REGULATION OF CCS TRANSPORTATION INFRASTRUCTURES: INSIGHTS FROM A BI-ELEVEL OPTIMIZATION MODEL

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Carbon Capture and Storage (CCS), CO_2 pipelines, Regulation, Rate-of-return

Overview

Carbon Capture and Storage (CCS) is commonly referred to as a critical technology for mitigating climate change. However, its large-scale deployment relies on the installation of CO_2 transportation infrastructures. A microeconomic representation of CO_2 pipelines shows that this system exhibits economies of scale and verifies the conditions of a natural monopoly. Since exit is costly for this type of industry, the exercise of market power is an issue. In this paper, we build a simple dynamic bilevel optimization model to evaluate the regulation of this monopoly under a rate-of-return constraint. First, we consider the extreme cases of the unconstrained monopoly and the welfare-maximizing social planner. We quantify the social distortion that occurs under the unregulated monopoly scenario. Conversely, we show that the monopoly incurs losses in a welfare-maximizing case. Therefore, we consider the intermediate case where a social planner regulates the monopoly through a rate-of-return constraint. While the deadweight loss obtained with this solution remains moderate, our findings indicate that allocative efficiency is an issue, and we document the associated environmental impact. Finally, sensitivity analyses allow us to quantify the influence of parameters on the behavior of the monopoly, such as the probability of an increase in demand for CO_2 transportation and the discounting rate. Indeed, our model imposes the monopoly to install capital in anticipation of future demand. Our model thus analyses the impact of building ahead of demand. Overall, our findings trigger an important public policy debate on the need to regulate these emerging infrastructures.

Methods

We build a simple bilevel optimization model with two time periods, with uncertainty on demand for transportation in the second period. The pipeline operator decides which quantity of capital to be installed in the first period but can vary the energy of the pumps during transportation during each period. The pipeline transportation follows a Cobb-Douglas production function based on engineering equations.

Results

The monopoly installs far less capital in the unregulated scenario than in the first-best welfare-maximizing scenario. However, in this second scenario, the monopoly's profit is negative. Applying a rate-of-return constraint to the monopoly reduces the deadweight loss and increases the amount of capital installed, and the quantity of CO_2

transported compared to the unregulated scenario. However, the quantity of CO_2 transported is much lower than in the welfare-maximizing scenario.

Conclusions

A rate-of-return regulation reduces social losses while ensuring a reasonable profit for the pipeline operator. However, this type of regulation does not consider the environmental aspects: under this regulation constraint, the quantities of CO_2 transported are low compared to a first-best scenario. In this paper, we identify and illustrate the allocative efficiency problem between environmental and economic concerns.