveals that introducing carbon pricing leads to immediate and substantial emission reductions. The assessment covers 21 carbon pricing schemes implemented across the globe, out of which at least 17 have achieved significant emission reductions, ranging between 5% and 21%. This finding is particularly significant given that these reductions were achieved despite relatively modest carbon prices in most jurisdictions. The meta-analysis quantifies the emission reduction rates achieved by the EU ETS at 7.3%, averaging the findings from 13 primary policy evaluations, which assessed the policy effectiveness for the first one to twelve years of the ETS being in place.

Policy evaluations for the years after 2017 are not yet available. Compared to carbon pricing policies in other jurisdictions, the EU ETS ranges rather at the lower end of the achieved emission reductions (see Figure 1). However, there is a large agreement across empirical studies that the ETS has significantly contributed to the emission reductions achieved within the EU since 2005.

The EU ETS has significantly contributed to the emission reductions achieved within the EU, even before the prices started to increase strongly in recent years.

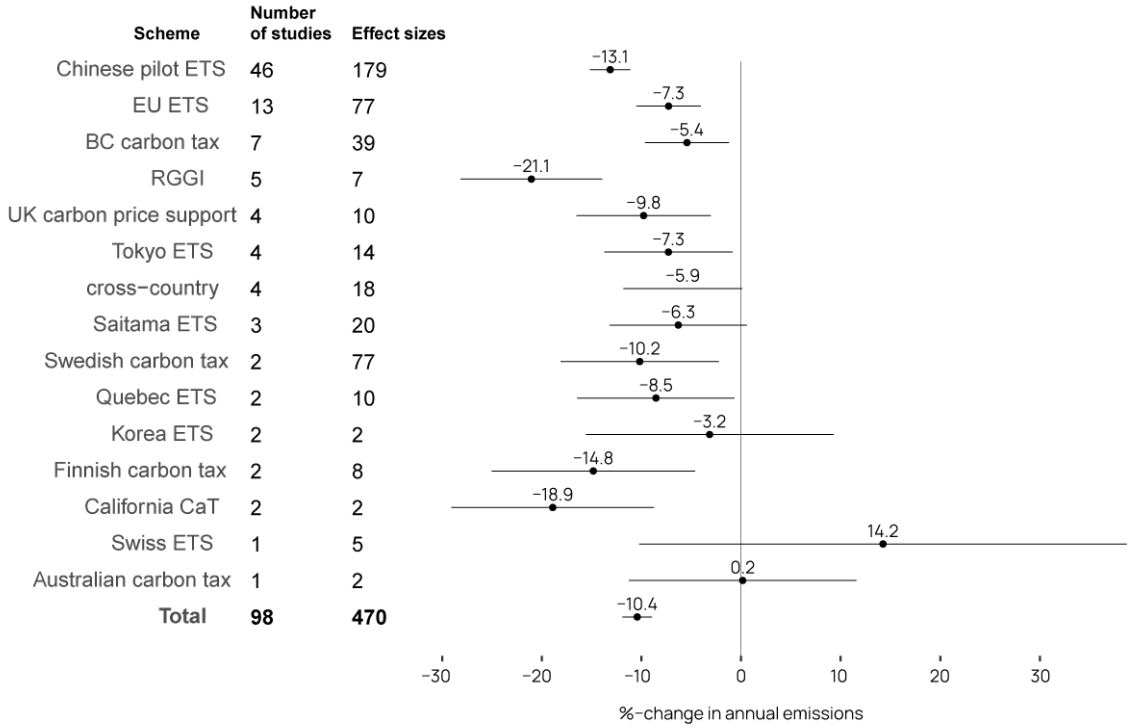

Figure 1 Mean emissions reductions caused across carbon pricing schemes. Note: Weighted mean effect sizes are presented together with their 95% confidence intervals based on multilevel random and mixed effects models and represent the effect of the policy observed in each period after its introduction in comparison to the counterfactual emissions without the policy. The estimates are ordered according to the number of studies they comprise (depicted on the left). The average treatment effect for the Chinese ETS pilots comprises the effects of all eight regional pilot schemes. Cross-country collects the evidence from studies assessing countries with and without carbon pricing, not focusing on a specific carbon pricing scheme.

