ON THE SOCIAL WELFARE IMPLICATIONS OF POLICIES DESIGNED TO PROMOTE THE ADOPTION OF CARBON CAPTURE AND STORAGE TECHNOLOGY

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Overview

In this preliminary work, we have begun to explore the social welfare implications of policies designed to incentivize the adoption of carbon capture and storage ("CCS") technology. CCS is the process of capturing CO_2 emissions that would otherwise be emitted, possibly transporting those emissions (e.g., via pipeline), and injecting them underground to permanently isolate them from the atmosphere. CCS may prove an important tool in decarbonizing the electricity sector while slowing down and potentially reversing some of the more deleterious consequences of climate change (Pilorgé et al. (2020)). A variety of regulatory incentive schemes have been proposed to incentivize the adoption of CCS technology (Esposito et al. (2019)). In this work, we explore the effects of a tax on net emissions and a subsidy that is paid for carbon that is captured and stored. We demonstrate that in certain instances, a subsidy on CCS activity may result in the opposite of its intended effect, namely, incentivizing an increase in net emissions. We discuss the scenarios where this may occur and why it may prove beneficial to couple a subsidy on CCS activities with a tax on net emissions that escape capture.

We consider a stylized model of Cournot competition where firms are taxed for their carbon emissions. Taxation as a means of mitigating pollution has been studied widely in the industrial organization and public economics literature. Building on the work of Barnett (1980), who examines Pigouvian taxation in the case of a polluting monopolist and Requate (1993) who studies taxation versus permits for the case of Cournot duopolists, we consider the welfare implications of a policy that entails a firm being subsidized for undertaking CCS activities. Given that CCS technology is not capable of perfectly capturing all emissions, even with the adoption of this technology there will be positive net emissions that have escaped capture. In light of this reality, we demonstrate situations where a policy of subsidizing the capture, transport, and storage of CO_2 emissions may potentially generate perverse incentives that result in firms ramping up production purely to produce more emissions to receive payment in exchange for capturing and storing them. We discuss the implications for social welfare and the overall effect on net emissions. A policy of both subsidizing CCS coupled with a tax on net emissions that escape capture may prove more beneficial than either a policy of taxing net emissions alone or subsidizing CCS alone.

Methods

We will be conducting game theoretic analyses of CCS under a variety of different market design regimes. This will necessitate formulating formal game-theoretic models to encapsulate the specifics of the CCS policies and the market design in question. Upon formulation of the model, we will need to derive how different regulatory policies impact investment in CCS technology, net emissions, and overall market performance. This will be an iterative process requiring a mix of pen-and-paper calculations and running numerical simulations. These results will then be compared to market designs used in practice to help make policy relevant recommendations and will help establish a foundation for further empirical study and analysis.

Results

We have developed a game-theoretic approach to investigate the relationship between policies that incentivize CCS through providing subsidies for CO_2 injection (i.e., 45Q) and policies that increase the cost of emitting CO_2 (e.g., CO_2 taxes) in a wholesale electricity market. We developed a highly stylized model of Cournot competition that considers the market implications of utilizing a CCS subsidy alone, a carbon tax alone, or both policies simultaneously. By first considering the case of a single firm monopoly, we find that a policy of subsidizing CCS results in lower electricity prices and higher consumer surplus. In addition, we find that the profits of the generating firm are higher after the introduction of the subsidy. However, given that CO_2 capture technology does not capture 100% of emissions produced, the effect on net emissions may be ambiguous even with a CCS subsidy. That is, under certain demand and cost parameters, it is possible for a subsidy to create perverse incentives for a firm which results in an increase in carbon-emitting activity simply to capture and store the CO_2 in exchange for subsidy payment. This effect can be counterbalanced with a tax. This result is particularly relevant in the duopoly setting where we examine a market consisting of one firm that produces no carbon emissions with a firm that does produce carbon emissions. In this case, the derivation of the Nash equilibria for the duopoly game illustrates how a CCS subsidy alone may incentivize an

increase in carbon emitting activity while simultaneously discouraging production from the firm that does not produce any emissions. This framework illustrates the importance of understanding the market dynamics at play in introducing a subsidy scheme to ensure that it has proper incentives.

Conclusions

This study will provide two main contributions. By studying the welfare implications of different regulatory schemes to incentivize the adoption of CCS technology, this work will contribue to the theoretical industrial organization, applied game theory, and market design literature. This study will also have practical relevance for regulators and public policy analysts in that it will aid our understanding of how market interventions designed to reduce carbon emissions will impact social welfare and market behavior. Given the debates surrounding how market designs may need to be rethought in light of goals towards decarbonization and the introduction of renewable generation (Rodrik (2014), Fabra (2021)), this study may represent a step towards better informed electricity market design decisions.

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