Marginal Emissions Pathways: Drivers and Implications

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Governments frequently use policies that target the expansion of a clean technology to achieve greenhouse gas emissions mitigation goals, such as those submitted by countries under the Paris Agreement. Policymakers need accurate estimates of emissions reductions expected to be achieved by these efforts both individually—to inform the level of mitigation sought by any given nation, as well as collectively—to attribute national contributions to global mitigation. However, evaluating mitigation from clean technology policies is difficult because each unit of clean technology added by a policy need not result in the same change in emissions. As a result of direct and indirect market adjustments induced by a particular policy, marginal emissions from expanding a clean technology may vary in the amount of clean technology, reflecting a *marginal emissions pathway*. This paper explores the drivers of marginal emissions pathways and assesses how the shapes of marginal emissions pathways affect the prediction and attribution of mitigation from clean technology policies.

To this end, we first illustrate the drivers of marginal emissions pathways using a simple conceptual model that illustrates that marginal emissions from a mandate and a subsidy—the most common clean technology policies—can be decomposed into input and output effects. Since input and output effects depend on economic conditions in affected markets and the output effect depends on how a particular policy distorts markets, marginal emissions may vary with respect to the amount of clean technology and/or the policy driving the clean technology expansion.

Using a rich sectoral economic model that is coupled to a detailed emissions model, we then evaluate the marginal emissions pathways arising from a mandate and subsidy to promote corn ethanol in the United States. Marginal emissions pathways from each policy are non-constant in the amount of biofuel and, due to differential impacts on output markets, move in opposite directions and eventually have opposite signs. The same drivers that cause marginal emissions pathways to be non-constant, also explain the sensitivity of marginal emissions pathways to alternative parameter assumptions.

Finally, we consider the implications of non-constant marginal emissions pathways for predicting and attributing mitigation. Efforts to predict emissions reductions that explicitly or implicitly ignore the channels by which marginal emissions vary (e.g., amount of clean technology in the baseline and/or added, policy driving the expansion) can give rise to significant prediction errors. Similarly, with respect to decentralized efforts to address climate change such as the Paris Agreement, simple estimates of collective mitigation, such as the sum of all countries' mitigation pledges, are unlikely to be accurate which, in turn, may make it difficult to attribute each country's mitigation contribution. Numerically, we show that failing to account for non-constant marginal emissions can give rise to predicted changes in emissions that are of the wrong sign and/or that diverge by an order of magnitude from true estimates. Due to differences in the shapes of the marginal emissions pathways, these errors differ drastically across policies. Taken together our findings illustrate the potential for sizeable harm from implicitly or explicitly ignoring non-constancy in marginal emissions pathways when predicting or attributing mitigation from non-marginal changes in a clean technology.

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