Environmental policies such as the European Union Emissions Trading System (EU ETS) aim to reduce emissions, but people often worry about their impact on jobs and the economy. How does shifting from free allocation to auctioning affect employment and economic outcomes?

The CAPABLE project investigated how a major policy change in Phase 3 of the EU ETS (implemented in 2013) affected local economies across Europe between 2008 and 2020. Specifically, the study explored how shifting from free allocation of carbon allowances to auctioning impacted employment, economic outcomes (gross value added), and productivity per employee in different provinces, finding that areas more exposed to the changes in the EU ETS experienced job losses and economic slowdowns in the most carbon-intensive sectors, relative to regions that were less affected by the changes. However, the policy did not lead to significant reductions in overall employment when looking at the aggregate of all sectors, and it also led to a significant reduction in emissions from regulated firms, with only mild effects on economic inequalities across regions. While there were some economic costs, the policy's success in cutting emissions is clear, and the impact on regional differences was less pronounced than expected (Hernandez Carballo, Mallarino, and Percoco, 2025)

Shifting from free allowance to auctioning significantly reduced emissions, had minimal effects on overall employment and inequality, despite causing job losses and economic slowdowns in carbon-intensive sectors.

Before insights on the effectiveness of carbon pricing and its dynamics can be utilized to improve climate policy, consensus or at least a shared understanding is needed. But to what extent do researchers from different disciplines and regions agree on key aspects of carbon pricing? A study within the CAPABLE project explored this question by surveying 800 researchers from a wide variety of fields and countries who published on climate policy (Savin et al., 2024).

The findings reveal critical gaps in our understanding of carbon pricing dynamics, particularly regarding policy implementation, impact, and acceptability (see Figure 2). Specifically, researchers addressed topics like policy support among the general public and policymakers, possible synergies of carbon pricing schemes with other policies, and its global implementation.

This knowledge gap is especially relevant for policymakers considering the optimal design of carbon pricing mechanisms, as it suggests that while the basic effectiveness of carbon pricing is well-established, there remains considerable uncertainty about how to calibrate prices to achieve specific emission reduction targets.

The findings underscore the importance of continued monitoring and evaluation of carbon pricing schemes to build a more complete understanding of their effectiveness across different economic and policy contexts. In addition, Savin et al. (2024) found some misalignment in perceived knowledge gaps across disciplines, which suggests the need for more exchange of arguments and evidence to ensure more consistency regarding advice for society and politics.

For example, gaps exist between researchers from wealthier and poorer countries, which may be explained by carbon pricing having been implemented and studied mostly in more developed countries. Moreover, the usefulness of and barriers to carbon pricing may also be perceived differently due to local experiences.

