CARBON PRICING AS A CATALYST FOR EMISSION REDUCTION AND ENERGY TRANSITION: EMPIRICAL INSIGHTS FROM THE UK

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Overview

Carbon pricing has emerged as a vital policy tool for reducing greenhouse gas (GHG) emissions and stimulating investment in low-carbon technologies. As of April 2024, 75 national or subnational carbon pricing schemes are operational, comprising 39 carbon taxes and 36 emissions trading schemes (ETSs), collectively covering approximately 24% of global GHG emissions—equivalent to 12.8 gigatons of carbon dioxide (World Bank, 2024). ETSs, exemplified by the EU Emissions Trading System (EU ETS), feature market-determined flexible pricing and high emission reduction efficiency. However, concerns persist regarding price volatility and insufficient price levels. To address these issues, countries like the UK, Germany, and Canada have adopted hybrid approaches that combine ETSs with carbon taxes. While interest in these combined mechanisms is growing, their long-term effectiveness, especially within the evolving international carbon market, remains uncertain.

Due to its high emission intensity, the power sector is a primary focus of most carbon pricing schemes. These typically target manufacturing, power generation, and road transportation, with a growing trend toward expanding coverage to buildings, aviation, and maritime transport. Among 48 countries implementing carbon pricing schemes from 1990 to 2020, 47 included the power generation sector, making it the most widely covered, followed by manufacturing, which is covered in 46 countries. Investments in emissions reduction and energy transition within sectors already subject to carbon pricing provide valuable insights and lay the groundwork for extending these mechanisms to emerging areas.

This study focuses on the UK's approach to emission reduction and energy transition under its carbon pricing framework, leveraging its unique policy setting that combines an ETS with a carbon tax. The UK has actively engaged in multiple carbon pricing schemes to achieve its decarbonization goals. From 2005 to 2020, it participated in the EU ETS. To complement this system, the UK introduced the Carbon Price Floor (CPF) in 2013—a carbon tax targeting the power sector. The CPF was designed to stabilize and elevate carbon prices, addressing the limitations of the EU ETS's fluctuating and often insufficient prices. By incentivizing investments in renewable energy and low-carbon technologies, the CPF has been instrumental in decarbonizing the UK's power sector, significantly reducing coal reliance and promoting cleaner energy sources. Following Brexit, the UK established its own Emissions Trading Scheme (UK ETS) in 2021 to replace its participation in the EU ETS. Despite this transition, the CPF remains a cornerstone of the UK's carbon pricing framework, reinforcing its ambitious decarbonization objectives.

By examining the UK's dual approach of combining ETSs with a carbon tax, this study contributes to the understanding of how hybrid carbon pricing mechanisms can enhance emission reductions and support energy transitions. It offers empirical evidence on the effectiveness of such mechanisms, providing valuable insights for policymakers seeking to refine and expand carbon pricing frameworks globally.

Methods

We employ the synthetic control method (SCM) to evaluate the impact of the UK's Carbon Price Support (CPS) on carbon emissions. SCM is a robust tool for estimating causal effects in policy evaluation and comparative case studies (Abadie, Diamond, & Hainmueller, 2010, 2015). Our donor pool comprises the UK (treated country) and 13 EU ETS Phase I countries without additional carbon pricing policies (control group) from 1990 to 2020, ensuring consistent data availability. The CPF, implemented in 2013, marks the policy year. Using pre-treatment emissions data (1990–2012), we construct synthetic UK emissions by minimizing the gap between actual and synthetic emissions under convexity constraints. The CPF's effect is measured as the difference between actual and synthetic emissions in the post-treatment period (2013–2020). Emissions are expressed as the logarithm of $CO2$ emissions per capita, controlling for economic performance, structure, energy mix, and urbanization. A sectoral SCM analysis of UK sectoral emissions serves as a robustness check. Additionally, time-series analysis of energy sources, electricity generation, and prices examines the CPF's role in the power sector's energy transition. Together, these methods offer a comprehensive evaluation of the CPF's impact on emissions reduction and energy transition in the UK power sector.

Results

Impact on aggregate emissions. Our analysis demonstrates that the implementation of the CPF in the UK has resulted in significant emissions reductions. A consistent divergence is observed between actual and synthetic UK emissions, with the emission gap remaining negative throughout the entire post-treatment period, indicating that actual emissions in the UK were consistently lower than in the counterfactual scenario without the CPF. Moreover, the absolute value of these emission gaps shows an increasing trend over time, reaching its peak in 2020, when the UK achieved a 25% reduction in emissions compared to the synthetic counterfactual. These findings highlight the substantial impact of the CPF in driving decarbonization and align with reports from the UK government. The results are robust across alternative emissions measures and model specifications, underscoring the reliability of our conclusions.

Impact on emissions generated from the power sector. Our findings confirm that the Carbon Price Support (CPS) has significantly reduced emissions in the power sector. The power sector emission gap remains consistently negative and widens over time, indicating increasing emission reductions in later years. The most substantial reduction was observed in 2020, with a 43.3% decrease in emissions compared to the synthetic counterfactual. Sectoral SCM estimates further demonstrate that the electricity, gas, steam, and air conditioning supply sector achieved significantly greater emissions reductions than sectors not regulated under the CPF. These results underscore the effectiveness of the CPF in driving substantial decarbonization within the power sector, which has been directly regulated under the policy.

Impact on energy transition in the power sector. Our analysis shows that the Carbon Price Support (CPS) has driven a significant shift in the UK power sector from traditional fossil fuels to renewable energy sources. The proportion of coal used for power generation declined sharply, from 41.94% in 2013 to 2.80% in 2020, while natural gas usage increased from 23.69% to 38.14%. Meanwhile, the share of renewable energy—including wind, solar, and nuclear—rose substantially, from 31.44% to 53.52% over the same period. Total energy consumption for power generation also decreased, from 74.71 million tonnes of oil equivalent (MTOE) in 2013 to 52.38 MTOE in 2020. Importantly, these transitions in energy sources did not result in higher costs for consumers, as the CPF had no significant impact on electricity prices.

Conclusions

Leveraging the unique context of the UK's implementation of the CPF within its power sector alongside the existing EU ETS, we evaluate the effectiveness of hybrid carbon pricing schemes. Our country-level and sectoral SCM results demonstrate that the UK's CPF has led to significant emissions reductions both at the aggregate level and within the power sector, despite the latter already being regulated under the EU ETS. Additionally, we find no significant adverse economic impact associated with the CPF.

A stable and sufficiently high carbon price is essential for incentivising decarbonization efforts in regulated sectors. It provides a clear and predictable economic signal, encouraging businesses to adopt low-carbon technologies and improve energy efficiency. High price levels make investments in renewable energy and cleaner production processes more economically viable, accelerating the shift away from fossil fuels. Additionally, stable pricing reduces uncertainty, enabling long-term planning and innovation. Mechanisms like carbon price floors ensure that the price remains consistently impactful, driving sustained emission reductions while fostering a systemic transition to low-carbon economies.

The coexistence of multiple carbon pricing schemes, such as combining ETSs with carbon taxes, can enhance the effectiveness of decarbonization by addressing the limitations of each mechanism. ETSs provide market-driven flexibility, while carbon taxes ensure price stability, creating a balanced and comprehensive framework. For instance, the UK's CPF stabilised carbon prices alongside the EU ETS, driving significant emissions reductions. Expanding such hybrid schemes to additional sectors, like buildings and maritime transport, holds potential for broader coverage and deeper emissions cuts, supporting global decarbonization efforts while fostering innovation in low-carbon technologies.

References

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