

Carbon Pricing Co-Benefits for Countries

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Overview

Production processes lead to joint by-products including multiple types of greenhouse gases that cause multiple sustainability problems. This paper provides an international assessment of the impact of carbon pricing on pollutants beyond just carbon dioxide emissions. Although the use of the CPM has dominated the discussion on climate change policies, the literature lacks extensive evaluations of its actual performance (Green, 2021; Sterner, 2015). This study complements prior analysis on the impact of carbon pricing on carbon dioxide emissions which tends to be at country or regional scales. This paper will be one of the first studies to empirically assess co-benefits of carbon pricing. The extent of these co-benefits is important to understand as it could provide countries with additional local motivation for employing carbon pricing, beyond the global motivations related to reduction in climate change risk.

Separate literatures have started to emerge on a range of empirical carbon-pricing issues. For example, there is a distinguishable literature on public acceptability (Carattini et al., 2018). Political feasibility analysis on what leads to carbon price uptake or intensity differences across countries is another important area (Best and Zhang, 2020; Levi et al., 2020). There is great potential for new models and frameworks to further understand what drives carbon pricing in general (Nazifi et al., 2021; Sun and Huang, 2020). Understanding has also been advanced for specific schemes such as in China and the European Union (Adekoya, 2021; Ji et al., 2021). After understanding what drives carbon pricing across countries and within schemes, a subsequent issue of importance is the effect of these carbon prices on environmental and sustainability outcomes.

We find that carbon pricing reduces total-greenhouse-gas and carbon-dioxide emissions by approximately 3 percentage points per year on average. There is a similar impact on particulate matter exposure. There is some evidence of impacts on some greenhouse gases such as methane and nitrous oxide. This is particularly the case for nitrous oxide emissions from the energy sector, as expected given that carbon pricing has often targeted energy sectors.

This paper seeks to make three main contributions related to the environmental and sustainability outcomes of carbon pricing. The first two contributions relate to expanding the breadth of prior analysis in multiple dimensions. This involves analysis of co-benefits of carbon pricing through reduction in non-CO₂ emissions, adding to prior analysis on the impact on CO₂ emissions. The global focus of the study is the other means of broadening analysis. Our third contribution is the way in which interpretation of the analysis is conducted, providing perspective that may be useful for future studies.

Methods

This paper empirically assesses co-benefits of carbon pricing. A fundamental concept related to cleaner production is that there are by-products along with the intended outputs of production. For example, production of energy through fossil-fuel combustion involves the emission of pollutants such as carbon dioxide, particulate matter, methane, and nitrous oxide. This can be reflected in a general production function. The inputs for production vary across economic sectors. This motivates attempts to control for economic structures in our empirical assessments that try to explain waste-product outcomes.

Followed by the Kaya Identity (Kaya, 1989), in our study, the level of emissions is decomposed into level-effects relating to population, GDP per capita, energy intensity, and carbon intensity. Thus, in our econometric approach, we use the level of these variables to explain the subsequent growth in emissions. To try to identify the impact of carbon pricing, it is important to attempt to separate its impact from other correlated variables. For instance, countries with carbon pricing might also be more likely to introduce other climate or energy policies. This motivates the inclusion of other policies as control variables in our model.

For non-CO₂ greenhouse gases, data are available from the International Energy Agency (IEA) for select years such as 2010, 2012, and 2015 (IEA, 2021). These emissions relate to energy, agriculture, industry, and other sectors (IEA, 2021). We use a cross-sectional approach for explaining growth in these non-CO₂ emissions. An ordinary least squares regression model with robust standard errors is used. For particulate matter, there is a panel of data that covers 2010-2017 (World Bank, 2021), so we use a fixed effects panel when explaining growth in particulate matter exposure. For the purpose of robustness check, we also conduct separate regressions that restrict the methane and nitrous oxide variables to energy-sector emissions to focus on this sector that has generally been the target of carbon pricing schemes.

Results

Our findings demonstrate that countries with carbon pricing have lower emissions of total greenhouse gases, carbon dioxide, nitrous oxide in the energy sector, and particulate matter exposure by approximately three percentage points per year on average. We also find that the gasoline tax and feed-in tariff policies have significantly impacted carbon dioxide emissions. Based upon this analysis, the implementation of carbon pricing played an important role in decreasing greenhouse gas emissions. The findings also reveal that the carbon pricing has led to a reduction in both methane and nitrous oxide emissions growth from the energy sector. Our analysis contributes to debates by providing evidence of additional benefits of carbon pricing beyond the impact on carbon dioxide emissions and through providing international analysis. Our approach suggests value in detailed future analysis of each distinct impact of carbon pricing.

Conclusions

Our paper contributes in three main areas. Our global study contrasts with prior country-level or regional studies of the impact of carbon pricing on CO₂ emissions. We present novel evidence on the impact of carbon pricing on non-CO₂ emissions, in contrast to studies that focus only on CO₂ emissions. The third main contribution relates to the interpretation of our results and the implications for communication on carbon pricing. Our findings showed that carbon pricing has larger point estimates of coefficients (in absolute-value terms) for the impact on CO₂, rather than other pollutants. This is consistent with carbon pricing historically targeting energy sectors where CO₂ emissions are pronounced, as opposed to agricultural sectors where pollutants such as methane and nitrous oxide are more important. These findings could be crucial for policymakers to make better-informed regulatory decisions when designing climate policies to reduce domestic emissions and support international efforts and, more specifically, when considering a carbon pricing mechanism.

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