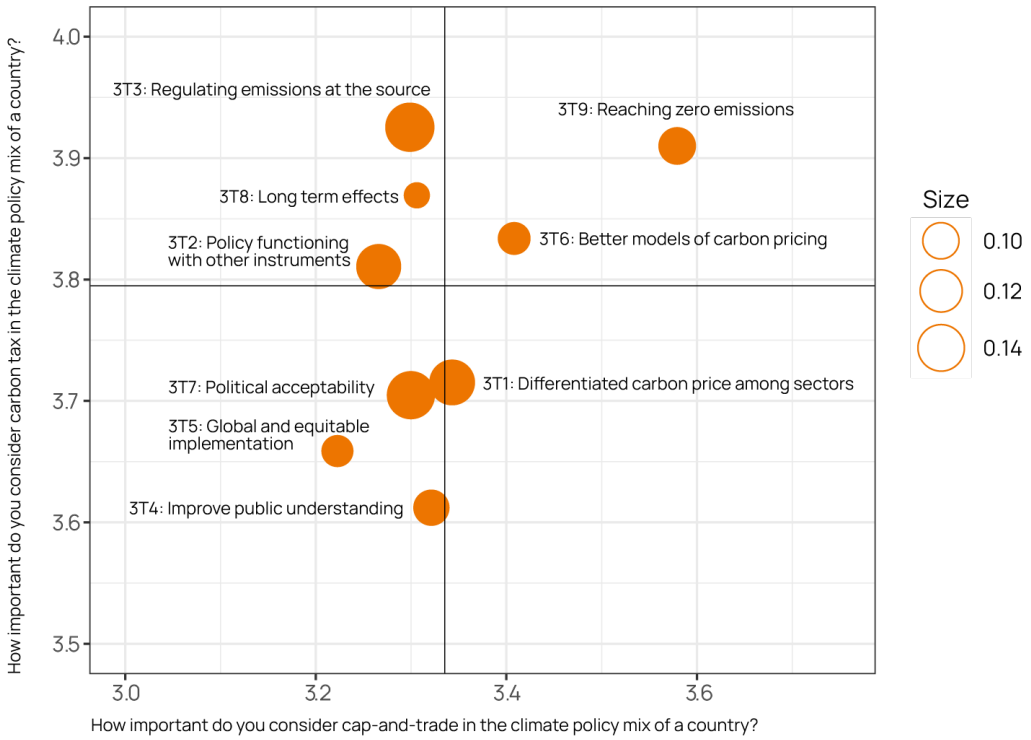

Figure 2 Perceived knowledge gaps in research about carbon pricing depending on the rated importance of carbon tax and cap-and-trade in a country's policy mix. Note: the size of the topic reflects its prevalence in the overall set of responses. The position of each topic on the X- and Y-axes is the weighted average response on the Likert scale from 1 (unimportant) to 5 (extremely important) on the corresponding questions.

Research reveals critical knowledge gaps in researchers' understanding of carbon pricing implementation, with significant variations in perspectives across researchers' disciplines and affiliations, highlighting the need for enhanced interdisciplinary and international knowledge exchange.

Speculation and Credible Policies - What affects ETS prices?

Carbon markets rely on stable price signals to guide long-term investments in decarbonization, but market behavior and policy credibility can significantly influence price dynamics. Recent research examines how policy signals, speculation, and financial actors shape the functioning of the EU ETS.

Carbon markets facilitate an efficient decarbonization of the economy when market participants are rational and well-behaved. However, how does policy credibility influence market behavior and price formation in the EU ETS? It is commonly assumed that market participants know and do not doubt the schedule of further emission permit issuance and do not try to game the system by indulging in speculative trade. In research that relaxed these assumptions, the CAPABLE project has analyzed the determinants of the carbon price in the EU ETS, finding a remarkable evolution in the credibility of policies and market maturity (Sitarz et al. 2024a, 2024b).

The carbon price dynamics show a clear progression from Phase I, characterized by bounded rationality and limited market understanding, to Phases II and III, where price formation increasingly reflects perfect foresight and sophisticated market behavior. This transformation can be attributed to the strengthening of policy signals and the establishment of a more predictable regulatory framework, which has enabled market participants to develop longer time horizons in their decision-making processes.

The research particularly emphasizes the role of policy credibility in shaping market outcomes. Strong, consistent policy announcements have been effective in extending market participants' planning horizons and improving overall market efficiency. This finding is supported by a quantitative analysis published in Nature Energy, which demonstrates that observed carbon price dynamics in recent years align more closely with the assumption of perfect foresight rather than bounded rationality, suggesting that market participants have developed increased confidence in the long-term stability of the EU ETS, leading to more efficient price discovery and better-informed investment decisions in low-carbon technologies.

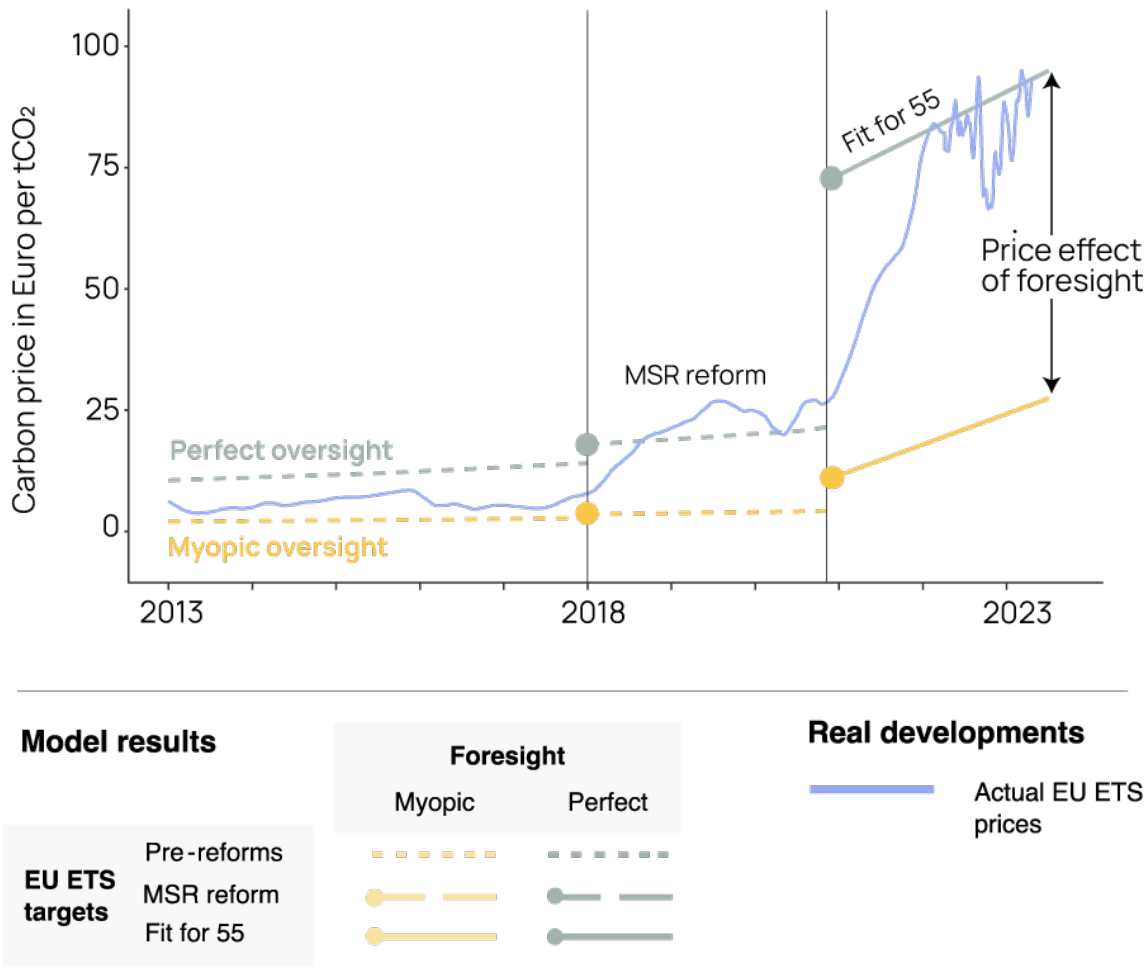

Figure 3 Impact of reforms and actors' foresight on carbon prices. Historical carbon prices on the EU ETS (blue) and modelled carbon price trajectories over the three periods (i)–(iii) that are separated by the two ETS reforms. For each period, we show the carbon price trajectory that would result from the cap that was valid during that period — once assuming short-sighted actors (yellow) and once assuming far-sighted actors (grey). The far-sighted actors bank certificates to account for future scarcities, and accordingly, the carbon price is (much) higher. Jumps in same-coloured trajectories from one period to the next show the effect that the change in the ETS cap and MSR parameters has under unchanged actor foresight. 'Myopic' here corresponds to a rolling foresight horizon of ten years. Historical prices are historical allowance (EUA) prices on the EEX spot market. Prices are nominal until 2023 and real EUR2023 from 2023 on. Figure adapted from Sitarz et al. Nat. Energy https://doi.org/10.1038/ s41560-024-01505-x (2024)The carbon price dynamics show a clear progression from Phase I, characterized by bounded rationality and limited market understanding, to Phases II and III, where price formation increasingly reflects perfect foresight and sophisticated market behavior. This transformation can be attributed to the strengthening of policy signals and the establishment of a more predictable regulatory framework, which has enabled market participants to develop longer time horizons in their decision-making processes.

Strong policy signals and a predictable framework have successfully enhanced the credibility of the EU ETS, fostering market confidence and long-term planning. This allowed market actors to act with greater foresight and increase their certificate banking in order to take into account future certificate scarcity, which likely contributed more than half (50 EUR/tCO2) to the observed EUA price increase from 2018 to 2023.

The CAPABLE project's analysis of speculative activity in the EU ETS reveals that, between 2017 and 2022 – a period characterized by rapid permit price increases – EUA futures experienced multiple speculative bubbles, where prices deviated from their fundamental values (Terranova et al., 2024). When did such bubbles occur, and what was the role of regulatory events? Figure 4 depicts these price bubbles, with shaded areas marking their occurrence. Overall, explosive periods occurred frequently, accounting for roughly 10% of the total days in the period studied. Notably, many of these speculative episodes coincided with regulatory events related to the EU ETS, underscoring the importance of careful policy implementation and effective communication to mitigate price volatility.

The analysis also examined the less liquid and less studied EUA options traded on the European Energy Exchange (EEX) and the Intercontinental Exchange (ICE). Findings indicate concerns in this market segment as well. Compared to the EUA futures market, the options market exhibits significantly lower liquidity, suggesting heightened vulnerability to price manipulation and speculative behavior. Our analysis identified multiple instances of unusual trading activity, some coinciding with key regulatory announcements. These findings underscore the need for policymakers to implement more targeted monitoring of the options market to ensure price stability and market integrity across all segments of the EU ETS.

Speculative activity in the EU ETS between 2017 and 2022 caused significant price volatility and deviations from fundamental values, highlighting the need for robust policy design and clear communication to mitigate market instability.

Speculative activities not only increase price volatility but can affect the level of the ETS price. Further research has shown that when speculators acting as irrational noise traders take large positions in the market, they can exert downward pressure on prices, pushing them below their fundamental value and indirectly leading to higher cumulative emissions. The research demonstrates that these market dynamics are significantly influenced by the Market Stability

Reserve (MSR), which was designed to improve market stability but may interact with speculative behavior in ways that were not fully anticipated.

Figure 3 EUA futures prices in 2017 - 2022. Shaded areas correspond to detected periods of explosive behaviour.

Conversely, a reform of the MSR can address speculative activity and increase the resilience of the ETS. The role of the MSR was studied in a dynamic behavioral model with shocks to system credibility whose effects on permit prices are exacerbated by the trading behavior of speculators.

Under current rules, the MSR's upper and lower thresholds for circulating permits are fixed, becoming increasingly large relative to the market as the emissions cap declines. The proposed reform allows these thresholds to decrease in line with the cap, reaching zero in the same year as the cap under the current linear reduction factor. The results indicate that this reform significantly improves the system's alignment with the planned cap trajectory, increases the resilience of the system to negative credibility shocks, and provides policymakers with greater control over the timing of net-zero emissions, reinforcing the effectiveness and credibility of the EU ETS. This research is particularly relevant for policymakers considering modifications to the MSR or other market stability mechanisms. The findings suggest that while speculation can contribute to market liquidity and price discovery, it may also introduce additional complexities that need to be carefully managed through market design and oversight mechanisms.

Speculation in the EU ETS can drive prices off their fundamental values, thus affecting emissions. Speculation can also make the system more vulnerable to credibility shocks. It is important to consider reforms to the MSR that improve the effectiveness of ETS.

An analysis of transactions in the EU ETS highlights the evolving role of financial intermediaries in the market and their interactions with regulated firms. But how do financial actors influence market liquidity, price formation, and overall system stability? Based on a micro-analysis of the data, the research proposes a framework to identify and classify financial actors active in the system. The study confirms that financial actors play an active role of intermediation and are responsible for the largest share of permits exchanged.

Studying key network metrics of these actors in the transaction network also highlights that financial actors play a central role. This has important implications for market liquidity and price formation, as financial intermediaries can both facilitate more efficient market operation and potentially introduce additional price volatility.The findings suggest that the relationship between financial intermediation and firm behavior is complex, with implications for how policymakers should approach market oversight and support for regulated entities.

The detection of anomalies in EU carbon permit trading and market oversight of the EU ETS can be improved by (a) performing a microdata analysis of the physical transfers of permits and (b) applying key network metrics to capture market activity.

ETS 2 and CBAM - Extending Carbon Pricing Beyond the ETS

Achieving the EU's ambitious climate targets requires expanding carbon pricing in scope and ambition to cover emissions from all major sectors. For this, the EU has planned to introduce new instruments to complement the carbon price of the EU ETS: the Emission Trading System 2 (ETS) and the Carbon Border Adjustment Mechanism (CBAM). The envisioned ETS 2 includes buildings and transport under a dedicated system, ensuring a more comprehensive and consistent approach to decarbonization. At the same time, the CBAM is essential to maintain a level playing field, preventing carbon leakage and supporting competitiveness as climate ambition increases.

Investing in energy efficiency is essential to reducing emissions from the residential housing sector, which accounts for a significant share of Europe's greenhouse gas emissions. Is the ETS 2, which extends carbon pricing to the housing sector, sufficient to trigger such investments? Most EU buildings are energy inefficient, and retrofitting them offers a substantial opportunity to lower energy consumption and emissions. However, the choice of policies to achieve these goals involves critical trade-offs. Carbon pricing, such as the planned Emissions Trading System (ETS 2) for buildings, can incentivize cleaner energy use and energy efficiency improvements. However, its cost burden on households can reduce political feasibility. Complementary policies, such as subsidies for retrofitting, can help alleviate these costs but introduce economic inefficiencies. Recent research demonstrates that carbon pricing alone, while cost-effective in theory, may not be sufficient to ensure a fair and politically feasible transition (Blanz & Gaitan, 2023). It emphasizes that subsidies for retrofitting, although capable of reducing immediate financial burdens on households, can lead to higher aggregate costs and crowd out other productive investments. The findings highlight the need for a balanced policy mix. For example, a phased introduction of carbon pricing, complemented by subsidies for retrofitting, can mitigate welfare losses while achieving substantial emissions reductions.

In comparing policy approaches, the EU's regulatory framework under the Fit-for-55 package focuses on energy performance standards for buildings. In contrast, the US emphasizes subsidies for retrofitting, as proposed in the Inflation Reduction Act. The paper finds that relying solely on subsidies can result in less effective emissions reductions and higher long-term costs. However, a combination of targeted subsidies and gradually phased-in carbon pricing, as proposed for ETS 2, may better balance the objectives of reducing emissions, minimizing household burdens, and maintaining economic efficiency. Ultimately, the study underscores that decarbonizing the housing sector requires coordinated investments and policy measures. Complementary tools, such as carbon pricing and subsidies, can address both efficiency and equity concerns, but their design must account for the broader economic and welfare impacts to ensure a just and effective transition

While ETS 2 provides a cost-efficient framework for reducing emissions in buildings, complementary policies are essential to balance household affordability concerns with broader economic impacts, ensuring a just and effective transition.

To address carbon leakage and promote global decarbonization, the EU introduced the Carbon Border Adjustment Mechanism (CBAM), which imposes tariffs on imported carbon-intensive goods. Using a global economic model, a CAPABLE study examines CBAM's economic and environmental impacts, particularly in relation to major trading partners like China and India (Rocchi et al. 2024).

While CBAM is expected to globally reduce CO_2 emissions, the reduction is modest, though this result does not take into account important indirect effects, such as fostering EU Member State consensus on phasing out free allowances in energy-intensive sectors and provoking decarbonization responses from trading partners. However, emissions may rise in Eastern Europe due to increased demand for energy-intensive goods, highlighting the need for robust industrial decarbonization policies. Macroeconomic impacts are negligible, but CBAM significantly affects energy-intensive sectors and trade flows, favoring imports from cleaner producers like the USA and EU.

The policy also strengthens global carbon pricing by addressing carbon leakage and elevating emission reporting standards. Its strategic implications suggest CBAM can align carbon policies among trading partners, particularly in export-driven economies, though concerns about trade reshuffling and developing nations remain. Future studies should explore CBAM's evolving dynamics and price sensitivity.

The EU CBAM fosters global decarbonization by addressing carbon leakage, aligning trade and climate policies, and provoking international responses, but its success hinges on robust industrial policies, global cooperation, and effective carbon pricing frameworks.

Recent research highlights a critical challenge in global climate governance: existing frameworks like the Paris Agreement fall short of ensuring ambitious, harmonized climate action. Despite near-universal participation, the lack of enforcement mechanisms leads to free-riding, carbon leakage, and insufficient commitments, leaving the world on track for 2.5-2.9°C warming, far exceeding the 1.5–2°C targets. Within this context, the "climate club" concept has emerged as a promising strategy to address these shortcomings. When a small group of frontrunner countries

employs border carbon adjustments (BCAs), they can create strong incentives for others to join the coalition, gradually expanding participation and fostering more ambitious global action (Núñez-Yebra et al., 2024). These clubs are most successful when revenues from BCAs are partially redistributed to offset abatement costs for lower-income countries, reducing barriers to participation.

Such mechanisms align with existing policies, including the EU's Emissions Trading System (ETS) and Carbon Border Adjustment Mechanism (CBAM), while addressing key gaps such as harmonized global policy enforcement and engagement of low-income countries. The combination of the EU ETS and the CBAM provides the European Union with an excellent position to initiate a climate club, as suggested in the literature. This strategic alignment could enable the EU to lead in forming a coalition of frontrunner countries, setting a precedent for more ambitious global climate action. Future policies should focus on refining revenue redistribution methods within the club, modeling potential retaliation risks, and enhancing carbon accounting frameworks to maximize the feasibility and effectiveness of climate clubs as pathways to an ambitious global treaty.

Climate clubs initiated by economically influential countries, combined with well-designed border carbon adjustments, can facilitate substantial international cooperation.

Conclusions

The research findings from the CAPABLE project underscore the central role of the EU Emissions Trading System (EU ETS) in reducing greenhouse gas emissions and fostering innovation in low-carbon technologies. The EU ETS has evolved into a mature and effective policy instrument, offering valuable lessons for global carbon pricing mechanisms. By aligning market operations with clear, credible policy signals, the system has significantly enhanced market confidence and long-term planning among participants.

At the same time, the research identifies challenges that merit attention, including the uneven decarbonization responses among firms and the risks posed by speculative activity. These findings highlight the need to ensure equitable participation and market stability, particularly as carbon pricing expands to new sectors.

The broader implications of the EU ETS extend to global climate governance, with mechanisms like the Carbon Border Adjustment Mechanism and climate clubs showcasing its potential to influence international decarbonization efforts. As the EU moves toward more ambitious climate targets, refining and expanding the EU ETS offers a pathway to achieving deeper emissions reductions, fostering economic resilience, and strengthening global cooperation.

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Disclaimer

This is the first Policy Brief of a collection of six high-level summaries of the main results of the CAPABLE research project. It summarizes the actionable policy recommendations developed within CAPABLE on key research topics for policymakers, practitioners, business and consumers' representatives.

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